POLICY ISSUE
(Notation Vote)

March 25, 1991 SECY-91-078

For: The Commissioners

From: James M. Taylor
Executive Director for Operations

Subject: CHAPTER 11 OF THE ELECTRIC POWER RESEARCH INSTITUTE'S (EPRI'S) REQUIREMENTS DOCUMENT AND ADDITIONAL EVOLUTIONARY LIGHT WATER REACTOR (LWR) CERTIFICATION ISSUES

Purpose: To inform the Commission of the staff's intent to issue the draft safety evaluation report (DSER) for Chapter 11 of the EPRI Requirements Document. Additionally to request Commission approval of staff recommendations concerning additional proposed changes to regulatory practice for the evolutionary advanced light water reactors (ALWRs).

Background: In the staff requirements memorandum (SRM) of December 15, 1989 pertaining to SECY-89-334, "Recommended Priorities for Review of Standard Plant Design," the Commission provided the following guidance to the staff:

> The SERs on the EPRI Requirements Document for both the evolutionary and the passive plant designs should be submitted to the ACRS for review and to the Commission for information and for review and approval of policy issues for which the Commission has not previously decided.

Further, in the SRM of June 22, 1990 pertaining to SECY-90-146, "Process, Schedule, and Resources For the Review of Evolutionary and Passive Advanced Light Water Reactors," the Commission directed the staff to follow the process presented in SECY-90-065, "Evolutionary and Passive Advanced Light Water Reactor Resources and Schedules." The staff included

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NOTE: TO BE MADE PUBLICLY AVAILABLE WHEN THE FINAL SRM IS MADE AVAILABLE.

the aforementioned guidance to SECY-89-334 as an element of the process described in SECY-90-065. In SECY-90-401, "Draft SER for Chapters 6, 7, 8, 9, 12, and 13 of EPRI's ALWR Documents for Evolutionary Reactor Plant Designs," the staff, following this guidance, informed the Commission that it would issue DSERs for Chapters 6, 7, 8, 9, 12, and 13 of the EPRI Requirements Document for evolutionary reactor plant designs. The staff issued these documents on January 15, 1991. This paper provides the DSER for Chapter 11, "Electric Power Systems." The remaining DSERs for the evolutionary design criteria, Appendix A to Chapter 1 and Chapter 10, are currently in preparation by the staff.

Discussion: Operating experience and a number of studies (e.g., probabilistic risk assessments (PRAs)) have identified a number of issues significant to reactor safety. In addition, in SECY-90-016, "Evolutionary Light Water Reactor Certification Issues and Their Relationship to Current Regulatory Requirements," the staff identified several policy issues that apply to future evolutionary ALWR designs and for which the Commission provided guidance in its SRM of June 26, 1990. The staff, in its continued review of the EPRI ALWR Requirements Document, has identified the following two additional issues:

1. alternate source of power for non-safety loads
2. connection of safety bus offsite power sources through non-safety buses

Enclosure 1 contains a detailed discussion of each of these issues and addresses those instances in which the staff positions differ from current regulatory requirements or in which the staff is substantially supplementing or revising interpretive guidance applied to currently licensed light water reactors (LWRs). In this enclosure, the staff also discusses the nature of the current regulatory requirement or interpretation, the positions of the ALWR vendors and of EPRI, the departure that the staff is proposing, and the basis for the proposed departure. To aid in identifying the staff's positions, the staff has underlined its positions and has cross-referenced them with the sections in the Chapter 11 DSER where they are discussed.

The staff developed the recommendations identified in this paper after (1) reviewing current generation reactor designs and evolutionary ALWRs, (2) considering operating experience, and (3) evaluating the results of the PRAs of LWRs. In addition, these positions are consistent with current design practices at recently licensed operating reactors.

To follow the process outlined in SECY-90-065, the staff will need to identify policy issues and bring them to the Commission for guidance before completing and distributing the DSERs.

However, the staff identified the issues discussed in this paper as it developed the DSER on Chapter 11 of the EPRI ALWR Requirements Document. Accordingly, the staff has enclosed the completed DSER (Enclosure 2) to provide the Commission additional information regarding these matters and to put the identified issues into their proper technical context. Additionally the staff believes that it would be beneficial to provide EPRI with the DSER in parallel with Commission review. The DSER would indicate that the previously identified policy issues are before the Commission for consideration. Distribution of the documents would expedite the review schedule by providing EPRI with a listing of staff identified open issues. Resolution of these issues will be addressed in the final SER on the EPRI Requirements Document.

Conclusions: The staff believes its conclusions and recommendations regarding these matters are in keeping with the Commission's policy expectation that future designs for nuclear plants will achieve a higher standard of safety performance.

The staff requests the Commission's approval of, or alternate guidance on, the proposed resolution of these issues in order to continue to review Chapter 11 of EPRI's ALWR Requirements Document for evolutionary plants and to perform the design certification of General Electric's ABWR, and Combustion Engineering's System 80+ designs.

By permitting the issuance of the DSER for Chapter 11 to EPRI, the Commission could expedite the review schedule while it considers these policy issues. In the DSER, the staff states that these policy issues are before the Commission for consideration. The staff will provide a regulatory departure analysis, based on Enclosure 1 of this paper, as Appendix C to the DSER on Chapter 11.

The staff will promptly inform the Commission during its reviews if it determines that additional enhancements to existing requirements, beyond those already identified, are necessary for evolutionary ALWR designs.

Coordination: The Office of General Counsel has reviewed this paper and has no legal objection. This paper is being forwarded to the ACRS for their review and comments.

Recommendations: That the Commission

(1) Approve the staff positions detailed in Enclosure 1

(2) Note that if the staff identifies other policy issues, the staff will inform the Commission of its positions in a timely manner

(3) Note that absent alternative Commission guidance, the staff will issue the enclosed DSER on Chapter 11 of the EPRI ALWR Requirements Document for evolutionary plant designs 10 working days after the date of this paper. The DSER will identify the two instances in which the staff is proposing to depart from current regulatory requirements and will state that the Commission is reviewing the basis for the approach that the staff is proposing and, accordingly, may determine that such issues involve policy questions that the Commission may wish to consider.

James M. Taylor
Executive Director
for Operations

Enclosures:
1. Policy Issues Analysis
and Recommendations
2. Draft Safety Evaluation
Report on Chapter 11

Commissioners' comments or consent should be provided directly to the Office of the Secretary by COB Tuesday, April 9, 1991.

Commission Staff Office comments, if any, should be submitted to the Commissioners NLT Tuesday, April 2, 1991, with an information copy to the Office of the Secretary. If the paper is of such a nature that it requires additional review and comment, the Commissioners and the Secretariat should be apprised of when comments may be expected.

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POLICY ISSUES ANALYSIS AND RECOMMENDATIONS

1. Alternate Source of Power for Non-Safety Loads

General Design Criterion (GDC) 17, "Electric Power Systems," requires that an onsite electric power system and the offsite electric power system be provided to permit functioning of structures, systems, and components important to safety. The offsite electric power system must have two physically independent circuits from the transmission network to the onsite electric distribution system.

Although the NRC has not established regulatory requirements on the number of power sources to the following non-safety related loads, the licensees for almost all nuclear power plants in the United States have provided two power sources to nonsafety-related loads such as reactor coolant pumps, reactor recirculation pumps, main feedwater pumps, condensate pumps, and circulating water pumps. During unit operation, a fast transfer of the nonsafety loads is usually provided to the startup transformer when imminent loss of the unit auxiliary transformer is sensed, such as following a main generator trip or a fault of the unit auxiliary transformer circuit. This process maintains power to the identified nonsafety loads and allows the plant to be shut down under these circumstances without a loss of normal feedwater systems or of forced circulation to the reactor coolant system.

The Electric Power Research Institute (EPRI) has specified requirements in the Requirements Document that only provide for a single source of power from the unit auxiliary transformer to nonsafety loads such as reactor coolant pumps, reactor recirculation pumps, main feedwater pumps, condensate pumps, and circulating water pumps. This one power source provides power to these loads during power operation, startup, and shutdown. A generator circuit breaker will isolate the main generator from the unit auxiliary transformer circuit during startup and shutdown when the main generator is unavailable. In existing plant designs, the main generator circuit breaker/unit auxiliary transformer configuration provide this isolation. However, an alternate source of power to this group of nonsafety loads is also provided at recently licensed operating plants, but not in the criteria of the EPRI Requirements Document.

The General Electric (GE), Combustion Engineering (CE), and Westinghouse standard plant designs all use the main circuit breaker/unit auxiliary transformer configuration as the primary power source to the subject nonsafety loads. However, the Westinghouse SP/90 design also provides an alternate source of power to the nonsafety loads, and the GE ABWR design provides an alternate source of power to a portion of the nonsafety loads (one of four main nonsafety buses). The CE System 80+ design uses the EPRI approach (it does not provide for an alternate power source).

An additional source of power would significantly reduce the number of plant trips that involve a loss of power to the nonsafety loads and require that the plant be shut down under natural circulation. Such an additional source of power would improve plant safety, because these events continue to be identified as more severe than the turbine-trip-only event in standard plant safety analysis reports.

The staff concludes that EPRI should enhance the ALWR design criteria in this area because they are less conservative than those that have been provided in existing, recently licensed plant designs. Therefore, the staff's position is that an evolutionary ALWR design should include an alternate power source to the nonsafety loads unless the design can demonstrate that the design margins in the evolutionary ALWR will result in transients for a loss of nonsafety power event that are no more severe than those associated with the turbine-trip-only event in current existing plant designs.

The staff addressed this issue in Section 4.2.1 of the Chapter 11 DSER (Enclosure 2 of this paper).

2. Connection of Safety Bus Offsite Power Sources Through Nonsafety Buses

GDC 17 requires that an onsite electric power system and offsite electric power system be provided to permit functioning of structures, systems, and components important to safety. The offsite electric power system must have two physically independent circuits from the transmission networks to the onsite electric distribution system. Although GDC 17 specifies that two offsite power circuits are required, and although it provides further additional design criteria on these circuits, it does not specify whether the circuits should directly connect the safety buses to the offsite power sources or whether this connection could be made through intervening nonsafety buses. The Institute of Electrical and Electronic Engineers (IEEE) Standard 308-1974, which is endorsed by Regulatory Guide 1.32, Rev. 2, "Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants," provides a figure that shows the Class 1E safety buses are directly connected to an offsite power transformer (startup transformer). However, the figure is for illustration only, and the Standard does not require the direct connection. IEEE Standard 765-1983 allows the Class 1E safety buses to be connected through nonsafety buses to the offsite transformers, but it also states that direct connection of the two circuits to each redundant Class 1E bus may further improve availability. However, the staff has not endorsed IEEE Standard 765, with a regulatory guide. Therefore, no regulatory requirements or guidance address the connection of safety bus offsite power sources through nonsafety buses.

EPRI's position is that many current designs of U.S. and foreign plants feed safety buses through nonsafety buses or from common transformer windings, and operating experience with these designs has not indicated any particular shortcomings. EPRI stated that there are real benefits in not connecting the safety buses directly to the offsite power supply, such as better protection of Class 1E systems against voltage surges affecting the offsite source. EPRI also states that the ALWR design makes provisions for a direct connection between safety buses and the offsite source in the event of problems with the nonsafety buses through which the safety buses are fed. EPRI indicated that some circuits are manually actuated and directly connect the safety buses to the reserve offsite transformer. The staff accepts such circuits. However, the EPRI Requirements Document does not require such a feature.

In the GE ABWR standard plant design, all the offsite power sources are directly connected to the Class 1E safety buses with no intervening nonsafety buses. In the Westinghouse SP/90 design, one circuit provides a direct connection between the Class 1E safety buses and an offsite power source while the remaining circuits connecting the safety buses to the offsite sources are all routed through intervening nonsafety buses. The CE System 80+ design in this area is identical to the EPRI approach in that it provides for a direct connection between safety buses and the offsite source in the event of problems with the nonsafety buses through which the safety buses are fed.

The staff concludes that feeding the safety buses from the offsite power sources through nonsafety buses or from a common transformer winding with nonsafety loads is not the most reliable configuration. Such an arrangement increases the difficulty in properly regulating voltage at the safety buses, subjects the safety loads to transients caused by the nonsafety loads, and adds additional failure points between the offsite power sources and safety loads. Therefore, it is the staff's position that at least one offsite circuit to each redundant safety division should be supplied directly from one of the offsite power sources with no intervening nonsafety buses, in such a manner that the offsite source can power the safety buses upon a failure of any nonsafety bus.

The staff discusses this issue in Section 4.2.2 of the Chapter 11 DSER (Enclosure 2 to this paper).

DRAFT SAFETY EVALUATION REPORT

ON

CHAPTER 11 OF THE ADVANCED LIGHT WATER REACTOR

REQUIREMENTS DOCUMENT

FOR EVOLUTIONARY PLANT DESIGNS

prepared by the

Office of Nuclear Reactor Regulation

U.S. Nuclear Regulatory Commission

March 1991

ABSTRACT

The Electric Power Research Institute (EPRI) is preparing a compendium of technical requirements, referred to as the Advanced Light Water Reactor (ALWR) Requirements Document that is applicable to the design of an ALWR power plant. When completed, this document is intended to be a comprehensive statement of utility requirements for the design, construction, and performance of an ALWR power plant for the 1990s and beyond.

The Requirements Document consists of three volumes. Volume I, "ALWR Policy and Summary of Top-Tier Requirements," is a management-level synopsis of the Requirements Document, including the design objectives and philosophy, the overall physical configuration and features of a future nuclear plant design, and the steps necessary to take the proposed ALWR design criteria beyond the conceptual design state to a completed, functioning power plant. Volume II consists of 13 chapters and contains utility design requirements for an evolutionary nuclear power plant [approximately 1350 megawatts-electric (MWe)]. Volume III contains utility design requirements for nuclear plants for which passive features will be used in their designs (approximately 600 MWe).

The staff of the Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, is preparing draft safety evaluation reports (DSERs) to discuss the results of its review of the original version of the Requirements Document. On September 7, 1990, EPRI submitted the rollup document on the design criteria for evolutionary plants. After EPRI has submitted its responses to these DSERs, the staff will issue a final SER to discuss its conclusions regarding its review of EPRI's responses and the rollup document. The DSERs do not address the rollup document submitted on September 7, 1990. On September 7, 1990, EPRI also submitted its original version of the Requirements Document providing the design criteria for plants in which passive design features will be used. The staff will issue DSERs on this document, and after EPRI's submittal of the rollup document on passive plant designs, it will issue a final SER discussing the results of its review of the passive design.

In September 1987, the staff issued the first DSER in this series. The DSER addressed the Requirements Document "Executive Summary" and Chapter 1, "Overall Requirements," regarding the overall objectives and requirements of the ALWR program for evolutionary plant designs. This DSER was modified in February 1988. Chapter 2, "Power Generation Systems," was evaluated in the second DSER, which was issued in February 1988. The third DSER, issued in May 1988, covered Chapter 3, "Reactor Coolant System and Reactor Non-Safety Auxiliary Systems." The fourth DSER, issued in June 1988, covered Chapter 4, "Reactor Systems." The fifth DSER, issued in February 1990, covered Chapter 5, "Engineered Safety Systems." DSERs on Chapter 6, "Building Design and Arrangement," Chapter 7, "Fueling and Refueling Systems," Chapter 8, "Plant Cooling Water Systems," Chapter 9, "Site Support Systems," Chapter 12, "Radioactive Waste Processing Systems," and Chapter 13, "Main Turbine-Generator System," were issued in December 1990.

This DSER discusses the staff's review of Chapter 11, "Electric Power Systems." This chapter was prepared by Bechtel Power Corporation, Combustion Engineering, Inc., Commonwealth Edison Company, Duke Power Company, General Electric Company, MPR Associates, Inc., S. Levy Incorporated, Sergeant and Lundy Engineers, Stone and Webster Engineering Corporation, Westinghouse Electric Corporation, and Yankee Atomic Electric Company under the project direction of the Electric Power Research Institute, Palo Alto, California, and the ALWR Utility Steering Committee. The requirements apply to boiling water reactors and pressurized water reactors in sizes up to 1350 MWe.

Key topics in the Chapter 11 review include

- onsite power systems
- medium and low voltage ac distribution systems
- onsite standby ac power supply system
- dc power supply system
- offsite power systems
- normal and emergency lighting
- electrical protective systems
- resolution of certain generic safety issues

In staff requirements memoranda, the Commission instructed the staff to provide an analysis detailing where the staff proposes departure from current regulations or where the staff is substantially supplementing or revising interpretive guidance applied to currently licensed light water reactors. The staff considers these to be policy issues. Appendix C of the DSER provides that analysis. These issues have been forwarded to the Commission in SECY-91- . The Commission is reviewing the basis for the approach that the staff is proposing for those issues discussed in Appendix C and, accordingly, may at some future point in the review determine that such issues involve policy questions that the Commission may wish to consider. These issues are considered fundamental to agency decisions on the acceptability of the evolutionary ALWR designs. For easy identification, the staff's positions regarding these issues have been underlined in Appendix C and have been cross-referenced with the other sections in the DSER in which they are discussed.

On the basis of its review, the staff concludes that there are issues that require satisfactory resolution before it can complete its review of Chapter 11 of the Requirements Document. These issues are discussed in detail in the attached report (see Section 1.4 of the report for a summary of these issues).

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

APPENDICES

DRAFT SAFETY EVALUATION REPORT
ADVANCED LIGHT WATER REACTOR REQUIREMENTS DOCUMENT
CHAPTER 11, "ELECTRIC POWER SYSTEMS"
FOR EVOLUTIONARY PLANT DESIGNS

1 INTRODUCTION AND GENERAL DISCUSSION

The Electric Power Research Institute (EPRI) is preparing a compendium of technical requirements, referred to as the Advanced Light Water Reactor (ALWR) Requirements Document, that is applicable to the design of an ALWR power plant. When completed, this document is intended to be a comprehensive statement of utility requirements for the design, construction, and performance of an ALWR power plant for the 1990s and beyond.

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The staff of the Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission (NRC), is preparing draft safety evaluation reports (DSERs) to discuss the results of its review of the original version of the Requirements Document. On September 7, 1990, EPRI submitted the rollup document on the design criteria for evolutionary plants. After EPRI has submitted its responses to these DSERs, the staff will issue a final SER to discuss its conclusions regarding its review of EPRI's responses and the rollup document. The DSERs do not address the rollup document submitted on September 7, 1990. On September 7, 1990, EPRI also submitted its original version of the Requirements Document providing the design criteria for plants in which passive feature will be used. The staff will issue DSERs on this document, and, after EPRI's submittal of the rollup document on passive plant designs, it will issue a final SER discussing the results of its review of the passive design.

The staff's review of the Requirements Document is being conducted as described in NUREG-1197, "Advanced Light Water Reactor Program." As noted therein, the staff is using NUREG-0800, "Standard Review Plan [SRP] for the Review of Safety Analysis Reports for Nuclear Power Plants," for review guidance. In addition to the criteria of NUREG-0800, the staff's review reflects the requirements of 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Reactors," and the Commission's "Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants" (50 FR 32138). The staff's review approach is discussed further in Sections 1.3 and 10 of the DSER for Chapter 1 (February 1988). As noted therein, the Requirements Document places primary emphasis on preventing significant problems that have been experienced in existing plants; however, many details that will be provided in specific design applications are missing. Therefore, the staff has considered the proposed utility requirements at the level of detail presented by EPRI in order to identify any actual or potential conflicts with NRC requirements, but not to determine their adequacy to meet all such requirements.

In September 1987, the staff issued the first DSER in this series. The DSER addressed the Requirements Document "Executive Summary" and Chapter 1, "Overall Requirements," regarding the overall objectives and requirements of the ALWR program for evolutionary plant designs. This DSER was modified in February 1988. Chapter 2, "Power Generation Systems," was evaluated in the second DSER, which was issued in February 1988. The third DSER, issued in May 1988, covered Chapter 3, "Reactor Coolant System and Reactor Non-Safety Auxiliary Systems." The fourth DSER, issued in June 1988, covered Chapter 4, "Reactor Systems." The fifth DSER, issued in February 1990, covered Chapter 5, "Engineered Safety Systems." DSERs on Chapter 6, "Building Design and Arrangement," Chapter 7, "Fueling and Refueling Systems," Chapter 8, "Plant Cooling Water Systems," Chapter 9, "Site Support Systems," Chapter 12, "Radioactive Waste Processing Systems," and Chapter 13, "Main Turbine-Generator System," were issued in December 1990.

On April 10, 1989, the ALWR Utility Steering Committee submitted Chapter 11 of the Requirements Document entitled "Electric Power Systems" for staff review. Additional information was submitted by letters dated September 15, October 19, and December 22, 1989, and July 23, 1990. This chapter was prepared by Bechtel Power Corporation, Combustion Engineering, Inc., Commonwealth Edison Company, Duke Power Company, General Electric Company, MPR Associates, Inc., S. Levy Incorporated, Sergeant and Lundy Engineers, Stone and Webster Engineering Corporation, Westinghouse Electric Corporation, and Yankee Atomic Electric Company under the project direction of the Electric Power Research Institute, Palo Alto, California, and the ALWR Utility Steering Committee.

Key issues in the Chapter 11 review include

- onsite power systems
- medium and low voltage ac distribution systems
- onsite standby ac power supply system
- dc power supply system
- offsite power systems
- normal and emergency lighting
- electrical protective systems
- resolution of certain generic safety issues

The staff's evaluation of Chapter 11 of the Requirements Document is documented in Sections 2 through 10. Appendix A provides a list of acronyms and their meaning used throughout this report. Appendix B provides the staff's evaluation of the generic safety and licensing issue topic papers discussed in Chapter 11.

In staff requirements memoranda, the Commission instructed the staff to provide an analysis detailing where the staff proposes departure from current regulations or where the staff is substantially supplementing or revising interpretive guidance applied to currently licensed light water reactors. The staff considers these to be policy issues. Appendix C of this DSER provides that analysis. These issues were forwarded to the Commission in SECY-91- . The Commission is reviewing the basis for the approach that the staff is proposing for those issues discussed in Appendix C and, accordingly, may at some future point in the review determine that some issues involve policy questions that the Commission may wish to consider.

These issues are considered fundamental to agency decisions on the acceptability of the evolutionary ALWR designs. For easy identification, the staff's positions regarding these issues have been underlined in Appendix C and have been cross-referenced with the other sections in the DSER in which they are discussed.

The format of this DSER follows that of Chapter 11 of the Requirements Document as closely as possible. To provide continuity, however, the evaluations are grouped by system. Unless otherwise noted, references to sections of the Requirements Document are directed toward the Chapter 11 submittal. The staff concludes that those sections of Chapter 11 of the Requirements Document that are not mentioned are acceptable.

This report addresses the version of Chapter 11 submitted on April 10, 1989, and EPRI's responses to staff requests for additional information, but does not address the rollup submitted September 7, 1990.

Copies of this report are available for inspection at the NRC Public Document Room, 2120 L Street, N.W., Washington, D.C. 20555.

The NRC project managers for the staff's review of the ALWR Requirements Document are T. J. Kenyon and J. H. Wilson. They may be contacted by calling (301) 492-1118 or by writing to: Division of Advanced Reactors and Special Projects, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

1.1 Scope and Structure of Chapter 11

Chapter 11 of the Requirements Document defines the ALWR Utility Steering Committee's requirements for the design of the electrical power systems for ALWRs. The topics discussed in this report apply to evolutionary boiling water reactors (BWRs) and pressurized water reactors (PWRs) of approximately 1350 MWe. The staff will issue a separate DSER to address the parallel chapter of the ALWR Requirements Document that is applicable to facilities using such innovative concepts as passive safety systems.

1.2 ALWR Design Bases

The term "ALWR design bases," as defined by EPRI, refers to the three sets of requirements that form the foundation for the ALWR design criteria. The first set of requirements forms the "licensing design basis," which includes the requirements necessary to satisfy regulatory criteria. These requirements and associated analytical methods are based on conservative, NRC-approved methods, and equipment is designed to safety-grade standards. The second set is the "risk evaluation basis," which extends the licensing design basis to meet public safety objectives. The risk evaluation basis utilizes probabilistic risk assessment methods. The third set of design bases is the "performance design basis," which is based on economic and investment protection considerations for a utility and uses realistic, designer-selected, best-estimate methodology. EPRI states that the licensing design basis is intended to provide an adequate level of safety, whereas the risk evaluation and performance design bases provide additional or enhanced protection.

1.3 Regulatory Stabilization

Consistent with the overall ALWR program approach, as described in NUREG-1197, regulatory stabilization for an ALWR design can be achieved through the identification and resolution of plant optimization subjects and generic safety and licensing issues.

Generic safety and licensing issue topic papers related to electrical systems are addressed in Appendix B of this DSER.

Chapter 11 of the Requirements Document does not address any plant optimization subjects.

1.4 Outstanding Issues

As a result of the NRC staff's review of Chapter 11 of the ALWR Requirements Document, a number of items remain outstanding at this time. Because either it has not completed its review and reached a final position or it has reached a conclusion different from that of EPRI in these areas, the staff considers these issues to be open. These issues fall into one of four categories: (1) issues that require satisfactory resolution before the staff can complete its review of Chapter 11 of the Requirements Document, (2) issues for which staff review of other related chapters of the Requirements Document has not yet been completed, (3) confirmatory issues for which the staff will ensure followup of commitments in the Requirements Document, and (4) issues that require satisfactory resolution in support of a vendor- or utility-specific application. The open items, with appropriate references to sections of this report given in parentheses, are listed below:

<u>Issues To Be Resolved Before the Staff Can Complete Its Review of Chapter 11</u>

(1) human factors (2.1)

(2) environmental qualification test criteria for electrical power systems (2.2)

(3) use of IEEE standards not approved by the Commission (2.2.7)

(4) alternate source of power for non-safety loads (4.2.1)

(5) offsite power source to safety bus (4.2.2)

(6) security considerations for the combustion turbine generator (4.2.3)

(7) alternate ac power source (station blackout considerations) (5.2.2)

(8) load capability of combustion turbine generator (5.2.3)

(9) power rating of diesel generators (5.2.4)

(10) loading logic to respond to loss-of-coolant-accident/loss-of-offsite-power sequences (5.2.5)

(11) loss of power to a dc bus (7.2.1, B.3)

(12) design of lighting systems in safety-related areas and access routes to those areas (8.2.1, 8.2.2)

(13) illumination level of emergency lighting system (8.2.3)

(14) qualification and redundancy of emergency lighting system (8.2.3)

(15) control and mitigation of transformer fires (Generic Safety Issue 107) (B.1)

(16) electrical power reliability (Generic Safety Issue 128) (B.3)

Issues To Be Addressed in Staff Review of Subsequent Requirements Document Chapters

(1) location of oil-filled transformers (2.2.6, B.1)

Confirmatory Issues

(1) safety classification of loads (2.2.1)

(2) vital area access during emergency conditions (2.2.2)

(3) power rating of diesel generators (5.2.4)

(4) uninterruptible power supply for security equipment (7.2.3)

(5) compliance of emergency lighting with SRP and applicable codes (8.2.3)

Vendor- or Utility-Specific Issues

(1) minimization of Class 1E components (2.2.4)

(2) instrumentation and controls for electric motors (2.2.5)

(3) integrity of electrical cable penetration seals during a fire (2.2.6)

(4) integrity of bus duct penetrations during a fire (2.2.6)

(5) use of combustion turbine generator as alternate power source during shutdown (5.2.1)

(6) emergency diesel engine starting system (5.2.6)

(7) emergency diesel engine fuel oil storage and transfer system (5.2.6)

(8) allowed outage time for load center (6.2)

(9) outage time for dc safety buses in a BWR plant design (7.2.2)

(10) acceptability of lighting system for closed-circuit television system (8.2.4)

(11) technical specifications for vital buses (B.3)

2 GENERAL REQUIREMENTS AND POLICY STATEMENTS

2.1 Policy Statements

Section 1.5 of Chapter 11 of the Requirements Document identifies policy statements established by EPRI that form the basis for the specific design requirements included in Chapter 11 of the Requirements Document. Section 1.5.1 of Chapter 11 of the Requirements Document states that the overall objective of the design features specified in this chapter is to achieve the goals described in Section 1 of Chapter 1 of the Requirements Document.

Section 1.5.2 of Chapter 11 of the Requirements Document states that the plant designer should adopt design features, including the necessary redundancy and backup features, that will ensure that the adverse impact of transmission system disturbances, plant upsets, or component failures on the availability of offsite or onsite electric power will be kept to a minimum. The Requirements Document further directs the designer to improve the testability and maintainability of the electric power systems in order to maximize equipment reliability.

Section 1.5.3 of Chapter 11 of the Requirements Document states that the minimum number of components and interconnections required to provide the backup and redundancy features needed for safety and availability purposes should be used in the design of electric system configurations.

Section 1.5.4 of Chapter 11 of the Requirements Document indicates that EPRI's objective in the preparation of this chapter has been to define general system configurations for the offsite and onsite electric power systems that will suit the needs of most plants. This goal was established because electric power systems are not standardized among nuclear power plants in the United States. EPRI states that changes to the general configurations specified in Chapter 11 of the Requirements Document should be limited to only those forced by specific, unusual site conditions.

In Chapter 1 of the Requirements Document, EPRI states that it has considered the man-machine interface in its development of the design requirements in all of the chapters of the Requirements Document. In its letter dated August 30, 1990, the staff requested additional information regarding EPRI's approach to incorporating human factors considerations into the Requirements Document. The staff will complete its review of the Requirements Document after it receives EPRI's response. This is an open item that must be satisfactorily addressed before the staff can complete its review of Chapter 11 of the Requirements Document.

2.2 General Requirements

The requirements specified in Section 2 of Chapter 11 of the Requirements Document are intended to apply to an integrated set of electric power systems for an evolutionary ALWR plant design.

Section 2.3.2 of Chapter 11 of the Requirements Document calls for the use of a three-tier concept in the arrangement of the onsite power distribution systems. The first-tier distribution systems will feed non-safety loads required exclusively for unit operation; the second tier will feed permanent non-safety loads that, because of their specific functions, are generally required to remain operational at all times; and the third tier will feed the safety (Class 1E) loads. The non-safety power distribution systems (first and second tiers) will be divided into two divisions. Section 2.3.5 of Chapter 11 of the Requirements Document specifies that the safety power distribution systems (third tier) will be divided into two independent divisions for PWR plants and three independent divisions for BWR plants. The non-safety power distribution systems (second tier) supplying power to the plant's permanent non-safety loads will be provided with an independent onsite standby power source (combustion turbine generator). Each division of the safety power distribution systems (third tier) will be provided with independent onsite standby power sources (diesel generators).

Section 2.3.10 of Chapter 11 of the Requirements Document states that the sets of circuits that constitute the divisions of the safety power distribution systems will be physically separated and electrically independent. Independence and separation will be maintained throughout the load groups, and no cross-ties are to be used between buses or circuits - ac or dc - belonging to different safety divisions. Section 2.3.11 of Chapter 11 of the Requirements Document states that non-safety circuits are required to be physically separated from safety circuits throughout the plant, and non-safety circuits are not permitted to be connected to safety circuits or power sources.

Section 2.6.1 of Chapter 11 of the Requirements Document specifies that electric power systems are required to be designed for a 60-year operating life without replacement of major components or cabling. However, the design of the systems and the building arrangement are required to permit such replacement, if needed. The staff has determined that the Requirements Document does not specify test criteria to ensure that the electrical power systems are qualified for a 60-year service life without replacement of major components or cabling. The staff concludes that EPRI should include such equipment qualification test criteria for these electrical power systems. This is an open item that must be resolved before the staff can complete its review of Chapter 11 of the Requirements Document.

2.2.1 Three-Tier Concept

Section 2.3.2 of Chapter 11 of the Requirements Document requires that the arrangement of the onsite power distribution systems follow a three-tier concept. The first tier of systems will consist of the distribution systems feeding non-safety loads required exclusively for unit operation. EPRI designates their normal power source as the unit main generator. These systems will be able to be fed from the offsite power system through a backfeed configuration, when the main generator is unavailable.

The second tier will consist of the distribution systems supplying power to permanent non-safety loads that, because of their specific functions, are generally required to remain operational at all times. These loads will normally be fed from the same power source that feeds the first-tier loads, but they will also be able to be fed from a second independent offsite source or a combustion turbine generator if their normal power source is unavailable. In addition, EPRI specifies that the Class 1E diesel generators will be able to power a portion of the loads if necessary.

The third tier will consist of the distribution systems feeding the safety (Class 1E) loads. Their normal power source will be the same as that which normally feeds the first- and second-tier systems; however, like the second-tier systems, they will also be able to be fed from the Class 1E diesel generators, a second independent offsite source, or the combustion turbine generator.

By letter dated April 10, 1990, the staff asked EPRI whether any of the loads intended to be included in the permanent non-safety load category (second tier) were formerly categorized as safety loads. In its letter dated July 23, 1990, EPRI stated that the requirements of Chapter 5 of the Requirements Document determine the characteristics of the safety systems for an ALWR plant design, and all loads that are part of those safety systems will be included in the safety category. Loads that are not part of those safety systems will be included in one of the two non-safety categories. EPRI explained that justification for considering safety or non-safety of specific systems is not in Chapter 11 of the Requirements Document, but is included in that portion of the Requirements Document that defines the requirements for those specific systems.

From this response, the staff concludes that the three-tier concept is not intended to be used as a basis for reclassifying former safety loads as non-safety or for supplying safety loads from only a non-Class 1E distribution system and power source (second tier). The staff concludes that the other chapters of the Requirements Document must clearly define the category (safety or non-safety) of the loads, especially if they have been downgraded from previous designs. On this basis, the staff concludes that the three-tier concept is acceptable for the design of electric power systems. The staff will confirm that these changes have been acceptably incorporated into the rollup document.

2.2.2 Security Systems

Sections 2.3.2 and 2.3.4 of Chapter 11 of the Requirements Document include requirements for supplying power from an independent onsite standby power source to permanent non-safety loads required to remain operational at all times. Security systems are listed among the typical loads in this category. This power supply will be separate from the standby power supply for safety (Class 1E) loads.

NUREG-0908, "Acceptance Criteria for the Evaluation of Nuclear Power Reactor Security Plans," states that under an acceptable security program, the alarm stations would typically be provided with a source of emergency power capable of supplying power for all required security functions. American National Standards Institute/American Nuclear Society (ANSI/ANS Standard 3.3-1988) specifies that security intrusion detection aids should be supplied with uninterruptible power.

The staff concludes that EPRI's requirements are compatible with the NRC requirements for backup power to security systems.

Section 2.6.1.4 of Chapter 11 of the Requirements Document requires seismic protection of non-Class 1E equipment only if it is located in the vicinity of Class 1E equipment or support structures. By letter dated May 24, 1989, the staff asked whether non-Class 1E equipment supporting the card reader access control system for vital areas should be required to meet seismic standards in order to ensure access to vital areas after an earthquake.

In its letter dated September 15, 1989, EPRI stated that requirements compatible with the requirement of 10 CFR 73.55(d)(ii) (for the access control system to accommodate the need for rapid ingress or egress during emergency conditions) will be issued in an appendix to Chapter 1 as part of the rollup document. However, specific features of the access control system required to ensure necessary access to vital areas will not be described in the Requirements Document.

The staff agrees that means other than seismic qualification, as proposed by EPRI, would be sufficient for ensuring access to vital equipment if the security computer or security power were lost. Therefore, EPRI's response is acceptable. The staff will confirm that these changes have been acceptably incorporated into the rollup document.

2.2.3 Number of Safety Divisions

Section 2.3.5 of Chapter 11 of the Requirements Document specifies that the onsite safety power distribution systems (third tier) will be divided into two separate and independent divisions for PWR plants and three separate and independent divisions for BWR plants. Each division is required to be provided with its own separate and independent source of emergency standby power.

By letter dated April 10, 1990, the staff questioned why three distribution system divisions had been chosen for the BWR plant, while only two had been chosen for the PWR plant. In its letter dated July 23, 1990, EPRI stated that the fundamental reason for the difference between the electrical power systems of the BWR and PWR lies in the differing fluid system designs, which in turn derive from basic differences in these two types of reactors. It stated that both approaches satisfy all applicable regulatory requirements as well as EPRI's goals with regard to core damage frequency and performance during a severe accident.

The staff concludes that the three distribution system division design is a better approach because any of the required reactor shutdown loads could be powered from any of the three divisions; however, the staff agrees that both approaches meet all applicable regulatory requirements and are, therefore, acceptable.

2.2.4 Minimization of Class 1E Components

Section 2.3.8 of Chapter 11 of the Requirements Document requires that the number of Class 1E components be kept to a minimum. Equipment or systems that are not essential for emergency reactor shutdown containment isolation, reactor core cooling, and containment and reactor heat removal, or are not otherwise essential in preventing significant release of radioactive material to the environment, are not to be designated Class 1E unless they constitute auxiliary equipment required for the operation of Class 1E components.

In its letter dated April 10, 1990, the staff expressed its concern about this requirement because it allowed non-safety concerns (minimizing qualification, surveillance, and maintenance) to potentially impact safety improvements and could be misinterpreted or abused, resulting in the downgrading of components that had formerly been designated Class 1E. By letter dated July 23, 1990, EPRI responded that the safety systems should be designed for simplicity of operation, surveillance, and maintenance so as to optimize their reliability and address concerns regarding cost. EPRI indicated that higher levels of safety than those in existing plants will be achieved by specifying other safety improvement requirements; therefore, the staff's concern that this approach could lead to a downgrading of safety or performance was incorrect. EPRI also indicated that it believes that it is necessary to have definitive requirements in this area to provide a basis for standardization and to avoid the large number of "custom" designs. Finally, with regard to the staff's position that some level of qualification, surveillance, and maintenance requirements should be specified for some non-safety equipment commensurate with its importance to safety, EPRI stated that the staff had raised a similar concern in the DSER for Chapter 5 of the Requirements Document and that it will address the appropriate level of qualification for specific equipment and systems in that chapter. EPRI stated that Chapter 11 of the Requirements Document will be revised as appropriate to be consistent with Chapter 5.

The staff disagrees with EPRI that the subject requirement is "definitive" and will lead to a more standardized use of Class 1E and non-Class 1E equipment. Because the requirement is open to interpretation as to what is "essential" and what constitutes "auxiliary equipment required for the operation of Class 1E components," the staff cannot determine to which systems or components the requirement applies. For example, the staff cannot determine if this applies to the categorization of electrical protective overcurrent relaying and electrical monitoring instrumentation. Also, broad safety goals do not provide adequate assurance of well-designed and well-specified systems at this level of detail. The staff concludes that the resolution of the level-of-qualification issue in Chapter 5 of the Requirements Document will not identify electrical equipment or components down to the level of detail necessary for the staff's review. The staff will, therefore, evaluate how this requirement for minimization of Class 1E components has been applied during the design certification review process.

2.2.5 Equipment

In its letter dated September 14, 1989, the staff asked a question concerning the electric motor starting voltage requirements of Section 2.6.2 of Chapter 11 of the Requirements Document. In its letter dated December 22, 1989, EPRI stated that the voltage and frequency requirements for the associated instrumentation and control equipment are too specific to be included in the Requirements Document but, in general, the design of power supplies will satisfy functional and operational requirements. EPRI's response is not inconsistent with the Commission's regulations and policies and is, therefore, acceptable. However, the staff will evaluate the voltage and frequency values for the instrumentation and controls for electric motors during its review of the design certification application.

2.2.6 Fire Protection

The staff evaluated the criteria for the fire protection system in the Requirements Document against the criteria of SRP Section 9.5.1 (Branch Technical Position CMEB 9.5-1, July 1981) and supplemental guidance issued by the Commission. Three examples of such supplemental guidance are (1) Generic Letter 81-12, which contains information on safe-shutdown methodology; (2) Generic Letter 86-10, which contains some important technical information, such as that pertaining to conformance with National Fire Protection Association codes and standards; and, (3) the Commission's Staff Requirements Memorandum on "Evolutionary Light Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements," SECY-90-016, dated July 26, 1990. The criteria and basis for their use are discussed in Section 2.5 of the staff's DSER on Chapter 5 of the Requirements Document and in Section 3 of the staff's DSER on Chapter 9 of the Requirements Document.

The staff's evaluation of the fire performance requirements specified in Chapter 11 of the Requirements Document follows.

EPRI has generally followed the NRC's concept of defense-in-depth with regard to fire protection. The three steps of defense-in-depth and EPRI's implementation of these steps follow:

(1) Reduce the possibility of fire starting in the plant - EPRI specifies that fire-resistant and fire-retardant materials will be used in the design of reactor plants referencing the Requirements Document to minimize and isolate fire hazards. EPRI specifies that either low-voltage or fiber-optic multiplexed circuits will be used in ALWR designs, thus eliminating the need for cable spreading rooms and substantially reducing the amount of combustible cable insulation and higher voltage ignition sources in the control room.

(2) Detect and suppress a fire promptly - EPRI specifies that automatic detection and a suitable mix of automatic and manual fire suppression capability be incorporated into ALWR designs.

(3) Ensure that any fire that might occur will not prevent safe shutdown of the plant even if fire detection and suppression efforts should fail - EPRI has attempted to ensure this in the Requirements Document. A detailed evaluation of the effectiveness of this approach is provided below.

The fire protection program described by EPRI is intended to protect safe-shutdown capability, prevent the release of radioactive materials, minimize property damage, and protect personnel from injury as a result of fire.

EPRI considered not only the three aspects of defense-in-depth outlined above, but also such features of general plant arrangement as

° access and egress routes

° equipment locations

- structural design features that separate or isolate redundant safety-related systems
- floor drains
- ventilation
- construction materials

EPRI specifies that applicable National Fire Protection Association codes and standards will be incorporated in the design and layout of an ALWR facility. An ALWR designer or applicant will be required to identify any deviations from these codes and standards and to describe in the fire hazards analysis the deviations and measures taken to ensure that equivalent protection is provided.

Integrity of Electrical Cable Penetration Seals

In its letter of June 8, 1989, the staff stated that it was concerned about ensuring the integrity of the penetration seals that protect openings used for passing electrical cable through fire barriers if cable trays should collapse.

In its letter of October 19, 1989, EPRI stated that it would revise Section 2.6.4 of Chapter 11 of the Requirements Document to require that designers ensure that seals at locations where cables penetrate fire barriers remain effective should cable trays collapse from the effects of fire. Chapter 10 of the Requirements Document will reference the Chapter 11 design criteria so that it is clear that penetrations of barriers for instrumentation and control cables must meet the same requirements.

The staff concludes that EPRI's response meets the enhanced criteria discussed above and is acceptable. However, the staff will review the design-specific application to ensure the acceptability of the actual design and installation.

Integrity of Bus Duct Penetrations

In its letter of June 8, 1989, the staff stated that it was not clear whether there would be locations where bus ducts penetrate fire barriers. The staff further requested that EPRI clarify how it proposed to design such penetrations to satisfy the three-hour fire rating criteria should such penetrations be allowed in the design criteria.

In its letter of October 19, 1989, EPRI stated that only the isolated phase bus is expected to require air cooling in the design of an evolutionary ALWR and that it will pass through the turbine building wall and connect to an oil-filled transformer located at least 50 feet from the building. EPRI further stated that although it does not expect that a 3-hour fire rating will be required for this bus duct penetration, the fire hazards analysis required by Section 3.3.2.1 of Chapter 9 of the Requirements Document will assess the adequacy of the turbine building wall.

The staff concludes that EPRI's response meets the enhanced criteria discussed above and is acceptable. However, the staff will review the design-specific application to ensure the acceptability of the actual design and installation. In addition, in Section 2.3 of the DSER on Chapter 6 of the Requirements Document, the staff described an open item regarding the location of oil-filled transformers in relation to exterior building walls. The staff will evaluate the resolution of this issue in its evaluation of Chapter 6 of the rollup document. The staff's evaluation of Generic Safety Issue 107, "Generic Implications of Main Transformer Failure," is discussed in Section B.1 of this report.

2.2.7 Use of Revisions to IEEE Standards Not Yet Endorsed by the Commission

In a number of sections of Chapter 11 of the Requirements Document, EPRI specifies that the implementation of its requirements will be in accordance with the latest revision of an Institute of Electrical and Electronics Engineer (IEEE) standard, as modified by applicable regulations. By letter dated April 10, 1990, the staff indicated that this should be changed so that the implementation of the requirements is in accordance with the latest revision of the IEEE standard that is endorsed by an NRC regulatory guide and modified by applicable regulations. This was considered necessary because the latest revisions of IEEE standards have often not yet been endorsed by the Commission.

In its letter dated July 23, 1990, EPRI stated that the requirements as written in the Requirements Document indicate that precedence is to be given to regulatory requirements over IEEE standards, and reference to the latest revisions of IEEE standards is appropriate because this does not conflict with the commitment to comply with the regulatory requirements but requires compliance with improvements made to the standards.

The explanation provided by EPRI is acceptable to the extent that it indicates that precedence is to be given to regulatory requirements over IEEE standards if there is a conflict between the two. Revisions of an IEEE standard, however, may include unacceptable changes in sections of the previous standard that was endorsed by a regulatory guide but was not specifically addressed in the regulatory guide, so that a conflict between the regulatory guide and the new standard is not apparent. The revisions may also provide additional detail or information in an area not previously reviewed by the staff or addressed by the regulatory guide. Again, no conflict between the regulatory guide and standard would be apparent.

Therefore, the staff concludes that Chapter 11 of the Requirements Document should be revised to reference only those revisions of IEEE standards that are endorsed by regulatory guides. Alternatively, the latest revision of the IEEE standard may be referenced, provided the Requirements Document stipulates that during the design certification process, the plant designers identify all changes from and additions to the last version of the IEEE standard that was endorsed by a regulatory guide. The staff will then review the changes and additions for acceptability during its design certification review. This is an open item that must be satisfactorily addressed before the staff can complete its review of Chapter 11 of the Requirements Document.

2.2.8 Emergency Response Facilities

In its letter dated May 24, 1989, the staff requested that EPRI clarify which power supply will be used to support the emergency response facilities (ERFs) and to provide the rationale for the assignment of electrical loads to these facilities.

In its letter dated September 15, 1989, EPRI indicated that the power supplies for the ERFs will be designed to meet the criteria in NUREG-0696, "Functional Criteria for Emergency Response Facilities." EPRI stated that the ERF loads are considered permanent non-safety loads that will be able to be fed from either a normal offsite, reserve offsite, or standby onsite non-vital source. Power will also be made available from the onsite safety (Class 1E) power source, if necessary.

The staff concludes that EPRI's response satisfactorily addresses the staff's concern, and is, therefore, acceptable.

2.3 Conclusion

The staff concludes, with the exceptions noted above, that the requirements in Section 2 of Chapter 11 of the Requirements Document do not conflict with current regulatory requirements and are, therefore, acceptable.

3 OFFSITE POWER SYSTEM

3.1 Functional Description

Section 3.1 of Chapter 11 of the Requirements Document states that the offsite power system will include the set of electrical circuits and associated equipment that will be used to interconnect the offsite transmission system, the main generator of the plant, and the onsite electric power distribution systems. It will include the plant switchyard(s) or remote station(s), the main step-up transformers, the unit auxiliary and reserve transformers, the high voltage lines, and the isolated phase buses, with their associated auxiliary systems, including protection relays and local instrumentation and controls.

In general, Section 3 of Chapter 11 of the Requirements Document calls for one offsite power circuit to use the main generator circuit in the backfeed direction from the switching station (plant switchyard or remote station) through the main step-up transformer to the unit auxiliary transformers. EPRI refers to this circuit as the "main offsite power circuit," and it will be the normal source of power for all plant loads (safety, non-safety, and permanent non-safety) during all modes of operation (operating and shutdown). A low voltage generator circuit breaker is provided to isolate the main generator from this circuit when the generator is inoperative.

A second offsite power circuit is provided as a second source of offsite power to only the safety and permanent non-safety loads when the main offsite power circuit is unavailable. EPRI refers to this circuit as the "reserve offsite power circuit." Section 3.3.4 of Chapter 11 of the Requirements Document requires that the main and reserve offsite power circuits be connected to switching stations that are independent and separate.

3.2 Evaluation

3.2.1 Use of Separate Low Voltage Switching Station

As stated above, Section 3.3.4 of Chapter 11 of the Requirements Document specifies that the main and reserve offsite power circuits will be connected to switching stations that are independent and separate. EPRI states that the design criteria takes advantage of the low capacity requirement of the reserve offsite power circuit to connect the circuit to a different transmission system, typically, a local grid of lower capacity and lower voltage than the transmission system to which the main offsite power circuit is connected.

The staff recognizes the benefits inherent in connecting the offsite power circuits to sources that are separate and independent. However, the staff is concerned about EPRI's use of lower voltage circuits to accomplish this because higher voltage transmission circuits are more reliable than the lower voltage circuits. This is at least partially due to the superior construction and separation employed in the higher voltage circuits.

By letter dated July 23, 1990, EPRI stated that the lower voltage circuits were referenced because its review of loss-of-offsite-power events showed that when a separate, independent reserve circuit is provided, it is generally connected to relatively low voltage, low capacity transmission lines. EPRI stated that although the overall reliability of the transmission lines is probably not higher than that of the transmission lines to which the main circuit is connected, the probability of such a reserve circuit remaining energized following a loss of the main circuit is much higher than that of a reserve circuit connected to the same transmission lines as the main circuit. EPRI indicated that this higher conditional availability results mainly from the independence of and the separation between the main and reserve circuits rather than from the characteristics of the transmission lines to which the latter circuit is connected.

The staff concludes that the higher conditional availability combined with the likely lower normal availability of a separate and independent lower voltage switching station makes it suitable primarily as a standby offsite power source, that is, one that is used as an alternate offsite power source to power its loads only when the normal offsite power source is unavailable. This is the way it is specified in the Requirements Document. When separate and independent switching stations of approximately the same voltage and capacity are used, then, assuming everything else is equal, both would be appropriate as normal offsite power sources to plant loads. Therefore, the staff concludes that EPRI's response with regard to this matter is acceptable.

3.2.2 Connection of the Offsite Transmission System to the Safety Onsite Power Distribution System

Section 3.2.1 of Chapter 11 of the Requirements Document states that the safety and non-safety power distributions systems will both normally be fed directly from the main generator (i.e., the power flow path will not go through the switching station) during normal plant operation and following a separation of the plant from the transmission system without reactor trip. Figures 11.2-1 and 11.2-2 in Chapter 11 of the Requirements Document show this power feed being derived from two unit auxiliary transformers connected to the main generators through a generator breaker. When the main generator is unavailable and isolated by the generator breaker, power would be backfed from the switching station through the main step-up transformer to the unit auxiliary transformer. This circuit is called the "main offsite power circuit." The advantage of this configuration is that the normal power supply to the plant auxiliary and safety systems can be supplied continuously and unswitched from the unit auxiliary transformers during and throughout startup, operation, and shutdown of the nuclear generating unit. It avoids the need for fast-transfer schemes on plant trip that have not been reliable and can produce stressful transients on plant electrical equipment.

The staff has determined that there are, however, also some shortcomings with this configuration that include the following:

° The offsite circuit is connected through the unit main step-up transformer which the Requirements Document identifies as the main cause of losses of plant availability among the electrical systems at nuclear power plants.

- A trip of the high voltage main generator circuit breakers in the switchyard causes both a load-rejection event together with the simultaneous loss of the main offsite power circuit.

- Reliance is still placed on the correct actuation of active system components (the low voltage generator circuit breaker and its related auxiliary support systems, logics, and controls) to maintain operation of the main offsite power circuit following a main generator trip.

- Generation system disturbances that involve real and reactive power swing through the main generator directly affect this circuit and increase the potential of its loss during these events.

As a result of these shortcomings, the staff recommended to EPRI that it consider adding a second reserve transformer to the one already called for in the Requirements Document to improve the connection of the offsite transmission system to the safety portion of the onsite distribution systems (third tier). Each transformer, which is directly connected to a switching station (switchyard), could then be made the normal source of power to one safety division (one powering two divisions for the BWR) and the backup power source for the opposite division. The advantage of this configuration is that the safety buses are always connected to an offsite power source with minimal intervening components (non-safety buses, breakers, etc.) requiring no actuation of active system components when changing modes, and a loss of one offsite power source affects only one safety division (two possible for the BWR plant design).

In its letter dated July 23, 1990, EPRI stated that it considers the arrangement adopted in the ALWR design criteria to be preferable, because of the expected low frequency of loss of power at the terminals of the auxiliary transformers and the high conditional availability of the reserve circuit. The low frequency of loss of power at the terminals of the auxiliary transformers is attributed to the fact that these transformers can be fed from either the transmission system or the main generator. The staff agrees that on the surface this appears to be an advantage. However, it is not clear that this advantage would not be eliminated or reversed by connection of the transmission system through the lesser reliable main step-up transformer, by the need for actuation of the main generator breaker on unit trip, by combined load-rejection and loss of power events, or by the direct effects of generation disturbances on the offsite circuit. Also, although the connection to the main generator is a benefit in that it makes available an additional power source to the safety loads, it is not clear how large a benefit it will be. Historically, continued operation of main generators following full-load rejection have not been successful, and the BWR requirements call for only a 40-percent load-rejection capability. This benefit, therefore, may be greater during operation at lower power levels.

The staff's recommended configuration, with two reserve transformers, however, will suffer if one of the reserve transformers that is normally powering a safety division is connected to a separate switching station of lower voltage. As indicated in Section 3.1 of this report, the lower normal availability of a separate lower voltage switching station makes it suitable primarily as a standby offsite power source. The two-reserve-transformer configuration could be modified so that all the safety divisions would normally be powered from the one reserve transformer connected to the higher voltage switchyard. Backup would then be provided from the other reserve transformer connected to the lower voltage switching station. This, however, would eliminate the benefit of having only one safety division affected by the loss of a single offsite power source. In designs that use two switchyards of approximately equal voltage ratings and capacities or that have only one switchyard, the two-reserve-transformer configuration would gain additional worth.

In summary, the staff concludes that the reliability of the offsite power supplies to the safety buses and, in particular, the normal power supply to the safety buses specified in the Requirements Document will, to a large extent, be dependent on the individual reliabilities of its subsystems (main step-up transformer, generator circuit breaker, generator load-rejection capability, system control and protection logics, etc.). The configuration specified in Section 3 of Chapter 11 of the Requirements Document is an improvement over past designs in which fast-transfer schemes on a generator trip are used, and, with a reliable main generator 100-percent load-rejection capability, will be a significant improvement over past designs. Therefore, the staff concludes that this configuration meets all regulatory requirements and is acceptable. However, the staff further concludes that the two-reserve-transformer configuration suggested by the staff would likely be a better choice in those designs where the reliabilities of the main step-up transformer, generator circuit breakers, generator load-rejection capabilities, etc., are not high - especially when only one switchyard or separate switchyards of equal voltage and capacity are used in the design.

3.3 Conclusion

The staff concludes that the requirements in Section 3 of Chapter 11 of the Requirements Document do not conflict with current regulatory requirements and are, therefore, acceptable.

4 MEDIUM VOLTAGE AC DISTRIBUTION SYSTEM

4.1 Function and Description

Section 4.1 of Chapter 11 of the Requirements Document states that the medium voltage ac distribution system will consist of the onsite electric power distribution circuits that operate at voltages ranging typically from 4.16 kV to 13.8 kV and supply power to medium-voltage safety, permanent non-safety, and non-safety loads. The system will include switchgear buses, circuit breakers, and unit substation transformers as well as their associated local instrumentation, controls, and protective relays. It also will include all buses and cables connecting the switchgear buses to their sources and loads.

Section 4.2.2 of Chapter 11 of the Requirements Document specifies that, in case of a loss of power from the unit auxiliary transformers, the safety and permanent non-safety loads will be automatically transferred to the reserve source of offsite power. In case of a loss of power from both the unit auxiliary transformers and the reserve transformer, the safety loads are to be automatically transferred to standby safety power sources (diesel generators), and selected permanent non-safety loads are to be automatically transferred to a standby non-safety power source (combustion turbine generator). The medium voltage ac distribution system is also required to be designed to permit feeding the safety loads from the combustion turbine generator following a manual load transfer, and conversely to permit feeding the permanent non-safety loads from the diesel generators following manual load transfer.

Two safety buses are specified in the PWR design criteria to power the safety loads, while three safety buses are specified in the BWR design criteria to power the safety loads. Two dedicated non-safety buses are specified in both design criteria for powering the permanent non-safety loads.

4.2 Evaluation

4.2.1 Lack of Alternate Power Source for Non-Safety Loads

One of the major differences between the distribution systems specified in Chapter 11 of the Requirements Document and those found in most recently licensed nuclear plants is that no alternate power source is provided for the non-safety loads required for unit operation. Section 4.2.2 of Chapter 11 of the Requirements Document requires that only the safety and permanent non-safety loads have the capability to transfer to the reserve source of offsite power. The non-safety loads that will not have an alternate source of power include the reactor coolant pumps, reactor recirculation pumps, feedwater pumps, condensate pumps, and circulating water pumps. As a result, a loss of power to these loads that could be caused by a failure (fault) anywhere on the unit auxiliary transformer, main step-up transformers, or their connecting feeders would result in a plant trip and loss of reactor coolant system forced circulation and normal feedwater systems. The same would occur for a 100-percent load rejection caused by the opening of the main generator high-side circuit breakers located in the switching station if the generator load-rejection capability was unreliable (see the discussion in Section 3.2.2 of this report concerning staff concerns related to the main offsite power circuit that will feed the non-safety loads). Reliance, following the above events, must therefore be placed on natural circulation and safety systems such as the auxiliary feedwater and reactor core isolation cooling systems. In most current designs, including those in which generator breakers are used (e.g., Millstone Unit 3, Summer, Catawba, and McGuire), two sources of power are provided to these non-safety loads so that they would only be lost if these events occurred simultaneously with a loss of offsite power.

In its letter dated July 23, 1990, EPRI stated that for the events considered by the staff, an additional source of power would not reduce the number of trips, nor would it greatly reduce the frequency of loss of power to the non-safety loads, since this frequency is dominated by the frequency of loss-of-offsite-power events. The staff disagrees that an additional source of power would not reduce the frequency of loss of power to the non-safety loads. If the majority of loss-of-offsite-power events were due to grid blackout and severe weather, an additional power source connected to the blacked-out switchyards would be of little use. However, the majority of the loss-of-offsite-power events have been plant-centered events. These events, which typically involve hardware failures, design deficiencies, human errors, localized weather-induced faults (lightning), or combinations of these failures, are more localized in nature and, therefore, less likely to result in the blackout of an entire switchyard or grid. An additional transformer connected to that switchyard and supplying non-safety loads should therefore significantly improve the frequency of loss of power to those loads.

With regard to reducing the number of plant trips, the staff has not maintained that this is a primary reason for recommending an additional power source for the non-safety loads. A primary reason for the additional power source is not to reduce the number of plant trips, but rather to reduce the subset of those trips that involve a loss of power to the non-safety loads. The combination loss-of-non-safety-power and subsequent turbine-trip event would likely be replaced with the turbine-trip-only event for the initiations (main step-up transformer fault, etc.) considered by the staff. The transients associated with a turbine-trip-only event have been identified as less severe than those associated with the loss-of-non-safety-power event analyzed in plant safety analysis reports and standard plant safety analysis reports.

EPRI also stated that the ALWR design is based on fundamental guiding principles, which include increased design margins intended to make the ALWR plant referencing the Requirements Document particularly robust. The core damage frequency will be less than 1.0 X 10 E-5 per reactor-year. The ALWR design achieves significant improvements in plant safety (and availability) over current designs. The contribution of sequences initiated by a loss of offsite power has been minimized, and the incremental improvements that could be achieved by requiring a second source of power for the non-safety loads that are only required for unit operation are considered very small and unwarranted.

The staff does not agree that the improvements that could be achieved by installing a second source of power for non-safety loads are very small and unwarranted. For the reasons discussed above, the staff concludes that the second source would significantly reduce the number of plant trips that involve a loss of power to the non-safety loads, and because these events continue to be identified as more severe than the turbine-trip-only event in standard plant safety analysis reports, plant safety will be improved. The staff concludes that the ALWR design criterion in this area is less conservative than that in existing plant designs and, therefore, is not acceptable. An alternate power source for the non-safety loads should be required in Chapter 11 of the Requirements Document, or EPRI should demonstrate that the design margins alluded to in its response of July 23, 1990, result in transients for a loss-of-non-safety-power event in an ALWR plant that are no more severe than those associated with the turbine-trip-only event in current existing plant designs. This is an open item that must be satisfactorily addressed before the staff can complete its review of Chapter 11 of the Requirements Document.

4.2.2 Connection of Safety Bus Offsite Power Sources Through Non-Safety Buses

Section 4.2.1 of Chapter 11 of the Requirements Document specifies that the medium voltage ac distribution system will be designed to supply power to the safety loads from the normal power source (i.e., the unit auxiliary transformers). Section 4.2.2 of Chapter 11 of the Requirements Document specifies that in case of a loss of power from the unit auxiliary transformers, the safety loads will be automatically transferred to the reserve source of offsite power (i.e., the reserve transformer). Figures 11.2-1 and 11.2-2 of Chapter 11 of the Requirements Document show the safety loads normally powered from the unit auxiliary transformers through the permanent non-safety load buses (second tier). The unit auxiliary transformer winding that will feed these loads also will feed a portion of the non-safety loads (first tier). The safety and permanent non-safety load buses are also shown as being fed from common windings of the reserve transformer when the unit auxiliary transformer is unavailable.

The staff concludes that feeding the safety buses from the offsite power sources through non-safety buses, or from a common winding with non-safety loads, is not the most reliable configuration. It makes it more difficult to obtain good voltage regulation at the safety buses, it subjects the safety loads to transients caused by the non-safety loads, and it adds additional failure points between the offsite power sources and the safety loads.

In its letter dated July 23, 1990, EPRI stated that in many current designs of U.S. and foreign plants, safety buses are fed through non-safety buses or from common transformer windings, and operating experience with these designs has not indicated any particular shortcomings. EPRI stated that there are real benefits in not connecting the safety buses directly to the offsite power supply, such as better protection of Class 1E systems against voltage surges affecting the offsite source and reduced risk of faulty paralleling of the onsite standby emergency sources with the offsite sources. EPRI also stated that the ALWR design criteria provide for a direct connection between safety buses and the reserve offsite source in the event of problems with the non-safety buses through which the safety buses are normally fed.

The staff concludes that EPRI should clarify its assertion that the connection of safety buses through non-safety buses or from common transformer windings would reduce the risk of faulty paralleling of the onsite standby emergency sources with the offsite sources. In general, it has been the staff's experience that the benefits to safety of not connecting safety buses through non-safety buses or to common transformer windings usually outweigh whatever safety benefits may be achieved. IEEE Standard 765-1983, "IEEE Standard for Preferred Power Supply for Nuclear Power Generating Stations," also states that the direct connection of the two offsite circuits to each redundant safety bus may further improve availability.

However, the staff also recognizes that this design feature must be viewed in the context of the overall plant electrical system design, and that some of the ALWR design concepts and objectives such as the three-tier concept and the objective to simplify the design bear on the choices made by EPRI. Therefore, the staff concludes that, as a minimum, at least one offsite circuit to each redundant safety division should be supplied directly from one of the offsite power sources with no intervening non-safety buses, in such a manner that the offsite source can power the safety buses if any non-safety bus should fail.

The transfer to this circuit should be automatic if the circuit is not normally connected to the safety buses and is one of the two normal paths of power from the main and reserve offsite power sources to the safety buses. The transfer to this circuit may be manual if the circuit is an additional third path of offsite power from the main or reserve offsite power sources to the safety buses.

Such a manual circuit is already shown in Figures 11.2-1 and 11.2-2 of Chapter 11 of the Requirements Document; however, the figures are provided for illustrative purposes only. The staff concludes that the text of the Requirements Document does not require such a feature. The text should be amended to require this feature or the other options described above. This is an open item that must be satisfactorily addressed before the staff can complete its review of Chapter 11 of the Requirements Document.

4.2.3 Security

Section 4.1.3 of Chapter 11 of the Requirements Document specifies that the security systems will be one of the loads supplied via the medium voltage power system. In its letter dated May 24, 1989, the staff concluded that the combustion turbine (CT) generator will need to be protected as vital equipment. In its September 15, 1989, response, EPRI stated that the CT generator and the equipment powered by it do not meet the definitions of vital equipment in 10 CFR 73.2 and in Section 5.2.1.1 of Chapter 9 of the Requirements Document. However, the staff notes that 10 CFR 73.55(e)(1)and (f)(4) and Generic Letter 87-08, "specify that onsite secondary power supply systems for security equipment must be located in a vital area. The staff concludes that current regulations would require the CT generator, its electrical distribution switchgear, and its supporting fuel, cooling, starting, and control systems to be protected as vital equipment; that is, the equipment will have to be located in a locked and alarmed area within the protected area. The cabling between the CT generator and the vital equipment it supports also would need to be in a vital area if it is identifiable, such as would be the case if the CT generator were in a separate building and accessible without requiring heavy equipment to remove hatches. The staff concludes that this is an open item that must be resolved before the staff can complete its review of Chapter 11 of the Requirements Document.

Section 4.2.3 of Chapter 11 of the Requirements Document includes provisions for the automatic transfer of a minimum set of the permanent non-safety loads to the onsite standby non-safety power source following a reactor trip concurrent with loss of offsite power. Other permanent non-safety loads will be manually loaded. The set of loads to be automatically transferred is limited to those that could facilitate operator response to the loss-of-power event and could be reuqired to operate within 30 minutes of the onset of the event.

ANSI/ANS Standard 3.3-1988 specifies that security intrusion detection aids should be supplied with uninterruptible power. In its September 15, 1989, reply to the staff's request for additional information, EPRI stated that security systems will be included in the battery-backed uninterruptible power system loads.

The staff concludes that temporary battery backup satisfies the need for uninterruptible power despite any delay in loading security systems onto the longer term standby non-safety power source and, therefore, the response is acceptable.

4.3 Conclusion

The staff concludes, with the exceptions noted above, that the requirements in Section 4 of Chapter 11 of the Requirements Document do not conflict with current regulatory requirements and are, therefore, acceptable.

5 ONSITE STANDBY AC POWER SUPPLY SYSTEM

5.1 Function and Description

Section 5.1 of Chapter 11 of the Requirements Document states that the onsite standby ac power supply system will include the onsite standby safety and non-safety ac power sources and their associated power supply circuits up to the source breakers of the onsite ac distribution systems. The standby power sources will consist of the prime movers and ac generators, their auxiliary systems, the fuel storage and transfer system, and the associated local instrumentation and control systems. The term "standby power source" as used in the Requirements Document refers to both safety and non-safety sources. EPRI states that Chapter 11 of the Requirements Document distinguishes between the safety and non-safety standby power sources where necessary.

Section 5.2 of Chapter 11 of the Requirements Document states that the onsite safety standby power sources will be emergency diesel generators (EDGs) and the onsite non-safety power source will be a combustion turbine generator. Section 5.4 of Chapter 11 of the Requirements Document specifies that two identical, functionally redundant, and electrically independent diesel generators will be supplied in the PWR design - one dedicated to each of the two independent safety divisions. Three identical, functionally redundant, and electrically independent diesel generators are required for the BWR design - one dedicated to each of the three independent safety divisions. Only one combustion turbine generator is required in both the PWR and BWR designs - with the capability to feed either or both permanent non-safety load buses.

Section 5.3.1 of Chapter 11 of the Requirements Document states that the diesel generators will be required to have sufficient capacity to operate the engineered safety features needed to maintain the plant in a safe condition in the event of a loss-of-coolant accident concurrent with a loss of offsite power. The combustion turbine generator is required by EPRI to be capable of coping with a station blackout, of feeding permanent non-safety loads during loss-of-offsite-power events, and of backing up the diesel generators in case of their failure or unavailability.

5.2 Evaluation

5.2.1 Use of the Combustion Turbine Generators To Satisfy Technical Specification Requirements

Section 5.1.2 of Chapter 11 of the Requirements Document states that when the plant is in cold-shutdown conditions, the non-safety portion of the onsite standby ac power supply system can also be used to supply plant power during maintenance of the offsite power supply system. In its letter dated April 10, 1990, the staff informed EPRI that although the onsite standby ac power supply system may have the literal capability to comply with EPRI requirements, the staff has made no judgment at this stage of its review as to what extent, if any, the combustion turbine generator could be used as an alternate power source to satisfy technical specification requirements for the purpose of performing maintenance on the offsite power supply system during shutdown.

By letter dated July 23, 1990, EPRI responded that it is expected that the combustion turbine generator will be capable of performing the safety function specified for an alternate power source during plant shutdown. Therefore, EPRI concludes that the use of the combustion turbine generator as an alternate power source under such conditions should satisfy technical specification requirements for the purpose of performing maintenance on the offsite supply system.

During its review of the ALWR Evolutionary Plant Technical Specifications, the staff will evaluate the use of the combustion turbine generator to satisfy technical specification requirements.

5.2.2 Use of the Combustion Turbine Generator To Meet Station Blackout Coping Requirements

Although Section 5.2.4 of Chapter 11 of the Requirements Document specifies that the combustion turbine generator will be capable of coping with a station blackout, EPRI in the rationale included with this design criterion states that the ability to qualify this onsite backup power supply as an alternate ac (AAC) power source will provide the plant owner with two options to comply with station blackout regulations: coping by means of an AAC power source or coping by means of battery and system capacities already specified in Section 2.3.3 of Chapter 5 of the Requirements Document.

EPRI's rationale indicates that the ALWR plant owner will be able to select either the combustion turbine generator or the battery and system capacities as the means that will be used at the plant to comply with the NRC station blackout regulatory requirements. The staff recognizes and endorses the much improved safety benefit that the combination of these two features provides to the ALWR plant; however, in SECY-90-016, "Evolutionary LWR Certification Issues and Their Relationship to Current Regulatory Requirements," as approved in the Commission's June 26, 1990, Staff Requirements Memorandum regarding SECY-90-016, the staff has taken the position that an AAC power source will be the primary means used in evolutionary ALWR plants to meet NRC station blackout regulatory requirements. Therefore, the staff concludes that the Requirements Document should be revised to clearly indicate that the combustion turbine generator will be qualified as an AAC power source by the ALWR plant owner and that it will be the means his plant used to comply with NRC station blackout regulatory requirements. This will ensure that any future regulatory requirements on AAC power sources, such as surveillances or limitation on allowed outage times necessary to maintain required levels of availability and reliability, will be applied to the combustion turbine generators in evolutionary ALWR plants. This is an open item that must be satisfactorily addressed before the staff can complete its review of Chapter 11 of the Requirements Document.

5.2.3 Power Rating of the Combustion Turbine Generators

Section 5.3.1.4 of Chapter 11 of the Requirements Document specifies that the combustion turbine generator will have a short-term power rating greater than the sum of the permanent non-safety loads and safety loads that must be powered by the unit at any one time. It further specifies that the unit will be sized for load starting and steady-state operation based on the more limiting of the following loading conditions:

- The unit supplies power to both divisions of permanent non-safety loads (intended normal operating condition).

- The unit supplies power to one safety division and one division of permanent non-safety loads (intended operating condition in case a diesel generator is unavailable).

Although the above requirements specify the loading that the combustion turbine generator is required to supply in terms of the divisions it must be able to supply, it is not clear during what scenarios and, therefore, what complement of loads it must supply within those divisions. In its letter dated April 10, 1990, the staff recommended that the combustion turbine generator be specified to power, as a minimum, the worst-case shutdown (to cold shutdown) or accident loads (whichever is greater) within the above-specified complement of divisions. In addition, the staff recommended that the combustion turbine generator have the capability to power those loads with some margin for load growth, when operating within its continuous rating.

By letter dated July 23, 1990, EPRI agreed to require that the combustion turbine generators be capable of powering the worst-case shutdown or loss-of-coolant-accident (LOCA) loads as recommended by the staff; but the unit was only required to have that capability when operating within its short-term power rating, rather than within its continuous rating as recommended by the staff. EPRI stated that it did not consider it justified to require that the combustion turbine generator be sized for continuous operation at maximum loading, including all initial design margins, given that operation of the unit under the specified conditions would not last more than a few hours.

The staff agrees with this rationale for operation during LOCA events, since the capability of the combustion turbine to power LOCA loads during these scenarios is provided only as a backup to the diesel generator power sources. For station blackout purposes, however, the combustion turbine generator should be the primary means of coping with a station blackout and bringing the plant to a cold-shutdown condition in an evolutionary ALWR plant. Therefore, the staff concludes that, as a minimum, the combustion turbine generator should be capable of powering one safety division and one division of permanent non-safety loads during the worst-case shutdown (to cold shutdown) and that it should have the capability to power these loads with some margin for load growth when operating within its continuous rating. This requirement should be specified in the Requirements Document, even though it may turn out that the combustion turbine generator may automatically have this capability if it is initially sized to power LOCA loads plus margin when operating within its short-term rating. This is an open item that must be satisfactorily addressed before the staff can complete its review of Chapter 11 of the Requirements Document.

5.2.4 Power Rating of the Diesel Generators

Section 5.3.1.1 of Chapter 11 of the Requirements Document specifies that each diesel generator unit will be capable of supplying the electric power required to operate the engineered safety features needed to maintain the plant in a safe condition in the event of a LOCA concurrent with a loss of offsite power. Section 5.3.1.2 of Chapter 11 of the Requirements Document specifies that the continuous power rating of each diesel generator unit will be determined on the basis of its worst-case load starting and steady-state operation when supplying power to the safety systems of its corresponding safety division. Specifically, it will be greater than the sum of all safety loads that must be powered by that unit at any time.

Neither of the above sizing requirements include provisions for powering permanent non-safety loads, although Sections 4.2.6 and 5.3.3.4 of Chapter 11 of the Requirements Document state that it is intended that the diesel generators have the capability to feed selected permanent non-safety loads in the event of a loss of all sources of power to those loads. Therefore, in its letter dated April 10, 1990, the staff informed EPRI that the sizing criteria should also specify that each diesel generator will be sized to power some portion of the permanent non-safety loads, and that the pressurizer heaters (that portion required by Three Mile Island Action Plan (TMI) Item II.E.3.1) should be included in the group of permanent non-safety loads that the diesel generators will be sized to handle.

In its July 23, 1990, letter, EPRI stated that the worst-case loading of safety loads is expected to occur under LOCA conditions, and no non-safety loads would be connected to the diesel generator under such conditions. Loading of some non-safety loads such as the pressurizer heater would only occur under non-LOCA conditions in the low-probability event of a loss of the normal and reserve offsite power supplies followed by a failure of the combustion turbine, and under those circumstances the expected load on the diesel generators including those non-safety loads is not expected to exceed the short-time rating of units sized in accordance with Section 5.3.1.2 of Chapter 11 of the Requirements Document. EPRI indicated that the diesel generator would be sized to comply with Regulatory Guide 1.9, "Selection, Design, and Qualification of Diesel-Generator Units Used as Standby (Onsite) Electric Power Systems and Nuclear Power Plants," under all design conditions.

The staff concludes that the diesel generators should not be sized for only the LOCA condition and that their capability to supply a portion of the permanent non-safety loads should be defined in the Requirements Document - particularly when at least a portion of those loads (e.g., pressurizer heaters and lighting) has some safety significance. The staff concludes that the Requirements Document should therefore specify that the continuous power rating of the diesel generators be sufficient to supply a portion of the permanent non-safety loads, including as a minimum, some portion of the pressurizer heaters (as required by TMI Item II.E.3.1) and lighting. The capability of the diesel generators to supply a portion of the permanent non-safety lighting loads within this continuous rating should be provided for both LOCA and non-LOCA events. This is an open item that must be satisfactorily addressed before the staff can complete its review of Chapter 11 of the Requirements Document.

Section 5.3.1.2 of Chapter 11 of the Requirements Document also specifies the amount of load-carrying margin to be included in the sizing of the diesel generators. It states that sufficient margin will be provided in the size of the diesel generators to accommodate the load growth expected to occur over the life of the plant. It further states that this margin, however, will be kept to a minimum, not to exceed 10 to 15 percent.

In its April 10, 1990, letter, the staff stated its concern regarding the small amount of margin specified by EPRI considering the proposed 60-year design life of an ALWR plant, the specified capability of the diesel generator to feed a portion of the permanent non-safety loads, and the experience with load creep in older plants. The staff recommended that consideration be given to specifying a margin requirement of "at least 20 percent" and that it be made clear that the full amount of this margin be included within the continuous rating of the diesel generator rather than the short-time power rating.

By letter dated July 23, 1990, EPRI stated that system expansion and load growth should not occur with a standardized certified plant design that is based on mature technology. Therefore, no expansion of essential systems and no growth among loads that are important enough to be powered by the diesel generators are expected. Nevertheless, EPRI believes it prudent to require some minimum margin and estimates that 10 or 15 percent is all that should be needed. EPRI agreed that this margin should not be included in the short-time rating of the diesel generators and will modify Chapter 11 of the Requirements Document accordingly.

The staff concludes that the question of insufficient load-growth margin is primarily an economic concern that could result in the need for future additional diesel generator capacity. There are no regulatory requirements governing load-growth margin in safety-grade diesel generators. EPRI has agreed to provide the full amount of the margin specified in the Requirements Document in the continuous rating of the diesel generators. Therefore, the staff concludes that EPRI's response is acceptable and will confirm that EPRI's commitments with regard to the design capacity of the diesel generators are acceptably incorporated into the rollup document.

5.2.5 Emergency Diesel Generator LOCA/LOOP Sequences

Section 5.3.3.3 of Chapter 11 of the Requirements Document specifies that following a loss of offsite power (LOOP), either without a loss-of-coolant accident (LOCA) or concurrent with a LOCA, each diesel generator unit will automatically start, accelerate to rated speed, reach nominal voltage, and supply power to required safety loads. In its letter dated April 10, 1990, the staff requested that EPRI specify that each diesel generator unit will automatically start (if it is not already running) and load the required safety loads whenever a LOOP occurs, either preceded by or followed by a LOCA. The staff indicated that the most likely LOCA/LOOP sequences would probably not occur at precisely the same time, so this provision is necessary to ensure that the diesel generators respond properly regardless of the sequence.

By letter dated July 23, 1990, EPRI stated that the requirement as currently written has the same meaning as the staff's comment, and that there is no requirement regarding the sequencing of LOCA and LOOP events. To ensure there is no misunderstanding, however, EPRI indicated the requirement would be revised to read as follows:

> Following a loss of offsite power (LOOP), each EDG will (if not already running) automatically start, accelerate to rated speed, reach nominal voltage, and be ready to supply power to the required safety loads.

The staff concludes that the above revision does not address its concern that the Requirements Document does not require that the load-sequencing design for the ALWR provide for the capability of responding to a LOCA and LOOP in whatever order a combined LOCA and LOOP might occur. For instance, one of the more likely combined LOCA/LOOP sequences is a LOCA followed by a delayed LOOP. The scenario is that the LOCA occurs, resulting in a plant trip and load sequencing of the LOCA-mitigating loads onto the offsite power source. The loss of generating capacity to the offsite grid caused by the plant trip, however, results in grid instability or depressed voltage and eventual loss of offsite power some seconds later. This loss of offsite power occurs while the LOCA-mitigating loads are being loaded sequentially onto the offsite power source. The load-sequencing logic must now call for the LOCA-mitigating loads to be resequenced onto the diesel generators.

A requirement to design for such a scenario is necessary because some plant design do not in fact have the capability to respond to such an event. They are only designed to respond to a combined LOCA and LOOP when they occur simultaneously. Although the simultaneous occurrence of a LOCA and LOOP is analyzed as a bounding event in order to determine the limiting response times of the safety equipment for the event, it is unlikely the LOCA and LOOP would occur at precisely the same time. The loading logic must therefore be designed to respond to the LOCA and LOOP in whatever order they might occur (LOOP only, LOCA only, LOCA followed by delayed LOOP, LOOP followed by delayed LOCA, or simultaneous LOCA and LOOP).

Section 4.5.5 of Chapter 11 of the Requirements Document partially addresses this issue by requiring that the load shedding and sequential loading schemes be automatically reset to perform as intended in the event the source breaker of the alternate power source trips during or after loading and the loads are to be reapplied. It would not, however, necessarily require that the LOCA loads be resequenced on the diesel generators for the LOCA/delayed LOOP event discussed above, nor would it require that LOCA loads be applied in the LOOP/delayed LOCA event, since the initiation of the LOCA does not necessarily result in a trip of the diesel generator source breaker. It also does not require automatic reset for a loss of an alternate power source that occurs for reasons other than a trip of the source breaker.

Therefore, the staff concludes that Chapter 11 of the Requirements Document should specifically require that the loading logic be designed to respond to a LOCA and LOOP in whatever order they might occur. This is an open item that must be satisfactorily addressed before the staff can complete its review of Chapter 11 of the Requirements Document.

5.2.6 Emergency Diesel Engine Auxiliary Support Systems

Each emergency diesel generator (EDG) has the following auxiliary systems:

- starting system
- combustion air intake and exhaust system
- cooling water system
- lubricating system
- fuel oil storage and transfer system

A discussion of the design criteria proposed by EPRI for these systems follows. The staff has evaluated these systems against the guidelines described in the following sections of the SRP: Section 9.5.4, "Emergency Diesel Engine Fuel Oil Storage;" Section 9.5.6, "Emergency Diesel Engine Starting System;" Section 9.5.7, "Emergency Diesel Engine Lubrication System;" and Section 9.5.8, "Emergency Diesel Engine Combustion Air Intake and Exhaust System."

Emergency Diesel Engine Starting System

The design function of the emergency diesel engine starting system is to provide a reliable method for starting the emergency diesel engines for all modes of operation.

In Section 5.5.2 of Chapter 11 of the Requirements Document, EPRI establishes the following key requirements for the starting system:

- Each EDG will be provided with two dedicated, redundant air starting systems.

- Each air starting system will be sized for five consecutive starts without recharging.

- To avoid corrosion or scaling problems, each air starting system will be provided with air dryers and air filters, and the piping material will be stainless steel or copper.

- The EDG units, including all auxiliary systems, will be classified as Class 1E and seismic Category I equipment.

In its December 22, 1989, response to a staff's request for additional information, EPRI stated that the detailed design of the system, which will vary somewhat between system designers and according to the equipment manufacturer, has not been defined and is not intended to be covered by the Requirements Document.

On the basis of its review, the staff concludes that the requirements established in the Requirements Document for the emergency diesel engine starting system do not conflict with regulatory requirements and are, therefore, acceptable. However, the staff will review details of this system during the plant-specific licensing or design certification process.

Emergency Diesel Engine Combustion Air Intake and Exhaust System

The basic function of the emergency diesel engine combustion air intake and exhaust system is to supply combustion air of suitable quality to the diesel engines and to exhaust the combustion products from the diesel engine to the atmosphere.

In Section 5.5.3 of Chapter 11 of the Requirements Document, EPRI establishes the following key requirements for the combustion air intake and exhaust system:

- Each EDG will be provided with an independent combustion air intake and exhaust system. The system will be sized and physically arranged so that no degradation of engine function will be experienced when the unit is required to operate continuously at its maximum rated power output.

- Each combustion air intake system will be provided with means of reducing airborne particulate material entering the system, assuming the maximum expected airborne particulate concentration at the combustion air intake.

- The arrangement and location of the combustion air intake and exhaust structures will be such as to preclude a reduction of engine power output due to intake of exhaust gases or other diluents (e.g., fire suppression agents) that could reduce oxygen content below acceptable levels.

- The components of the combustion air intake and exhaust system that are exposed to atmospheric conditions will be protected from possible clogging due to ice, snow, dust, etc.

On the basis of its review, the staff concludes that the requirements established in the Requirements Document for the emergency diesel engine combustion air intake and exhaust system do not conflict with regulatory requirements and are, therefore, acceptable.

Emergency Diesel Engine Cooling Water System

The design function of the emergency diesel engine cooling water system is to maintain the temperature of its associated diesel engine within a safe operating range under all load conditions and to keep the engine coolant preheated during standby conditions to improve starting reliability.

In Section 5.5.5 of Chapter 11 of the Requirements Document, EPRI establishes the following key requirements for the cooling system:

- Each EDG will have its own independent cooling system, which will include a primary engine and turbocharger cooling loop.

- The cooling system will be a closed-cycle system and will serve as an intermediate system between the diesel engine and the component cooling water system of the same division as the particular EDG.

- Each EDG will be equipped with a set of engine-driven cooling water pumps designed to meet the full-load requirements for water circulation through the primary engine and turbocharger cooling loops.

- Water circulation through the cooling system of the EDG for prewarming purposes will be by natural convection of the heated water.

- The prewarming system will be sized to maintain water temperature above 120°F and oil temperature above 80°F.

On the basis of its review, the staff concludes that the design requirements established in the Requirements Document for the emergency diesel engine cooling water system do not conflict with regulatory requirements and are, therefore, acceptable.

Emergency Diesel Engine Lubrication System

The basic function of the emergency diesel engine lubrication system, which is an integral part of the diesel engine, is to provide essential lubrication and cooling for the components of the diesel engines.

In Section 5.5.6 of Chapter 11 of the Requirements Document, EPRI establishes the following key requirements for the lubrication system:

- Each EDG will have its own independent lubrication system and be equipped with a set of engine-driven pumps.

- Each EDG will be provided with a pre/post-lubrication system consisting of an ac motor-driven pump and a backup dc motor-driven pump designed to ensure continuous prelubrication while the EDG is in the standby mode. Transfer from the normal ac motor-driven pump to the backup dc pump will be automatic in case of pump failure or loss of ac power.

On the basis of its review, the staff concludes that the requirements established in the Requirements Document for the emergency diesel engine lubrication system do not conflict with regulatory requirements and are, therefore, acceptable.

Emergency Diesel Engine Fuel Oil Storage and Transfer System

The basic function of the emergency diesel engine fuel oil storage and transfer system is to provide a separate and independent fuel oil supply train for each diesel generator and to permit operation of the diesel generator at full load for a minimum of 7 days without replenishing fuel.

In Section 5.5.10 of Chapter 11 of the Requirements Document, EPRI establishes the following key requirements for the emergency diesel engine fuel system:

- Each EDG will be provided with an independent fuel supply system in order to prevent a single failure from affecting more than one unit.

- Each fuel supply system will be provided with fuel filters and water separators in the supply lines to ensure fuel quality.

- Each fuel oil storage tank will be sized to support operation of the associated EDG at its maximum continuous rating for a minimum of seven days.

- Each day tank will have enough capacity to operate its associated EDG for at least 4 hours at its maximum rated capacity.

- Each fuel oil tank will have the capacity to be tested for the presence of water and, if necessary, to be drained of water from the tank bottom.

- Adequate access will be provided for sampling fuel oil throughout the fuel supply system.

In its December 22, 1989, response to a staff's request for additional information, EPRI stated that the Requirements Document does not define the detailed design features and administrative controls required to maintain the quality of the stored fuel oil, to protect the supply lines from contamination, or to minimize fire hazard during and after filling operations. These detailed design features and administrative procedures are expected to be defined by the plant designer in consultation with the plant owner and operator on the basis of the particular arrangement of the fuel oil storage and transfer system. In addition, the design of the filters and the location of the transfer pumps have not been defined. The final system design will ensure that the pumps will have sufficient head and capacity to transfer fuel oil to the day tanks as required.

On the basis of its review, the staff concludes that the design requirements established in the Requirements Document for the emergency diesel engine fuel oil storage and transfer system do not conflict with regulatory requirements and are, therefore, acceptable. However, the staff will review details of the system during the plant-specific licensing or design certification process.

5.2.7 Safeguards Consideration

As discussed in Section 5.2.2 of this DSER, Section 5.2.4 of Chapter 11 of the Requirements Document specifies that the combustion turbine (CT) will be able to back up the safety emergency diesel generator units to provide an additional means of coping with a station blackout. Section 5.5.5.5 of Chapter 11 of the Requirements Document requires an air cooling system for the CT unit.

The staff concludes that, in addition to the safety benefits derived from redundancy and diversity, these requirements will enhance the inherent resistance of the evolutionary ALWR plant to sabotage by preventing the sabotage of difficult-to-protect equipment such as transmission lines, switchyards, and service water system sources, which may be outside or on the periphery of the plant protected area, from causing the loss of all plant ac power. Therefore, these requirements are acceptable.

5.3 Conclusion

The staff concludes, with the exceptions noted above, that the requirements in Section 5 of Chapter 11 of the Requirements Document do not conflict with current regulatory requirements and are, therefore, acceptable.

6 LOW VOLTAGE AC DISTRIBUTION SYSTEM

6.1 Function and Description

Section 6.1 of Chapter 11 of the Requirements Document states that the low voltage ac distribution system will consist of the onsite electric power distribution circuits that will supply power to the safety, permanent non-safety, and non-safety loads at 600 V or less. EPRI states that the system will not include the low voltage vital ac power supply system or the normal and emergency lighting systems. These are covered in Sections 7 and 8 of Chapter 11 of the Requirements Document. The system will include safety and non-safety load centers, motor control centers (MCCs), distribution transformers, and distribution panels as well as the associated protective relaying and local instrumentation and controls. Also included will be the cables, connections, and electrical penetrations used throughout the system.

Section 6.2.2 of Chapter 11 of the Requirements Document specifies that the low voltage ac power distribution system will be designed so that the failure or unavailability of a single unit substation or distribution transformer will not preclude continuous system operation. Section 6.3.2 of the Requirements Document states that the load centers and MCCs are required to be of a double-ended design for the safety portions of the low voltage ac systems in PWR plants; that is, provisions will be made to allow power to be supplied to these load centers and MCCs via separate circuits. EPRI states that redundant power supply circuits to safety load centers and MCCs are not required for BWR plants because that design specifies three safety divisions, provided continuous plant operation at 100-percent power with one Class 1E load center or MCC out of service is permitted for at least 96 hours. For the non-safety portions of the low voltage ac distribution system, the Requirements Document states that load centers will generally be double ended with provisions to receive power from both feeders, and MCCs fed directly from a load center without an intermediate transformer will generally be single fed.

6.2 Evaluation and Conclusion

Although EPRI's requirement that redundant power supply circuits to safety load centers and MCCs are not required for a BWR design with three safety divisions does not conflict with current regulatory requirements, EPRI stated that this design criterion was acceptable to the industry only if continuous plant operation at 100-percent power is allowed for at least 96 hours following the loss of one Class 1E MCC load center. The 96 hours likely refers to an allowed outage time in the technical specifications for a BWR ALWR evolutionary plant. The specified allowed outage time for loss of a load center is eight hours in current Standard Technical Specifications.

During its review of the ALWR Evolutionary Plant Technical Specifications, the staff will evaluate the acceptability of a 96-hour allowed outage time for a load center in a BWR ALWR evolutionary plant.

The staff concludes, with the exception noted above, that the requirements in Section 6 of Chapter 11 of the Requirements Document do not conflict with current regulatory requirements and are, therefore, acceptable.

7 DC AND LOW VOLTAGE VITAL AC POWER SUPPLY SYSTEMS

7.1 Functions and Key Design Requirements

Section 7.1 of Chapter 11 of the Requirements Document states that the dc power supply system will consist of the electric power supply and distribution equipment and circuits that will provide dc power to the plant dc loads. The system will begin at the source terminals of the plant safety and non-safety battery chargers. It will end at the input terminals of the plant dc loads and at the input terminals of the inverters of the low voltage vital ac power supply system. EPRI states that the low voltage vital ac power supply system will consist of the electric power supply and distribution equipment and circuits that will provide low voltage ac power for continuous operation of safety instrument loads, computer systems, and other important plant loads. The system will begin at the input terminals of the inverters and backup regulating transformers and end at the input terminals of the system's loads.

The system will include battery sets, battery chargers, inverters, regulating stepdown transformers, motor control centers, distribution panels, associated protective relays and instrumentation, and all cabling and wiring from the source terminals up to the terminals of the system loads.

The following major provisions are specified in Section 7 of Chapter 11 of the Requirements Document for the dc and low voltage ac power supply systems:

- The dc power supply system is required to be designed with sufficient redundancy to ensure that, in the case of loss of offsite power, the loss of any battery or dc bus concurrent with a single independent failure in any other system required for shutdown cooling will not result in a total loss of reactor cooling capability.

- The dc and low voltage vital ac power supply systems are required to be designed with sufficient redundancy to ensure the following:

  - The failure or unavailability of a single battery, battery charger, or inverter will not result in a plant trip or a forced outage.

  - Each battery, battery charger, or inverter may be separately tested and maintained (including battery discharge tests, battery cell replacement, and battery charger and inverter replacement), and battery equalization may be performed off line with the plant at 100-percent power and without affecting plant operation.

- The batteries of the dc power supply system are required to be sized to meet the following operational requirements:

  - to supply power to their loads for a period of at least 2 hours on the basis of the most limiting load profile without load shedding

  - to permit operation of the station blackout coping systems for 8 hours, assuming manual load shedding and load management programs

- In the PWR plant, each dc bus is required to be connected to a battery and a battery charger. In addition, provision must be made to connect each bus to a standby, backup dc source (i.e., a combination of a battery and a battery charger). This backup source is required to have sufficient capacity to permit normal system operation in case of failure or unavailability of a single battery or battery charger.

- In the BWR plant, a similar configuration for the dc bus as indicated above for the PWR plant is required to be used. However, because of the BWR plant's triple redundancy of safety divisions for most accident scenarios, backup dc sources for the Class 1E dc buses are not required, provided continuous plant operation at 100-percent power with any one Class 1E battery or battery charger out of service is permitted for at least 72 hours.

- Uninterruptible power supplies are required to be provided for operation of low voltage vital ac safety loads, including reactor protection and safety systems actuation channels, and safety systems instrumentation and control loads.

- Each uninterruptible power supply is required to normally be fed from a dc bus so as to eliminate the need for dedicated ac sources and rectifiers.

- Each uninterruptible power supply must be provided with a backup ac source, consisting typically of a regulating transformer, with sufficient capacity to allow normal system operation in case of failure or unavailability of a single inverter.

- Each uninterruptible power supply is required to be provided with make-before-break static switches for automatic transfer of the loads to the backup source of ac power on failure of the inverter. Manual switches must be provided for manual transfer to the backup power source for maintenance of the inverter or the static switch.

- Four separate and independent Class 1E dc and low voltage vital ac uninterruptible power supplies are required to be dedicated to powering the four channels of the reactor protection system. Each dc source will include a battery and a battery charger capable of supplying power to its associated reactor protection system channel for a minimum of 2 hours.

- The non-safety portions of the dc and low voltage vital ac power supply systems are considered part of the permanent non-safety systems. As such, they must be energized from an ac source as long as power from an offsite power source or the onsite standby non-safety source is available.

- A separate 250-V dc non-safety dc power supply system is required to be provided for operation of the plant's large dc loads such as standby lube oil pumps or seal oil pumps.

- The non-safety 125-V dc power supply system will include redundant power supply buses, batteries, and battery chargers. Redundant chargers must be fed from separate ac buses.

- Uninterruptible power supplies are required to be provided for operation of non-safety low voltage vital ac systems, including plant computers, instrumentation and control loads, security lighting, and fire detection systems.

7.2 Evaluation

7.2.1 Loss of Power to a DC Bus

Section 7.2.2 of Chapter 11 of the Requirements Document specifies that the dc and low voltage vital ac power supply systems will be designed with sufficient redundancy to ensure that the failure or unavailability of a single battery, battery charger, or inverter will not result in a plant trip or a forced outage. In its letter dated April 10, 1990, the staff indicated that this requirement should also apply to the loss of a dc bus. That is, the loss of a dc bus should not result in a plant trip or a forced outage.

In its letter dated July 23, 1990, EPRI stated that the loss of power to a dc bus is usually the result of the failure or unavailability of the batteries or battery chargers supplying power to the bus rather than of a fault on the bus itself. EPRI indicated that this is particularly true if the dc system is operated ungrounded as required in the ALWR design criteria, and, therefore, it does not consider that establishing the same redundancy requirements for the dc buses as for the batteries and battery chargers is justified.

The staff's recommendation that the loss of a dc bus should not result in a plant trip or forced outage did not specifically identify the failure mechanism causing the bus loss (bus fault, failure of battery and charger, source breaker or fuse failure, etc.) because, assuming no other system anomalies such as voltage surges, harmonics, (or switching transients) occur as a result of the failure, the effect on the loads is the same, that is, loss of power.

The staff is still concerned about the wording of this requirement because the loss of a battery or of a charger does not necessarily result in a loss of power to the dc bus they supply. Therefore, a plant designer could conclude that the requirement specified in Section 7.2.2 of Chapter 11 of the Requirements Document is met by the installation of a charger qualified as a battery eliminator that can supply the bus when the battery is lost and a battery that can supply the bus when the charger is lost. However, the more specific requirements contained in Sections 7.3.2.2., 7.3.2.3, and 7.3.2.4 of Chapter 11 of the Requirements Document that call for four dedicated and independent sources of power to the four reactor protection system channels appear to result in a design that would meet the intent of a failed dc bus not resulting in a plant trip.

The basis for the staff recommendation is related to that addressed in Generic Safety Issue (GSI) A-30, "Adequacy of Safety-Related DC Power Supplies," which has been integrated into GSI 128, "Electrical Power Reliability." The concern is that a failure of a dc bus could cause a transient or plant trip requiring the response of safety systems, but those responses could fail because of a subsequent failure of an additional dc bus. GSI 128 is addressed in detail in Appendix B of Chapter 11 of the Requirements Document, which indicates that the ALWR design for the dc electrical power system will avoid the problems described in the issue. This issue is discussed in Appendix B of this DSER.

Based on its review of the dc system requirements, the staff concludes that some potential exists that not all losses of dc buses have been addressed. In addition, the same potential might exist that a loss of safety-related ac bus (low voltage or medium voltage) could result in a transient or plant trip. Therefore, for advanced plant designs, the staff concludes that the requirements of the EPRI Requirements Document are insufficient to assure that loss of an electrical bus (either ac or dc) will not result in a plant transient and simultaneous loss of single failure protection in any safety-related system. This is an open item that must be satisfactorily addressed before the staff can complete its review of Chapter 11 of the Requirements Document.

7.2.2 Allowed Outage Times for DC Safety Buses in ALWR Evolutionary Plant Technical Specifications

Section 7.3.1.4 of Chapter 11 of the Requirements Document specifies that provisions will be made in the PWR plant design to connect each dc bus to a standby, backup dc source (i.e., a combination of a battery and a battery charger). For the BWR plant, this section states that backup dc sources for the Class 1E dc buses will not be required, provided continuous plant operation at 100-percent power with any one Class 1E battery or battery charger out of service is permitted for at least 72 hours. In its letter dated April 10, 1990, the staff requested that EPRI clarify what it meant by "permitted for at least 72 hours."

In its letter dated July 23, 1990, EPRI stated that the provision in Section 7.3.1.4 of Chapter 11 of the Requirements Document for the BWR plant should be interpreted as referring to the operation of the plant as allowed by technical specifications (limiting conditions for operation). EPRI explained that this provision is intended to account for possible changes to existing technical specifications as a result of the higher redundancy of safety divisions provided by the ALWR design for the BWR plant. EPRI indicated that Section 7.3.1.4 of Chapter 11 of the Requirements Document would be modified to clarify its intent.

During its review of the ALWR Evolutionary Plant Technical Specifications, the staff will evaluate the acceptability of a 72-hour allowed outage time for a battery or battery charger in a BWR ALWR evolutionary plant.

7.2.3 Security

Security provisions for the dc and low voltage vital ac power supply systems in Chapter 11 of the Requirements Document include the security system as a plant support system receiving power from the dc and low voltage vital ac power supply systems.

ANSI/ANS Standard 3.3-1988 specifies that security intrusion detection aids should be supplied with uninterruptible power. 10 CFR 73.55(e)(1) and (f)(4) and Generic Letter 87-08 specify that onsite secondary power supply systems for security equipment must be located in a vital area. The dc and low voltage vital ac power supply systems also feed safety loads and fit the definition of vital equipment in Section 5.2.1.1 of Chapter 9 of the Requirements Document.

The staff concludes that the requirements in the Requirements Document do not conflict with the requirement that the dc and low voltage vital ac power supply systems be located in a vital area. Therefore, these requirements are compatible with NRC requirements and are acceptable.

Uninterruptible Power Supply for Security Equipment

Section 7.3.3.4 of Chapter 11 of the Requirements Document identifies the non-safety systems that will be provided with uninterruptible power. It specifically includes security lighting.

In its letter dated May 24, 1989, the staff requested that EPRI determine whether the requirement should also include uninterruptible power for other security equipment (e.g., security card readers, access control computer, alarm systems, and closed-circuit television).

In its letter dated September 15, 1989, EPRI agreed to revise Section 7.3.3.4 to read: "...including plant computers, instrumentation and control loads, security systems including security lighting, and fire detection systems." The staff concludes that this revision is acceptable and will confirm that it has been acceptably incorporated into the rollup document.

7.3 Conclusion

The staff concludes, with the exceptions noted above, that the requirements in Section 7 of Chapter 11 of the Requirements Document do not conflict with current regulatory requirements and are, therefore, acceptable.

8 NORMAL AND EMERGENCY LIGHTING

8.1 Function and Description

Section 8 of Chapter 11 of the Requirements Document provides design criteria for all onsite systems that will provide artificial illumination for rooms, spaces, and outdoor areas of the plant. These systems will include a normal station lighting system, a security lighting system, and an emergency lighting system. Section 8.2.1 of Chapter 11 of the Requirements Document states that illumination will be provided for each area of the plant in accordance with the guidelines of the IES Lighting Handbook, as published by the Illumination Engineering Society at the time the plant is designed.

EPRI states that the normal station lighting system will be used to provide normal illumination under all plant operating, maintenance, and test conditions. Section 8.3.3 of Chapter 11 of the Requirements Document states that the normal lighting system is considered by EPRI to be part of the plant permanent non-safety systems and, as such, is required by EPRI to be energized as long as power from an offsite power source or the standby non-safety source (combustion turbine generator) is available.

The security lighting system will provide illumination required to monitor isolation zones and all outdoor areas within the plant's protected perimeters, under normal plant conditions as well as on loss of all ac power. Section 8.4.1 of Chapter 11 of the Requirements Document states that the security lighting system is considered by EPRI to be part of the permanent non-safety systems and is required by EPRI to be fed from uninterruptible power supplies connected to non-safety batteries. EPRI requires that the non-safety batteries allow for at least 30 minutes of system operation on battery power in the event ac power is interrupted. The security lighting system can be fed from the offsite power sources or the combustion turbine generator.

The emergency lighting system will be used to provide acceptable levels of illumination throughout the station and, particularly, in areas where emergency operations will be performed, such as control rooms, battery rooms, and the containment, on loss of the normal lighting system. Section 8.5.1 of Chapter 11 of the Requirements Document specifies that the emergency lighting system will provide illumination units of at least 10 foot candles in those areas of the plant where emergency operations will be performed that could require the reading of printed or written material or of scales and legends. In other areas of the plant, EPRI requires the emergency lighting to be able to achieve a minimum illumination level of 2-foot candles.

Section 8.5.2 of Chapter 11 of the Requirements Document states that emergency lighting in the main control room will be powered from the safety uninterruptible (ac/dc) power supply. Outside the main control room, emergency lighting will be provided by dc self-contained, battery-operated units. The dc self-contained, battery-operated lighting units will be sized to provide at least 8 hours of operation at rated load.

8.2 Evaluation

8.2.1 Comparison of the ALWR Lighting System Requirements to Current Lighting System Design

The staff has determined that Section 8 of Chapter 11 of the Requirements Document does not provide in safety-related areas outside the control room and the access routes to those areas lighting from a Class 1E distribution system that can be powered from the Class 1E diesel generators. Many current plant designs include this feature.

The normal lighting system provided in the ALWR design criteria will be part of the plant permanent non-safety systems and, as such, can be totally powered from the standby combustion turbine generator or alternately the Class 1E diesel generators. The staff concludes that this is an improvement over past designs; however, the design of the distribution system (power panels, feeders, motor control centers, etc.) to the lighting is all non-Class 1E. No part of the distribution system that will supply continuous lighting outside the control room is required by EPRI to be qualified Class 1E. The staff assumes that the only qualified lighting outside the control room will be provided by dc self-contained, battery-operated lights (good for at least 8 hours). The staff is concerned that, following a seismic event with a resulting loss of the non-seismic, non-Class 1E distribution systems, all lighting outside the control room could be lost after 8 hours. In addition, reliance for continuous lighting in safety-related areas outside the main control room must be placed on an unqualified distribution system during non-seismic events.

In its letter dated April 10, 1990, the staff informed EPRI that lighting in safety-related areas outside the main control room and the access routes to those areas should be provided from the Class 1E distribution systems powered from Class 1E diesel generators. The distribution systems should, as a minimum, be qualified as Class 1E up to the lighting fixtures, and the lighting fixtures themselves should, as a minimum, be seismically supported (if the fixtures can be seismically qualified, they should be so qualified). The staff concluded that these qualification requirements should be specified in Section 8.5.2 of Chapter 11 of the Requirements Document. This system should be provided in addition to the dc self-contained, battery-operated lighting units.

In its letter dated July 23, 1990, EPRI stated that the assumptions made by the staff that led to the proposal to require a Class 1E lighting distribution system do not appear sufficiently plausible to support the proposed requirement. EPRI stated that the assumption of a need for extensive activities outside the main control room beyond 8 hours following a seismic or non-seismic design-basis event is not consistent with EPRI's design criterion, which is based on (1) ensuring the main control room is habitable and fully operable if a seismic event should occur and the necessary actions to maintain safety and protect the public involve the use of Class 1E equipment and systems that can be operated from the control room and (2) ensuring a low probability of loss-of-power events that last more than 8 hours. EPRI stated that there is little or no activity expected outside the control room beyond 8 hours, unless it is assumed that conditions are such that Class 1E equipment does not survive. Under this assumption, the provision of a Class 1E lighting distribution system cannot be counted on.

EPRI further stated that the staff's assumption of massive failure of the normal lighting system following an earthquake is not consistent with the actual performance of normal power distribution equipment during actual earthquakes, as documented in the Seismic Qualification Utilities Group (SQUG) program. EPRI stated that these data show that if electrical equipment is properly anchored, it has a high probability of surviving an earthquake. However, the data also demonstrates that lighting fixtures have been damaged and have fallen and represent a personnel and equipment hazard. EPRI's solution to this is to use safety wire ties to prevent fixtures from falling.

EPRI concluded that its approach of providing independent, self-contained, battery-operated lights in addition to continuous lighting in the control room provides high assurance that the necessary lighting will be available so that all activities required to respond to both seismic and non-seismic emergency conditions in the unlikely event that normal lighting is completely lost can be performed. EPRI stated, however, that a requirement will be added for lighting fixtures in normally occupied areas or over safety-grade equipment so that the structures are supported so they will not fall and present a hazard during seismic events.

The staff is also concerned about events other than seismic events. Experience at operating plants has shown that some events are often complex and require that operators be dispatched into the plant to perform some action (reposition a valve or verify its position, check protective relay flags and reset if necessary, verify operation of a pump, etc.). Chapter 10 of the Requirements Document identifies controls that will be located locally in the plant that operators may have to attend to. The EPRI ALWR design requirements, however, would allow continuous lighting outside the main control room to be provided only from a non-safety system for which there are few specific separation requirements and no specific requirements for protection from the effects of design-basis events such as high energy line breaks outside the containment.

In addition, the staff concludes that EPRI's statement that the ALWR design criterion ensures a low probability of loss-of-power events lasting more than

8 hours appears to be derived from the EPRI requirements to cope with a station blackout for 8 hours. The station blackout scenario, however, does not include the occurrence of seismic or design-basis events. Non-safety switchgear or power panels that power normal lighting and are damaged by the effects of a seismic or design-basis event with no station blackout will likely remain unavailable for more than 8 hours (regardless of the availability of offsite or standby power sources). The attendant loss of lighting could potentially hinder the ability of the operators to respond to the event.

The staff is also concerned about the lack of requirements regarding the proper anchoring of electrical equipment to ensure a high probability of the equipment surviving an earthquake. EPRI references data from the SQUG program to support its position that massive failure of the normal lighting system following an earthquake is unlikely. The staff concludes that there is no assurance that significant portions of the normal lighting system will not be damaged during an earthquake without implementing acceptable design criteria. Although EPRI admits that lighting fixtures have been damaged and have fallen during seismic events, EPRI proposes only to use safety wire ties to prevent them from falling - not necessarily to enhance their survival following a seismic event.

The staff concludes that EPRI should identify the design criteria in the Requirements Document that provide for a design wherein the safety-related systems necessary to mitigate the consequences of design-basis events and to bring the plant to a safe condition can all be operated from the main control room. In addition, for the continuous lighting systems in safety-related areas and the access routes to those areas, EPRI should provide design criteria that demonstrate that reasonable measures have been taken to address seismic survivability and the loss of lighting in those areas due to the effects of design-basis events. The Requirements Document should also specify that the continuous lighting systems in such areas will be powered from redundant electrical divisions and that they will be capable of being powered from the Class 1E diesel generators. These provisions should be made in addition to the use of dc self-contained, battery-operated lighting units. This is an open item that must be satisfactorily addressed before the staff can complete its review of Chapter 11 of the Requirements Document.

8.2.2 Normal Lighting System

Section 8.3.3 of Chapter 11 of the Requirements Document specifies that the normal lighting system will be considered part of the plant permanent non-safety systems and, as such, must be energized as long as power from an offsite power source or the standby non-safety power source is available. Section 4.2.6 of Chapter 11 of the Requirements Document specifies that the medium voltage ac distribution system will be designed to permit feeding the permanent non-safety loads from the onsite standby safety power sources (diesel generators) following a manual load transfer process. Consistent with these requirements and the staff position in Section 8.2.1 of this DSER, Section 8.3.3 of Chapter 11 of the Requirements Document should also require that, as a minimum, the portions of the normal lighting system that will provide lighting to safety-related areas and equipment and their access routes will be capable of being powered from the diesel generators following a manual load transfer process. This is an open item that must be satisfactorily addressed before the staff can complete its review of Chapter 11 of the Requirements Document.

In addition, Section 8.3.5 of Chapter 11 of the Requirements Document specifies that the circuits to the individual lighting fixtures in the normal lighting system will be staggered as much as possible to ensure some lighting is retained in a room in the event of a circuit failure. Consistent with the staff position in Section 8.2.1 of this DSER, this section should also require that, as a minimum, the staggered circuits to lighting fixtures in safety-related areas and their access routes be supplied from redundant electrical divisions capable of being powered from the diesel generators. This is an open item that must be satisfactorily addressed before the staff can complete its review of Chapter 11 of the Requirements Document.

8.2.3 Emergency Lighting

Section 8.5.1 of Chapter 11 of the Requirements Document requires that the emergency lighting system provide illumination units of at least 10 foot candles in those areas of the plant where emergency operations will be performed that could require the reading of printed or written material or of scales and legends.

The staff concludes that the wording of this requirement is confusing and could be interpreted to mean that illumination units (such as battery-operated lighting units) will be provided that can put out 10 foot candles of illumination at their source. This section should be clarified to specify that the lighting provided will achieve a minimum illumination of 10 foot candles at the printed or written material and the scales and legends. This is an open item that must be satisfactorily addressed before the staff can complete its review of Chapter 11 of the Requirements Document.

Section 8.5.2 of Chapter 11 of the Requirements Document requires that the emergency lighting be accomplished by the following systems:

° main control room: emergency lighting system fed from safety uninterruptible (ac/dc) power supply

° outside main control room: dc self-contained, battery-operated lighting units

The requirement for the emergency lighting in the main control room could be interpreted to mean that one uninterruptible power supply would be sufficient to power that lighting. This requirement should be clarified to require that two independent safety uninterruptible power supplies fed from redundant safety divisions be provided to power the emergency lighting. This is necessary to ensure that the emergency lighting meets the single-failure criterion. In addition, the qualification of the emergency lighting system is not clear. The staff concludes that the Requirements Document should specifically require that the emergency lighting system be qualified to ensure that adequate lighting remains operable following a seismic event. This is an open item that must be satisfactorily addressed before the staff can complete its review of Chapter 11 of the Requirements Document.

In its letter dated June 8, 1989, the staff stated that it was unclear whether the 8-hour battery-powered emergency lights would be installed in high-radiation areas or outdoor locations. The staff's concern resulted from difficulties that existing plants have had with such installations. In its letter dated

October 19, 1989, EPRI responded that the 8-hour battery-powered emergency lights will be installed throughout ALWRs referencing the Requirements Document as necessary, in accordance with the guidance of SRP Section 9.5.1 (NUREG-0800), in all areas needed for the operation of safe-shutdown equipment and in the access routes leading to these areas. In addition, similar lighting units with at least a 1.5-hour battery power supply will be provided throughout the plant to ensure personnel safety and property protection in accordance with the requirements of the Life Safety Code and the National Electric Code. EPRI also stated that although specific high-radiation areas or outdoor locations that may require battery-powered emergency lights are not addressed in the Requirements Document, it expects that some units may be required in outdoor locations, but few, if any, in high-radiations areas.

EPRI committed to include a statement of compliance with SRP Section 9.5.1, the Life Safety Code, and the National Electric Code in Chapter 1 of the rollup document. The staff concludes that the response is acceptable and will confirm that this matter has been satisfactorily addressed during its review of the rollup document.

8.2.4 Security Lighting System

Section 8.4.1 of Chapter 11 of the Requirements Document requires that the non-safety batteries provide at least 30 minutes of continued operation of the security lighting system in the event of an interruption of ac power. Section 8.4.2 of Chapter 11 of the Requirements Document requires that the security lighting system be designed to provide a minimum illumination of 0.2 foot candle.

Experience has shown that attention to the integration of exterior lighting systems with the closed-circuit television (CCTV) system, particularly uniformity of lighting within the camera field of view, can be critical to the assessment of alarm performance. NUREG/CR-1327, "Security Lighting Planning Document for Nuclear Fixed Site Facilities," recommends a light/dark ratio (the ratio of illumination level between the brightest area in the scene and the darkest area) of less than 6 to 1 for outdoor CCTV lighting. SAND 89-1924, "Video Assessment

Technology Transfer Manual," states: "A light/dark ratio of 6 to 1 should be considered to be the maximum, while a ratio of less than 4 to 1 is strongly suggested for exterior lighting." In its letter dated May 24, 1989, the staff asked EPRI to include a standard for uniformity of lighting intensity in the field of view of a CCTV camera. In its letter dated September 15, 1989, EPRI stated that this is an engineering detail beyond the scope of the Requirements Document.

The staff concludes that the requirements in Section 8 of Chapter 11 of the Requirements Document are consistent with the requirements of 10 CFR 73.55(c)(5) for security lighting. However, the staff will determine if the integration of the exterior lighting systems with the CCTV system is acceptable during its site-specific performance review.

8.3 Conclusion

The staff concludes, with the exceptions noted above, that the requirements in Section 8 of Chapter 11 of the Requirements Document do not conflict with current regulatory requirements and are, therefore, acceptable.

9 ELECTRICAL PROTECTIVE SYSTEMS

9.1 Functions and Description

Section 9 of Chapter 11 of the Requirements Document provides the design and performance requirements for the station grounding systems, surge protection systems, cathodic protection systems, and heat tracing systems.

The plant grounding systems will be designed to provide protection to personnel and equipment under normal and abnormal conditions. The major functions of the systems can be summarized as follows:

- to protect personnel by eliminating or reducing shock hazards
- to protect equipment by minimizing transient overvoltages
- to provide low impedance path to ground for ground fault currents, lightning discharges, and switching surge currents and to facilitate protective relaying for fast clearing of ground faults
- to stabilize circuit potential and to provide voltage reference for control and instrumentation systems

The plant grounding systems will include

- ground mats that will provide low resistance interface with the earth
- plant electrical distribution system grounding equipment that will be used to connect the electrical system's neutrals to ground
- equipment and structure grounding equipment that will be used to connect structures and equipment enclosures to ground

- instrumentation and control grounding equipment

The surge protection systems will be designed to protect plant equipment from exposure to overvoltage transients resulting from lightning strikes and switching operations. The surge protection systems will include surge arrestors and capacitors and lightning protection equipment.

The cathodic protection system will provide corrosion control of underground and submerged metallic surfaces. It will be used to protect buried pipes, tanks, and other metallic equipment in contact with potentially corrosive sprays, water, and dissimilar metals against long-term degradation in order to avoid or reduce repair or replacement costs and plant shutdowns.

The electrical heat tracing system will be designed to provide effective heating of fluids required for normal and transient plant operation. It will be applied to plant fluid systems, including piping, pumps, strainers, valves, and tanks, and will consist of electric heating cables, temperature controllers, power supplies, alarm and monitoring devices, and associated hardware.

9.2 Conclusion

The staff concludes that the requirements in Section 9 of Chapter 11 of the Requirements Document are consistent with regulatory requirements and are, therefore, acceptable.

10 CONCLUSION

On the basis of its review, subject to resolution of the identified open items, the staff concludes that the requirements established in Chapter 11 of the Requirements Document for the design of the electrical power systems do not conflict with current regulatory guidelines and are acceptable. However, by themselves they do not provide sufficient information for the staff to determine if the design and arrangement of plant-specific electrical power systems will be adequate. Therefore, applicants referencing the Requirements Document will be required to demonstrate compliance with the additional guidance provided in the Standard Review Plan (NUREG-0800), or provide justification or alternate means of implementing the associated regulatory requirements.

In staff requirements memoranda, the Commission instructed the staff to provide an analysis detailing where the staff proposes departure from current regulations or where the staff is substantially supplementing or revising interpretive guidance applied to currently licensed light water reactors (LWRs). The staff considers these to be policy issues. Appendix C of this DSER provides that analysis. These issues have been forwarded to the Commission in SECY-91- . For those issues discussed in Appendix C, the Commission is reviewing the basis for the approach that the staff is proposing for those issues discussed in Appendix C and, accordingly, may at some future point in the review determine that such issues involve policy questions that the Commission may wish to consider. In addition, certain technical issues still have to be resolved before the staff can complete its review.

Therefore, the staff concludes that Chapter 11 of the Requirements Document for evolutionary plant designs specifies requirements that, subject to the resolution of the identified open items, if properly translated into a design in accordance with the NRC regulations in force at the time the design is submitted, should result in a nuclear power plant that will have all the attributes required by the regulations to ensure that there is no undue risk to the health and safety of the public or to the environment. In addition to complying with existing regulations, such a facility would also be consistent with Commission policies for severe-accident protection and public safety goals.

APPENDIX A

DEFINITIONS

Appendix A of Chapter 11 of the Requirements Document contains definitions of terms and acronyms. Although the staff did not evaluate this appendix, the following is a list of acronyms and their meaning that are used throughout this report.

AAC	alternate ac
ACRS	Advisory Committee on Reactor Safeguards
ADS	automatic depressurization system
AFW	auxiliary feedwater
ALWR	advanced light water reactor
ANS	American Nuclear Society
ANSI	American National Standards Institute
ARSAP	Advanced Reactor Severe Accident Program
ASME	American Society of Mechanical Engineers
ATWS	anticipated transient(s) without scram
BTP	branch technical position
BWR	boiling water reactor
CCFP	conditional containment failure probability
CCIC	core coolant inventory control
CCTV	closed-circuit television
CE	Combustion Engineering, Inc.
CS	containment spray
CSS	containment spray system
CT	combustion turbine
DBA	design-basis accident
DHR	decay heat removal
DS	drywell spray
DSER	draft safety evaluation report
ECCS	emergency core cooling system

EDG	emergency diesel generator
EFW	emergency feedwater
EFWS	emergency feedwater system
EFWST	emergency feedwater storage tank
EPRI	Electric Power Research Institute
ERF	emergency response facility
ESF	engineered safety feature
FPLCS	fission product leakage control system
GDC	general design criterion(a)
GSI	generic safety issue
HEPA	high-efficiency particulate air
HPI	high-pressure injection
IDCOR	Industry Degraded Core Rulemaking
IEEE	Institute of Electrical and Electronics Engineers
ILRT	integrated leak rate test
IPE	individual plant evaluation
IRWST	in-containment refueling water storage tank
LOCA	loss-of-coolant accident
LOOP	loss of offsite power
LTOP	low-temperature overpressure protection
MCC	motor control center
MSIV	main steam isolation valve
NPSH	net positive suction head
NRC	Nuclear Regulatory Commission
NSSS	nuclear steam supply system
NUMARC	Nuclear Management and Resources Council
PORV	power-operated relief valve
PRA	probabilistic risk assessment
PWR	pressurized water reactor
RAI	request for additional information
RCIC	reactor core isolation cooling
RCS	reactor coolant system
RG	regulatory guide
RHR	residual heat removal
RPV	reactor pressure vessel

SDVS	safety depressurization and vent system
SER	safety evaluation report
SG	steam generator
SIS	safety injection system
SLCS	standby liquid control system
SRP	Standard Review Plan (NUREG-0800)
TDI	Transamerica Delaval, Inc.
TMI-2	Three Mile Island Nuclear Plant, Unit 2
USI	unresolved safety issue
WS	wetwell spray

APPENDIX B

GENERIC SAFETY AND LICENSING ISSUE TOPIC PAPERS

Appendix B to Chapter 11 of the Requirements Document contains generic safety and licensing issue topic papers. Topic papers present the ALWR Utility Steering Committee's approach to the resolution of unresolved safety issues and generic safety issues. Those applicable to the design and arrangement of the electrical systems are discussed in Chapter 11 of the Requirements Document and are evaluated below.

B.1 GENERIC SAFETY ISSUE 107, "GENERIC IMPLICATIONS OF MAIN TRANSFORMER FAILURE"

Issue: As a result of main transformer faults at the North Anna Power Station, generic concerns were raised concerning fire suppression for transformer fires and their impact on plant safety systems. A transformer fire of sufficient magnitude (location dependent) has the potential for degrading plant safety equipment and safety systems. Therefore, the generic concerns arising from this issue involve (1) the proper maintenance, storage, and handling of transformers to prevent transformer failure and (2) the mitigation and containment of transformer fires. It has been determined that there are four key areas in the prevention and control of transformer fires that should be addressed. These are the deluge system, drainage system, fire barriers, and firefighting and related procedures. Other generic concerns involve the layout and segregation of the transformer bay drains, use of fire barriers, and hindrances to firefighting related to access, communications, mobility, training, and procedures.

EPRI Proposal: Section B.1.4 of Chapter 11 of the Requirements Document states that the concern regarding the handling, storage, and maintenance of transformers is an operating plant concern and is not within the scope of the Requirements Document. However, Section B.1.4 of the Requirements Document does address the adequacy of the fire protection system in controlling transformer fires and mitigating their effects. EPRI states that its design criteria require a fire protection system that meets all regulatory requirements and that is specifically designed to deal with transformer fires. Section B.1.4.2 of Chapter 11 of the Requirements Document lists the following design criteria specified by EPRI in the Requirements Document to address this issue:

- In Chapter 1 of the Requirements Document, EPRI specifies a general requirement that the evolutionary ALWR plant design provide for an integrated approach to fire prevention and mitigation of fire damage.

- Section 2.3 of Chapter 5 of the Requirements Document specifies exposure protection by providing fire-rated barriers or spatial separation so that fire involving one transformer will not spread to other transformers or into the power plant.

- Section 2.3.3.10 of Chapter 6 of the Requirements Document requires that outdoor oil-filled transformers have oil spill confinement features or drainage away from the buildings. EPRI states that such transformers will be located at least 50 feet from the building, or if building walls are within 50 feet of the oil-filled transformers, these walls will not have openings and will have a fire-resistance rating of at least 3 hours.

- Section 3.3.3.3 of Chapter 9 of the Requirements Document specifies that automatic fixed water suppression over the fire area will be provided for any equipment identified by the fire hazards analysis as containing a sufficient quantity of oil to warrant a fixed suppression system. EPRI states that the outdoor oil-filled transformers will be protected by deluge systems and drainage to accommodate the flow of oil and water as determined by the fire hazards analysis.

In summary, EPRI states that the evolutionary ALWR plant designs referencing the Requirements Document will avoid the problems with transformer fires by meeting all pertinent regulatory requirements. EPRI further states that specific requirements are included in the Requirements Document to mitigate and contain transformer fires, including design criteria for deluge system protection and adequate oil and water drainage for oil-filled transformers. EPRI also states that oil-filled transformers will have oil spill containment features, drainage away from buildings, 50-foot segregation, and 3-hour fire barriers. In addition, EPRI requires that evolutionary ALWR plant designs meet any new guidance or requirements resulting from the generic resolution of this issue.

Staff Evaluation: The staff's evaluation of this generic safety issue has not yet been completed. The staff's evaluation of EPRI's proposed criteria on fire protection can be found in Section 2.3 of the DSER for Chapter 6 of the Requirements Document, Section 3 of the DSER for Chapter 9 of the Requirements Document, and Section 2.2.6 of this DSER. In Section 2.3 of the DSER for Chapter 6 of the Requirements Document, the staff described an open item regarding the location of oil-filled transformers in relation to exterior building walls. Therefore, the staff's review of EPRI's proposed resolution of this generic safety issue will remain an open item until the staff has completed its review of EPRI's response to the open item on transformer location in Chapter 6 of the Requirements Document.

B.2 GENERIC SAFETY ISSUE 91, "MAIN CRANKSHAFT FAILURE IN TRANSAMERICA DELAVAL EMERGENCY DIESEL GENERATOR"

Issue: During the 1970s, many utilities used large-bore, medium-speed diesel generators from Transamerica Delaval, Inc. (TDI) at nuclear plants in the United States. Concerns regarding the reliability of these diesel generators were first prompted by a crankshaft failure at the Shoreham nuclear plant in August 1983. However, a broad pattern of deficiencies in critical engine components subsequently became evident at Shoreham and at other power plants using TDI diesel generators.

In response to these problems, 13 U.S. nuclear utility owners formed a TDI Diesel Generator Owners Group to address operational and regulatory issues relative to diesel generator sets used for standby emergency power. The Owners Group program plan consisted of the following major elements:

(1) Phase I: Resolution of known generic problem areas

(2) Phase II: A design review and quality revalidation of engine components to ensure that their design and manufacture, specifications, quality control and assurance, and operational surveillance and maintenance are adequate

(3) Expanded engine tests and inspections as needed to support Phases I and II

The staff considered the overall plan of the Owners Group to be acceptable; however, it recommended a fourth element to the program, that is, implementation of the maintenance and surveillance programs as indicated by the results of Phases I and II. The staff issued an SER documenting the technical resolution of this issue in NUREG-1216.

<u>EPRI Proposal</u>: Section B.2.4 of Chapter 11 of the Requirements Document states that the emergency diesel generator (EDG) units in evolutionary ALWR plant designs referencing the Requirements Document will have a minimum target reliability of 0.98 over a 5-year period based on successful starts and load-runs. In case of new designs, the units will be qualified in accordance with the latest revisions of ANSI/IEEE Standard 387 and IEEE Standard 323. Therefore, EPRI states that only EDGs that have proven reliable or qualified to the highest standards and are not subject to crankshaft and bearing cracks will be used.

<u>Staff Evaluation</u>: The staff concludes that EPRI has specified requirements to use reliable diesel generator units and that it will follow the staff's recommendations as discussed in NUREG-1216. This issue is considered resolved for evolutionary ALWR plant designs referencing the Requirements Document.

B.3 GENERIC SAFETY ISSUE 128, "ELECTRICAL POWER RELIABILITY"

<u>Issue</u>: Concerns have been raised regarding the dependence on dc power of the decay heat removal systems required for long-term heat removal. Failure of one dc division would generally result in a reactor scram which would then require

removal of decay heat. The frequency of reported failures of single dc divisions gives rise to the concern that the second dc division may not be available.

Two of the specific reasons for the concern that safety-related power may be unreliable are also addressed by this issue. One is that some operating nuclear power plants do not have technical specifications or administrative controls governing operational restrictions for Class 1E 120 V ac vital instrument buses and associated inverters. Without such restrictions, these power sources could be out of service indefinitely and may place certain safety systems in a situation where they could not meet the single-failure criterion. The other is that the design of some plants do not provide interlocks to prevent the inadvertent closure of the single tie breaker between Class 1E buses of all voltages.

EPRI Proposal: Section B.3.4.1 of Chapter 11 of the Requirements Document states that the concerns raised by this issue can be resolved by avoiding the use of bus tie breakers that could compromise division independence and by providing a reliable dc power supply, especially when the failure of one dc power system leads to a reactor scram. Section B.3.4.2 of Chapter 11 of the Requirements Document lists the following design criteria specified by EPRI in the Requirements Document to address this issue:

° Section 2.2.F.7 of Chapter 1 of the Requirements Document specifies that the plant designer should identify potential system interactions to be avoided. Specifically, the design will require separation and isolation of electrical power systems to preclude interactions that could adversely affect such functions as diesel generator loading and normal to emergency power transfers.

° Section 2.2.8 of Chapter 5 of the Requirements Document states that each division of the engineered safety systems requiring electric power is to be provided with an emergency onsite source of ac and/or dc power.

- Section 2.2.9 of Chapter 5 of the Requirements Document states that at least two separate and independent connections will be provided to offsite power sources capable of starting and running all Class 1E loads required for safe shutdown.

- Section 2.3.1 of Chapter 5 of the Requirements Document states that the specified functions of engineered safety systems will be met by the use of redundant divisions.

- Section 2.3.2 of Chapter 5 of the Requirements Document specifies that the divisions of engineered safety systems will be totally independent and separated both mechanically and electrically except for areas in which it is physically impractical or less safe.

- Section 3.3.2 of Chapter 5 of the Requirements Document states that the decay heat removal system will be redundant and safety grade.

- Section 4.2.2.1 of Chapter 5 of the Requirements Document specifies that BWR designs will have three independent divisions for the core coolant inventory control (CCIC) and decay heat removal (DHR) systems.

- Section 4.2.7.1 of Chapter 5 of the Requirements Document states that each division of the CCIC and DHR systems for BWR designs will have its own independent emergency ac and dc power sources.

- Section 5.1.2.1 of Chapter 5 of the Requirements Document specifies that PWR designs will have two independent divisions for the CCIC and DHR functions.

- Section 5.2.3.1 of Chapter 5 of the Requirements Document states that the PWR designs will have two independent divisions for the residual heat removal function.

- Section 2.3.6 of Chapter 11 of the Requirements Document states that each division of engineered safety systems requiring electric power is to be provided with an independent emergency onsite source of ac and dc power.

- Section 3.2.3 of Chapter 11 of the Requirements Document states that at least two separate and independent connections for offsite power sources capable of starting and running all Class 1E loads required for safe shutdown will be included in the design.

- Sections 2.3.6, 2.3.7, and 2.3.10 of Chapter 11 of the Requirements Document provide requirements proposed by EPRI that will ensure that there will be separation of the electrical power systems to preclude interactions that could adversely affect the functioning of the dc power systems. EPRI states that it prohibits the use of bus ties between safety divisions.

- Sections 2.3.9 and 2.3.11 of Chapter 11 of the Requirements Document specify that non-safety-related loads will be placed on completely separate power supplies from safety-related loads.

- Section 7.2.1 of Chapter 11 of the Requirements Document states that the loss of any battery or dc bus concurrent with a single independent failure in any other system required for shutdown cooling will not result in a total loss of reactor cooling capability.

- Section 7.3.2.4 of Chapter 11 of the Requirements Document states that each reactor protection channel will normally be powered from a dedicated Class 1E source that is normally independent of other dc sources.

In summary, EPRI states that each division of the engineered safety systems will have an emergency onsite source of ac and dc power and at least two connections for offsite power, all of which will be separate and independent. Specifically, EPRI states that there will be three independent divisions of decay heat removal for the BWR design and two for the PWR, each with its own emergency ac and dc power source.

<u>Staff Evaluation</u>: The staff's concern that a failure of a dc bus could cause a transient or plant trip, coincident with a failure of an additional dc bus, is discussed in Section 7.2.1 of this DSER.

In Section B.3.2 of Chapter 11 of the Requirements Document, EPRI states that one of the two reasons for the concern that safety-related power may be unreliable is that the design of some plants does not provide interlocks to prevent the inadvertent closure of the single tie breaker between the 4160 volt Class 1E buses. The staff is concerned about the use of tie breakers of all voltages.

In addition, the staff concludes that limiting conditions for operation for vital buses will still be needed in the technical specifications. The staff will address this matter during its review of the ALWR Evolutionary Plant Technical Specifications.

Although the details of the operational aspects of Generic Safety Issue 128 are beyond the scope of the EPRI Requirements Document, the staff concludes that the operational, maintenance, and testing issues of Generic Issue 128 should be listed in the Requirements Document for later consideration by the designer. This is an open item that must be satisfactorily addressed before the staff can complete its review of Chapter 11 of the Requirements Document.

APPENDIX C

REGULATORY DEPARTURE ANALYSIS

The August 24, 1989, staff requirements memorandum regarding the DSER for Chapter 5 of the Requirements Document states:

> The staff should identify those instances where the staff is proposing to depart from current regulations or where the staff is substantially supplementing or revising interpretive guidance applied to currently licensed LWRs. In each case, the staff should discuss the nature of the current regulatory requirement or interpretation, the departure that the staff is proposing, and the basis for the proposed departure. The analysis should be provided to the Commission and, in addition, should be attached to the draft SER on Chapter 5 as an appendix.... The staff should approach each future draft SER in a similar manner, i.e., attach an analysis detailing where staff is proposing to depart from current requirements.

Accordingly, the following analysis is being provided. This analysis was forwarded to the Commission in SECY-91- . This appendix discusses those instances where the staff positions are different from current regulatory requirements or where the staff is substantially supplementing or revising interpretive guidance applied to currently licensed LWRs. The staff's discussion of these issues in this appendix includes the nature of the current regulatory requirement or interpretation, the departure that the staff is proposing, EPRI's position, and the basis for the proposed departure. For easy identification, the staff's positions regarding these issues have been underlined and have been cross-referenced with the other sections in the DSER in which they are discussed.

Note that these issues are considered fundamental to agency decisions on the acceptability of the evolutionary ALWR designs. The Commission is reviewing the basis for the approach that the staff is proposing, and accordingly, may at some future point in the review determine that such issues involve policy questions that the Commission may wish to consider.

[SPECIFIC ISSUE DISCUSSION TO BE PROVIDED LATER]

[THIS SECTION WILL BE BASED ON ENCLOSURE 1]