Advanced Safety Evaluation Report with no Open Items for the U.S. EPR

Chapter 8, "Electric Power"

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8 ELECTRIC POWER

Chapter 8 of this report describes the U.S. Nuclear Regulatory Commission (NRC) staff's review of the U.S. EPR electrical power systems, including the offsite power system, the onsite power system and the alternate alternating current (AAC) system. This information is included in the AREVA NP (also known as AREVA or the applicant) U.S. EPR Final Safety Analysis Report (FSAR), Chapter 8, "Electric Power."

8.1 Introduction

Offsite power is provided by at least two utility transmission lines connected to the station switchyard. The plant electrical distribution system interfaces with the switchyard at the output of the main generator via the main step-up transformers and at the station auxiliary transformers. During normal operation, the main generator connects to the switchyard via three single-phase step-up transformers to supply power to the transmission system. The plant electrical distribution system receives offsite power during normal plant operating modes, anticipated operational occurrences, and postulated accidents via four auxiliary transformers connected to the switchyard. The U.S. EPR design does not include the traditional unit auxiliary transformer that connects the plant electrical distribution system directly to the main generator output as the normal source during power operation. The preferred power supply (PPS) is the power supply from the transmission system to the safety-related Class 1E emergency power supply system (EPSS). Two emergency auxiliary transformers (EATs) provide the PPS from the switchyard to the EPSS with no intervening non-Class 1E switchgear. Two normal auxiliary transformers (NATs) provide power from the switchyard to the non-Class 1E normal power supply system (NPSS). The utility transmission system, location of rights-of-way, transmission lines and towers, and switchyard design and interconnections are site-specific. An applicant for a combined license (COL) that references the U.S. EPR design certification must provide site-specific information describing the interface between the offsite transmission system and the nuclear unit, including switchyard interconnections.

The onsite power system consists of the EPSS and the NPSS. The EPSS distributes 6.9 kiloVolt (kV) and 480 volt alternating current (Vac) power to safety-related and selected non-safety-related plant loads. The EPSS is comprised of four divisions of switchgear, load centers, motor control centers (MCCs), standby power sources, and distribution system transformers. Each division includes a Class 1E emergency diesel generator (EDG), which is the standby power source to its particular division in the event of a power loss. Each division has the ability to connect to one of two non-safety-related station blackout diesel generators (SBODGs) used as the AAC source during station blackout (SBO) conditions. The Class 1E uninterruptible power supply (EUPS) has four separate and redundant 250 volt direct current (Vdc) divisions that provide power to EUPS direct current (dc) loads and to inverters that power safety-related and selected non-safety-related loads. The EUPS inverters provide three-phase 480 Vac power to Class 1E MCCs that supply safety-related loads, including power to instrumentation and controls via alternating current/direct current (ac/dc) converters. The SBODGs can power a battery charger in each EUPS division during SBO conditions. The NPSS distributes 13.8 kV, 6.9 kV, and 480 Vac power to non-safety-related loads throughout the power plant, including the reactor coolant pumps. The system is configured in four trains of switchgear, load centers, MCCs, and distribution system transformers. Trains 1 and 2 provide the connection point for each SBODG. The SBODGs provide power to selected turbine island equipment for asset protection, if necessary, during loss of power events, and further provide power to the EPSS during SBO conditions.

FSAR Tier 2, Section 8.1 indicates that a COL applicant that references the certified U.S.EPR design will provide site-specific information describing the interface between the offsite transmission system and the nuclear unit, including switchyard interconnections (FSAR Tier 2, Table 1.8-2, “U.S. EPR Combined License Information Items,” COL Information Item 8.1-1). The staff’s assessment of the adequacy of this COL information item can be found in Section 8.2, “Offsite Power System,” of this Safety Evaluation Report.

8.2 Offsite Power System

The U.S. EPR offsite power system is intended to provide reliable electric power from the transmission system for the safe shutdown of the reactor.

8.2.1 Introduction

The safety function of the offsite power system (assuming the onsite power system is not functioning) is to provide sufficient capacity and capability to ensure that the structures, systems, and components (SSCs) important to safety perform as intended. The offsite power system must satisfy the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix A, General Design Criteria (GDC) 5, “Sharing of Structures, Systems, and Components,” GDC 17, “Electric Power Systems,” and GDC 18, “Inspection and Testing of Electric Power Systems,” and must perform its design function during all plant operating and accident conditions.

8.2.2 Summary of Application

FSAR Tier 1: In Section 2.5.5, “Preferred (Offsite) Power Supply System,” the applicant states that the preferred (offsite) power system provides the preferred power to the Class 1E EPSS via the EATs and offsite power to the NPSS via the NATs during normal and abnormal operation.

FSAR Tier 2: The applicant has provided a system description in Section 8.2, “Offsite Power System,” provided here, in part, as follows:

> The offsite power system provides power from the transmission system, via the station switchyard, to the plant Class 1E and non-Class 1E electrical distribution systems. The offsite power system includes all transmission lines connected to the switchyard, the switchyard equipment (overhead buses, circuit breakers, disconnect air switches), and auxiliary transformers; and the system ends at the input terminals of the switchgear circuit breakers. The PPS is the offsite power from the transmission system to the EPSS that is preferred to provide power under accident and post-accident conditions. The offsite transmission system and connections to the station switchyard are site-specific. A COL applicant that references the U.S. EPR design certification will provide site-specific information regarding the offsite transmission system and connections to the station switchyard.
>
> The switchyard has connections to at least two transmission lines. The normally energized transmission lines are physically independent circuits that minimize the likelihood of their simultaneous failure under operating and environmental conditions and postulated events, including transmission tower or line failures. These lines do not cross, and no other transmission lines cross above these

two lines. Each offsite power circuit is sized to supply the station safety-related and non-safety-related loads during normal and abnormal operations.

The PPS supplies the station EPSS buses from two independent overhead lines between the switchyard and the station transformer area via two EATs. The station remains connected to the offsite power sources during normal plant operation regardless of main generator status, without transferring buses or power sources during startup, full power operation, or shutdown. Each PPS circuit is normally in service through its respective EAT.

Two additional overhead lines provide power to two NATs for the station NPSS buses.

Each auxiliary transformer is provided with two on-load tap changers to maintain the supplied bus voltage at the nominal value during transmission system voltage fluctuations. The reference voltage for the on-load tap changer operation is provided by voltage transformers at the respective bus to which the secondary winding is connected. Momentary bus voltage transients (e.g., motor starting) do not result in tap changers affecting bus voltage due to the short nature of the voltage transient.

Each Emergency Auxiliary Transformer (EAT) supplies the alternate power to the EPSS buses supplied by the other EAT. Each EAT has the capacity to supply all four EPSS divisions during postulated events to support core cooling and containment integrity and to maintain other safety-related function capability. An EAT failure results in the other EAT power source automatically accepting the load of the EPSS buses originally connected to the failed EAT.

The two normally in-service NATs provide power to four NPSS 13.8 kV trains. The offsite source to the NPSS switchgear is arranged so that there is an alternate supply to each bus (similar to the EAT configuration).

ITAAC: The inspections, tests, analyses, and acceptance criteria (ITAAC) associated with FSAR Tier 2, Section 8.2 are given in FSAR Tier 1, Table 2.5.5-1, "Preferred (Offsite) Power Supply System ITAAC," and Table 2.5.6-1 "Power Transmission System ITAAC."

Technical Specifications: Technical Specifications (TSs) applicable to the offsite power system can be found in FSAR Tier 2, Chapter 16, Sections 3.8.1, "AC Sources – Operating," and 3.8.2 "AC Sources – Shutdown." Bases for these TSs are in B3.8.1 "AC Sources – Operating," and B3.8.2 "AC Sources – Shutdown."

Conceptual Design: FSAR Tier 2 contains conceptual design information delineated by double brackets ([[ ]]), which is outside the scope of the U.S. EPR design certification related to the following systems:

- The auxiliary power and generator transformer areas. Conceptual design information for these components is included in Section 8.2 of this report.

- The offsite power transmission system including the main switchyard area. Conceptual design information for this system is included in Section 8.2 of this report.

U.S. EPR Plant Interfaces: FSAR Tier 2, Table 1.8-1, “Summary of U.S. EPR Plant Interfaces with Remainder of Plant,” contains information related to the following plant interfaces that will be addressed in the COL designs:

- Off-site alternating current power transmission system connections to the switchyard and the connection to the plant power distribution system (Item Number 8-1)
- Auxiliary power and generator transformer areas (Item Number 8-3)

8.2.3 Regulatory Basis

The relevant requirements of NRC regulations for the offsite power system, and the associated acceptance criteria, are given in NUREG-0800, Section 8.2, “Standard Review Plan [SRP] for the Review of Safety Analysis Reports for Nuclear Power Plants,” and are summarized below. Review interfaces with other SRP sections can also be found in NUREG-0800, Section 8.2.

1. 10 CFR Part 50, Appendix A, GDC 5, “Sharing of Structures, Systems, and Components,” as it relates to sharing of SSCs of the preferred power systems of different nuclear power plants

2. 10 CFR Part 50, Appendix A, GDC 17, “Electric Power Systems,” as it relates to the preferred power system's (1) capacity and capability to permit functioning of SSCs important to safety; (2) provisions to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit, the loss of power from the transmission network, or the loss of power from the onsite electric power supplies; (3) physical independence; (4) availability; and (5) simultaneous failure under operating and postulated accident and environmental conditions

3. 10 CFR Part 50, Appendix A, GDC 18, “Inspection and Testing of Electric Power Systems,” as it relates to the inspection and testing of the offsite electric power system

4. 10 CFR 50.63, “Loss of All Alternating Current Power,” as it relates to an AAC power source as defined in 10 CFR 50.2, “Definitions,” provided for safe shutdown in the event of a station blackout

5. 10 CFR 50.65, “Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,” Section (a)(4), as it relates to the requirements to assess and manage the increase in risk that may result from proposed maintenance activities before performing the maintenance activities for the offsite power system

Acceptance criteria adequate to meet the above requirements include the following Regulatory Guides (RGs):

1. RG 1.32, “Criteria for Power Systems for Nuclear Power Plants,”(see also Institute of Electrical and Electronics Engineers (IEEE) Standard (Std) 308-2001 “Criteria for Class 1E Power Systems for Nuclear Power Generating Stations,”) as it relates to the availability and number of immediate access circuits from the transmission network.

2. RG 1.155, “Station Blackout,” as it relates to the adequacy of the AAC source and the independence of the AAC power source from the offsite and onsite power systems and sources. New applications should provide an adequate AAC source of diverse design

(with respect to alternating current (AC or ac) onsite emergency sources) that is consistent with the guidance in RG 1.155 and capable of powering at least one complete set of normal safe shutdown loads.

3. RG 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," as it relates to the effectiveness of maintenance activities for onsite emergency ac power sources including grid-risk-sensitive maintenance activities (i.e., activities that tend to increase the likelihood of a plant trip, increase the loss of offsite power (LOOP) frequency, or reduce the capability to cope with a LOOP or SBO).

4. RG 1.182, "Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants," as it relates to activities implementing the provisions of 10 CFR 50.65 (a)(4) by endorsing Section 11 to Nuclear Management and Resources Council (NUMARC) 93-01, "Nuclear Energy Institute Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, February 22, 2000."

5. RG 1.204, "Guidelines for Lightning Protection of Nuclear Power Plants," and IEEE Stds 665-1995, "Guide for Generating Station Grounding," 666-2007, "Design Guide for Electric Power Service Systems for Generating Stations," 1050-2004, "Guide for Instrumentation and Control Equipment Grounding in Generating Stations," and C62.23-1995, "Application Guide for Surge Protection of Electric Generating Plants," as they relate to the design, installation, and performance of station grounding systems and surge and lightning protection systems.

6. RG 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," as it relates to power system analytical studies and stability studies to verify the capability of the offsite power systems and their interfaces with the onsite power system.

7. NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System," U.S. Nuclear Regulatory Commission, July 2012.

8.2.4 Technical Evaluation

The staff has evaluated the offsite power system described in FSAR Tier 2, Section 8.2, to determine whether: (1) The required minimum of two separate circuits from the transmission network to the onsite distribution system is provided; (2) the system has adequate capacity and capability to supply power to all safety loads; (3) both physical and electrical separation are designed between the two (or more) circuits to minimize the chance of simultaneous failure; and (4) there is an interface of the PPS with an AAC power source for safe shutdown in the event of a station blackout.

SRP Table 8-1, "Acceptance Criteria and Guidelines for Electric Power Systems," lists GDC, RGs, standards, and branch technical positions (BTPs) that are applicable to electrical power systems. The staff has reviewed the applicable FSAR information for compliance with and conformance to the offsite power system requirements and guidance as described below.

8.2.4.1 *Compliance with GDC 5*

GDC 5 requires SSCs important to safety, which includes the direct current (DC or dc) power system, not be shared among other nuclear units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions. Since the U.S. EPR design is a single-unit station, there are no offsite power SSCs important to safety that are shared between individual nuclear power units. Therefore, GDC 5 is not applicable to the offsite power system of the U.S. EPR design. However, GDC 5 may be applicable to a COL applicant that references the U.S. EPR design if its application includes two or more units, or if a proposed unit shares a system with one or more existing units, and in such cases, the staff will evaluate the COL applicant's compliance with GDC 5.

8.2.4.2 *Compliance with GDC 17*

In compliance with GDC 17 offsite power to the U.S. EPR is provided by a minimum of two independent transmission lines to the station switchyard. The power plant interfaces with the switchyard at the output of the main generator via the main step-up (MSU) transformers. Two normally energized overhead circuits connect to the switchyard via the EAT high-side connections, which provide immediate availability of each offsite power supply to the Class 1E buses. Two normally energized overhead circuits are also provided to the NAT high-side connections, which provide a normal and alternate offsite power supply only to the non-safety-related plant loads. Each offsite power circuit is sized to supply the station safety-related and non-safety-related loads during normal and abnormal operation.

The secondary side of each EAT is normally aligned to two Class 1E divisional buses. The plant remains connected to the offsite power sources regardless of main generator or onsite power source status. Because no transferring buses or power sources are needed during startup, full power operation, or shutdown, this minimizes the potential effects on Class 1E equipment from non-safety-related load transients, and it eliminates additional failure points between the offsite source and the Class 1E equipment. This connection of at least one offsite circuit directly to safety buses with no intervening non-safety-buses conforms to the recommendations in SECY-91-078, "Chapter 11 of Electric Power Research Institute's (EPRI's) Requirements Document and Additional Evolutionary Light Water Reactor (LWR) Certification Issues," March 25, 1991.

In Request for Additional Information (RAI) 11, Question 08.03.01-1, the staff requested that the applicant clarify how the automatic fast transfer scheme works and how it prevents transfer into a faulted bus. The staff also requested that the applicant elaborate on a single failure vulnerability of the transfer scheme between the motive (ac) and control power (dc) within the affected divisions. In an October 15, 2008, response to RAI 11, Question 08.03.01-1, the applicant provided details on how the fast transfer between the EPSS buses to an alternate EAT initiates, and explained that the single point vulnerabilities that can affect the fast transfer are limited to those that will affect only a single division. Based on the applicant's detailed explanation of the fast transfer scheme, the staff finds that transfer to a faulted bus would be prevented. The applicant also explained that a similar transfer scheme is used for the NPSS buses, but it uses a supervised design that allows transfer to occur if it is within the phase angle limit or if it moves into the phase angle limit during the fast transfer enable window. The staff confirmed that in Revision 1 of the design certification application, FSAR Tier 2, Section 8.3.1.1.1 was revised, as committed to in the RAI response, to eliminate the phrase, "that results in a loss of voltage at a BDA bus." The purpose was to remove a limitation on the meaning of faulted bus to include more than the simple loss of voltage. The staff confirmed that Revision 1 of the FSAR, dated May 29, 2009, contains the changes as committed to in the RAI response. Accordingly, the staff finds that the applicant has adequately addressed this issue and, therefore, considers this issue resolved.

The U.S. EPR plant is designed to operate within a transmission system operating voltage of ± 10 percent. The transmission system operator provides sufficient voltage during normal operation and single contingencies (e.g., loss of a single offsite transmission line) to safety-related loads during design-basis events (DBEs). Within this system's operating voltage range, the degraded voltage protective actions are not initiated.

In response to operating experience at the Byron facility, where a single-phase open circuit condition was not detected promptly and Unit 2 experienced an automatic reactor trip due to a sustained open phase condition, the staff issued NRC Bulletin 2012-01 to all operating reactors and COL applicants. Bulletin 2012-01 requested addressees to provide information to the NRC on their offsite power circuit protection scheme in regard to the potential design vulnerability presented by an undetected single-phase fault, with the goal of determining GDC 17 compliance.

In RAI 564, Question 08.02-8, the staff requested that the applicant provide information on how its electrical system design would detect, alarm, and respond to a single-phase open circuit condition, with/without a high impedance ground. The staff also requested that the applicant describe its plans for establishing its surveillance testing and operating procedures as they relate to the electrical system components that will provide detection, alarm, and response to an open circuit condition. In an October 25, 2013, response to RAI 564, Question 08.02-8, the applicant stated that the AREVA electrical group is participating in nuclear industry efforts to provide an effective design solution to address NRC Bulletin 2012-01. The applicant is also performing analyses of the U.S. EPR electrical system using Electrical Transient Analyzer Program (ETAP) in order to determine how best to monitor the EATs during normal plant operation to provide: (1) A reliable indication to operators of the loss of the offsite power supply phase to either of the EATs; and (2) a continuous monitoring scheme to ensure that the plant meets the GDC 17 requirements that pertain to this open phase condition. A model was created using ETAP Version 12.0N with guidance from NEI's "Consideration of Scenarios for the Open Phase Analysis," Draft 5.

Based on the analyses, the applicant stated that a digital relay system that monitors phase voltages and currents for the offsite power supplies to the EATs will be installed, and its continuous phase monitoring system (PMS) of the offsite power will address the vulnerabilities described in NRC Bulletin 2012-01. The applicant indicated further that the PMS will display off-normal source voltages during plant operation and send alarms for loss of phase or ground faults, which, in turn, will initiate a fast transfer to another available offsite power source (i.e., the second offsite power circuit) by tripping the affected EAT during normal or accident conditions.

To resolve the design vulnerability identified in NRC Bulletin 2012-01, the applicant proposed to add the PMS to the U.S. EPR electrical system. With the addition of the above described PMS, the applicant proposed the following changes in FSAR Tier 1 and Tier 2.

<u>In FSAR Tier 1</u>

1. Add Item 4.1, under 4.0, "Electrical Power Design Features," to FSAR Tier 1, Section 2.5.5, "Preferred (Offsite) Power Supply System," to describe that each of the two required GDC 17 independent offsite power sources are monitored by a PMS that detects:

    a. An open phase with no EAT high-side ground

    b. An open phase with an EAT high-side ground between the open phase and the EAT

c. Two EAT high-side open phases (simultaneously)

In the event Condition a, b, or c is detected, the PMS provides a control room alarm and automatically separates the EAT from the affected offsite power source and transfers EAT loads to the unaffected EAT or starts emergency diesel generators.

2. Provide an ITAAC (Item 4.1) under Table 2.5.5-1, “Preferred (Offsite) Power Supply System,” that includes (1) analysis to determine the setpoints and (2) a test to verify that the as-built PMS provides an alarm and initiates transfer to the unaffected offsite power source on detecting an open-phase circuit condition. The setpoints are evaluated under the approved setpoint calculation methodology, set forth in Chapters 7 and 16 of this report. The staff will track closure of this issue as **Confirmatory Item 8.2-1** during the reviews of Chapters 7 and 16.

<u>In FSAR Tier 2</u>

1. Revise FSAR Tier 2, Section 8.1.4.1 (Offsite Power System) and Section 8.2.2.4 “Compliance with GDC 17,” to elaborate on the addition of the PMS design and how it complies with GDC 17 in regard to the design vulnerability identified in NRC Bulletin 2012-01.

2. Identify the PMS as COL Information Item 8.2-9 for all COL applicants in FSAR Tier 2, Table 1.8-2, “U.S. EPR Combined License Information Items.” This COL information item describes essential elements of a program for the operation, setpoint determination, and surveillance testing of the PMS to ensure it performs its safety function in regard to an open-phase condition as required by GDC 17. The staff will track the closure of this issue as **Confirmatory Item 8.2-2** during the reviews of Chapters 7 and 16.

In connection with open-phase conditions identified in NRC Bulletin 2012-01, the staff has reviewed the applicant’s incorporation of the proposed PMS. The staff determined that the PMS uses state-of-the-art digital relaying, and uses voltage and current inputs for monitoring the offsite power supplies. Further, the staff determined that the PMS relay scheme incorporates design features that filter out potential spurious operation, and provides a phase-monitoring capability and a reliable loss of phase alarm system for operations personnel in the control room. Accordingly, the staff finds that: (1) the PMS would detect and respond to an open phase circuit for the credited offsite power circuit; (2) if the tests and analyses in the ITAAC in Section 2.5.5 are performed, and the acceptance criteria met, there is reasonable assurance the PMS has been constructed and installed as designed, and will function as described in the FSAR; and (3) COL Information Item 8.2-9 identifies a COL information item for all COL applicants to ensure that operating procedures, setpoint determination, and surveillance testing of the PMS will be developed.

Based on the above information, the staff concludes that the proposed PMS design will ensure detection of a loss of a single (or two) phase open circuit condition, with or without a ground, for the credited offsite power circuits and initiation of an adequate response to such a condition. Therefore, the staff finds the PMS adequate to address the design vulnerability identified in NRC Bulletin 2012-01. Accordingly, the staff concludes that an open phase condition will not prevent the electric power system from supplying ac power to U.S. EPR equipment that is important to safety and, therefore, the U.S. EPR electric power system satisfies GDC 17 requirements with respect to open circuit conditions. The staff confirmed that the revised FSAR Tier 2 contains the changes as committed to in the RAI responses and, therefore, the staff considers this issue resolved.

The utility transmission system, location of rights-of-way, transmission lines and towers, and switchyard design and interconnections are site-specific, and therefore, the following information will be provided by a COL applicant referencing the U.S. EPR design:

- Site-specific information describing the interface between the offsite transmission system and the nuclear unit, including switchyard arrangement such that each offsite circuit can be isolated from other circuits to permit re-establishment of offsite power to the onsite distribution system.
- Description of essential elements of a program for the operation and surveillance testing of the PMS for the GDC 17 offsite power circuits addressed in NRC Bulletin 2012-01.
- Information regarding power system analytical studies to verify the capability of the offsite power systems and their interfaces with the onsite power system.
- Site-specific grid stability analysis according to BTP 8-3. The COL applicant's grid stability analysis must demonstrate that a loss of: (1) The largest generating capacity being supplied to the grid; (2) the largest load from the grid; (3) the most critical transmission line; or 4) the unit itself will not cause grid instability. In addition, the grid stability analysis must demonstrate that the transmission system will not subject the reactor coolant pumps to a sustained frequency decay of greater than 3.5 Hz/sec, as bounded by the decrease in reactor coolant system flow rate transient and accident analysis described in FSAR Tier 2, Chapter 15.
- Programs to periodically monitor and test to detect possible cable degradation if cables are routed through underground cable ducts where water intrusion is suspected.
- Adequate procedures, administrative controls, and protocols to ensure that no modifications to the offsite power system circuits credited for satisfying GDC 17 are implemented by all offsite transmission system operating authorities responsible for maintenance, modification, and operation of the offsite transmission grid, without the performance of a proper technical evaluation by the regional reliability council.

In RAI 9, Question 08.02-6 and RAI 77, Question 14.02-34, the staff requested that the applicant clarify whether the U.S. EPR is designed to accept a 100 percent load rejection from full power without a turbine trip and continue to supply plant loads without interruption. In addition, the staff requested that the applicant clarify whether the transient voltage spike during the above load rejection test could trip the onsite safety-related equipment (e.g., battery chargers and UPS system). In an October 1, 2008, response, the applicant revised FSAR Tier 2, Section 14.2.12.21.4 (Test No. 221), to include a loss of offsite load by initiating the turbine-generator removal from the grid by opening the main generator output breakers in the switchyard. In this test condition, the plant auxiliary loads are supplied by offsite power through the switchyard. In addition, the applicant added FSAR Tier 2, Section 14.2.12.21.7 (Test No. 227), to test an island mode operation (i.e., a 100 percent load rejection). To ensure electrical transients from the test do not challenge safety-related equipment, a transient load-flow analysis was included as a test prerequisite. The transient analysis will determine anticipated system transient voltage and frequency response and verify that the expected transient will not exceed electrical system component capabilities. Including the analysis as a test prerequisite will assure satisfactory results prior to test implementation. The staff determined that this response was not adequate because the objective of the loss of offsite load test was not properly documented.

As a follow up to the above RAI 9, Question 08.02-6, in RAI 216, Question 08-02-7, the staff requested that the applicant review the objective (Item 1.1) of loss of offsite load test (Test No. 221), and whether it can correctly reflect the test purpose. In an April 16, 2009, response to RAI 216, Question 08-02-7, the applicant revised FSAR Tier 2, Section 14.2.12.21.4 and FSAR Tier 2, Table 14.2-1, and added Section 14.2.12.21.7, to be consistent with the test objectives. Because the initial test program clearly includes a 100 percent load rejection test, the staff finds that the applicant has adequately addressed the issue. The staff confirmed that the revised FSAR Tier 2 contains the changes as committed to in the RAI responses. Therefore, the staff considers this issue resolved.

The applicant has performed the failure mode and effects analysis (FMEA) for the U.S. EPR offsite electrical power system functional capability (assuming a single failure) prescribed in RG 1.206, Section C.1.8.2.1, to ensure the circuit design for the Class 1E distribution system from the transmission network indicated in IEEE Std 308-2001, "Criteria for Class 1E Power Systems for Nuclear Power Plants," and endorsed by RG 1.32, "Criteria for Power Systems for Nuclear Power Plants." The FMEA is provided in FSAR Tier 2, Table 8.2-1, "Offsite Power Failure Modes and Effects Analysis," and Table 8.2-2, "Switchyard 125 Vdc Battery System Failure Modes and Effects Analysis." The staff has reviewed FSAR Tier 2, Table 8.2-1, in which the applicant has assessed the possibility of simultaneous failure of both circuits as a result of single events, and Table 8.2-2, in which the applicant demonstrates reliability of the switchyard dc control power to the switchyard for the availability of the offsite power following each of the identified failure modes.

The staff finds that the applicant's FMEA examined an appropriate range of postulated failures to determine the consequences that switchyard equipment failure would have on the overall availability of offsite power. Accordingly, the staff's evaluation of FMEA concludes that no single failure event would simultaneously fail both offsite power circuits, thus verifying the requirements of GDC 17.

In addition, GDC 17 specifies the safety function of the electric power systems as providing sufficient capacity and capability to assure that: (1) specified acceptable fuel design limits and design conditions of the reactor coolant system pressure boundary are not exceeded as a result of anticipated operational occurrences; and (2) the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents. The systems to which the offsite power system supplies power that accomplishes these functions are governed by GDC 33, "Reactor coolant makeup," GDC 34, "Residual heat removal," GDC 35, "Emergency core cooling," GDC 38, "Containment heat removal," GDC 41, "Containment atmosphere cleanup," and GDC 44 "Cooling water," for SSCs important to safety during normal and accident conditions, as necessary for the specific system condition.

Since the switchyard is connected to a minimum of two independent and redundant transmission lines, and the switchyard design includes circuit breakers to isolate a faulted offsite transmission line upon a loss of one circuit (assuming the onsite power is not available), a loss of one circuit does not affect the availability of the other offsite circuit. Therefore, power supply to the offsite power to Class 1E buses will remain available to accomplish the safety functions identified in the above criteria. The staff finds that the applicant's design satisfies the requirements of GDC 17 with respect to the offsite power system on: (1) capacity and capability to permit functioning of SSCs important to safety; (2) provisions to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit or loss of power from the onsite electric power supplies; (3) physical independence of circuits; and (4) availability of circuits to ensure that fuel design limits and design conditions of the reactor pressure boundary are not exceeded. Based on the above discussion, the staff considers that the applicant's design complies with the requirements of GDC 17 with respect to the offsite power system.

8.2.4.3 *Compliance with GDC 18*

GDC 18 requires that the offsite electric power system equipment important to safety be designed to permit appropriate periodic inspection and testing of important areas and features to assess the continuity of the system and the condition of the components. The staff has reviewed the offsite power circuits plan that has been described in FSAR Tier 1, Section 2.5.5, and evaluated whether the equipment is designed to be tested and inspected periodically. The testing includes verifying: (1) Correct breaker alignment; (2) indication of offsite power availability; and (3) the transfer of power among the nuclear unit, offsite power system, and onsite power system. The plan also includes surge arresters and the lightning protection system that are capable of periodic inspection and testing, and includes maintaining records described in RG 1.204, "Guidelines for Lightning Protection of Nuclear Power Plants," Section C.2.

The staff has determined that the testing described above includes testing of all significant aspects of the continuity of the offsite power systems and the condition of its components. Accordingly, the staff finds that the applicant's design has met the requirements of GDC 18 with respect to the capability of inspection and testing of the offsite power systems and equipment.

8.2.4.4 *Compliance with 10 CFR 50.63*

The purpose of 10 CFR 50.63 is to withstand and recover from a loss of all ac power (station blackout). The applicant has provided SBODGs as an AAC source for safe shutdown in the event of an SBO event. The PPS protection and control schemes are designed such that a loss of offsite power will not prevent the use of the SBODGs. Additionally, PPS cables are routed independently from that of the AAC power source such that a failure of the PPS source does not prevent the use of the AAC source. FSAR Tier 2, Section 8.4, "Station Blackout," provides a detailed description of the SBODG capacity, capability, and reliability to achieve and maintain a safe shutdown, including the diversity requirement between SBODGs and EDGs. Specific compliance with 10 CFR 50.63 and conformance to RG 1.155 are evaluated in Section 8.4 of this report.

Site-specific information that identifies actions necessary to restore offsite power and use available AAC power sources for an SBO event will be provided by an applicant for a COL that references the U.S. EPR design. In addition, all COL applicants are required to develop procedures and training to cope with an SBO event.

As described in Section 8.4 of this report, the staff finds that the applicant's design meets the requirements of 10 CFR 50.63 by providing AAC power sources needed to withstand or cope with, and recover from, SBO events, and will ensure that core cooling and appropriate containment integrity are maintained. No additional offsite power circuits (e.g., from a nearby gas turbine or hydroelectric power source) are needed to cope with an SBO.

8.2.4.5 *Compliance with 10 CFR 50.65(a)(4)*

The requirements of 10 CFR 50.65(a)(4) (the Maintenance Rule) specify that COL applicants assess and manage the increase in risk that may result from proposed maintenance activities before performing maintenance activities in general, and this includes the offsite power transmission lines. For instance, grid stability and offsite power availability are examples of emergent conditions that may result in the need for assessment or that could change the conditions of a previously performed assessment. Accordingly, COL applicants should perform grid reliability evaluations as part of the maintenance risk assessment before performing "grid-risk-sensitive" maintenance activities (such as surveillances, post-maintenance testing, and preventive and corrective maintenance).

For qualitative risk assessments, the evaluation includes how the risk assessment and management programs will preserve plant-specific key safety functions. These programs are based on Nuclear Energy Institute Guideline NUMARC 93-01, endorsed by RG 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," and RG 1.182, "Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants."

The staff has reviewed the implementation of maintenance rule program (10 CFR 50.65) described in FSAR Tier 2, Section 17.6. The section stated, "A COL applicant referencing the U.S. EPR Design Certification will describe the plan or process for implementing the maintenance rule program in the COL application, which includes establishing program elements through sequence and milestones and monitoring or tracking the performance and/or condition of SSC as they become operational. The maintenance rule program will be implemented by the time that fuel load is authorized."

The Maintenance Rule, 10 CFR 50.65(a)(4), is applicable to all electrical maintenance activities (offsite, onsite, and SBO equipment). COL applicants referencing the U.S. EPR design are required to develop programs for maintenance risk assessment and maintenance rule implementation under FSAR Tier 2, Section 17.6. In RAI 183, Question 08.03.01-20, the staff requested that the applicant clarify whether programs for maintenance risk assessment and maintenance rule implementation (FSAR Tier 2, Section 17.6) in accordance with 10 CFR 50.65(a)(4) have been identified as COL information items. In a March 27, 2009, response to RAI 183, Question 08.03.01-20, the applicant referred to FSAR Tier 2, COL Information Item 17.6-5 of Table 1.8-2, which states: "A COL applicant that references the U.S. EPR design certification will describe the program for maintenance risk assessment and management in accordance with 10 CFR 50.65(a)(4). Since the removal of multiple SSCs from service can lead to a loss of Maintenance Rule functions, the program description will address how removing SSCs from service will be evaluated. For qualitative risk assessments, the program description will explain how the risk assessment and management program will preserve plant specific key safety functions." The applicant stated that no additional information is necessary, as FSAR Tier 2, Table 1.8-2, clearly indicates it is the COL applicant's responsibility for maintenance risk assessment and maintenance rule implementation programs. Since the applicant has added a COL information item to address plant-specific provisions related to the Maintenance Rule 10 CFR 50.65, given that the description of a Maintenance Rule program is the COL applicant's responsibility, the staff finds that the applicant addressed adequately the issue and, therefore, considers this issue resolved.

8.2.4.6 *Conformance to Branch Technical Position 8-3*

A COL applicant that references the U.S. EPR design will provide a site-specific grid stability analysis to demonstrate grid availability as described in BTP 8-3, "Stability of Offsite Power Systems." The purpose of the analysis is to demonstrate that the PPS will not degrade below a level that will activate EPSS degraded grid protection actions after any of the following single contingencies: (1) U.S. EPR turbine generator trip; (2) loss of the largest unit supplying the grid;

(3) loss of the largest transmission circuit or inter-tie; and (4) loss of the largest load on the grid. The results of the analysis will also demonstrate that the transmission system will not subject the reactor coolant pumps to a sustained frequency decay of greater than 3.5 Hz/sec as bounded by the decrease in reactor coolant system flow rate transient and accident analysis described in FSAR Tier 2, Section 15.3.2.

FSAR Tier 2, Section 8.2.2.9, states conformance to BTP 8-3. The staff finds that the U.S. EPR FSAR directs a COL applicant that references the U.S. EPR design to provide a site-specific grid stability analysis to demonstrate grid availability as stated in COL Information Item 8.2-4 and, therefore, finds that it conforms to BTP 8-3.

In RAI 9, Question 08.02-2, the staff requested that the applicant provide an explanation of the significance of the reactor coolant pump (RCP) frequency decay rate (3.5 Hz/sec) protection scheme that is related to transmission system stability and how this decay rate works with the RCP operation in FSAR Tier 2, Chapter 15. In a July 14, 2008, response to RAI 9, Question 08.02-2, the applicant stated that the maximum credible frequency decay rates associated with the RCP buses are determined by grid stability studies and should be less than or equal to 3.5 Hz/s. However, the staff noticed that FSAR Tier 2, Table 1.8-2, COL Information Item 8.2-4 indicates the COL applicant is to provide a site-specific grid stability analysis but does not include the frequency decay rate (3.5 Hz/sec). Since the frequency decay rate is the bounding assumption included in the safety analysis (i.e., FSAR Tier 2, Chapter 15), the applicant explained that there was no need to include it in the above table. Since the RCP breakers are designed to actuate so fast that the frequency decay rate is immaterial to the safety analysis, the staff finds that the applicant adequately addressed the issue and, therefore, considers this issue resolved.

8.2.4.7 *Conformance to Branch Technical Position 8-6*

For the U.S. EPR, the analysis, testing and selection of the undervoltage and degraded voltage setpoints, and associated time delays, was conducted as described in BTP 8-6, "Adequacy of Station Electric Distribution System Voltages." FSAR Tier 2, Section 8.2.2.10, states conformance to BTP 8-6. The BTP 8-6 analysis calculates the voltages on the onsite distribution system based on the expected range of offsite grid voltage conditions. These setpoints derived from this analysis have been identified in FSAR Tier 2 Chapter 16, Specification 3.3.1, Table 3.3.8-1, "EDG Actuation Instrumentation." These setpoints apply to relays that are part of the onsite power system, which are evaluated in Section 8.3.1.4.15 of this report. As more fully explained in that section, a licensee referencing the U.S. EPR design will measure the actual onsite distribution system voltages to verify that they coincide with the calculated values in the U.S. EPR FSAR or calculate site-specific setpoints in accordance with the setpoint methodology in accordance with the guidance in BTP 8-6. Accordingly, the staff finds that the analysis in the U.S. EPR FSAR conforms to BTP 8-6, and that if site-specific grid conditions warrant, site-specific analysis will be conducted in accordance with BTP 8-6.

8.2.4.8 *Conformance to SECY-91-078*

FSAR Tier 2, Section 8.2.2.4 states conformance to SECY-91-078, "Chapter 11 of the Electric Power Research Institute's (EPRI's) Requirements Document and Additional Evolutionary LWR Certification Issues." This SECY discusses the inclusion of an alternate power source for non-safety-related loads, and recommends that all the offsite sources should be directly connected to the Class 1E buses with no intervening non-safety buses for evolutionary plant designs. The staff finds that the U.S. EPR offsite preferred power is supplied directly to the

EPSS; and there are no intervening non-Class 1E buses. In addition, EPSS switchgear buses do not share windings from the preferred power EATs with the non-Class 1E switchgear. Rather, the NPSS non-Class 1E buses receive offsite power from the station switchyard via the NATs. Since the U.S. EPR offsite preferred power is supplied directly to the EPSS, there are no intervening non-Class 1E buses. The staff finds that the applicant's offsite PPS design conforms to SECY-91-078.

8.2.4.9 *Failure Modes and Effects Analysis*

The staff's evaluation of FMEA is provided in Section 8.2.4.2, "Compliance with GDC 17," of this report. RG 1.206, Section C.1.8.2.1, discusses two offsite circuits. The applicant should provide a FMEA of the switchyard components to assess the possibility of simultaneous failure of both circuits as a result of single event. The staff has reviewed FSAR Tier 2, Table 8.2-1, "Offsite Power Failure Modes and Effects Analysis," in which the applicant has assessed the possibility of simultaneous failure of both circuits as a result of single events and Table 8.2-2, "Switchyard 125 Vdc Battery System Failure Modes and Effects Analysis," in which the applicant demonstrates reliability of the switchyard dc control power for the offsite power system. The staff finds these analyses consistent with the guidance of RG 1.206, Section C.I.8.2.1.

8.2.5 Combined License Information Items

Table 8.2-1, which is provided below lists all of the offsite power system COL information items and descriptions from FSAR Tier 2, Chapter 8, Section 8.1.8.2 and Chapter 1, Table 1.8-2:

Table 8.2-1 U.S. EPR Combined License Information Items for Offsite Power System

Item No.	Description	FSAR Tier 2 Section
8.1-1	A COL applicant that references the U.S. EPR design certification will provide site-specific information describing the interface between the offsite transmission system and the nuclear unit, including switchyard interconnections.	8.1.1
8.2-1	A COL applicant that references the U.S. EPR design certification will provide site-specific information regarding the offsite transmission system and its connections to the station switchyard.	8.2.1.1
8.2-2	A COL applicant that references the U.S. EPR design certification will provide site-specific information for the switchyard layout design.	8.2.1.2
8.2-3	A COL applicant that references the U.S. EPR design certification will provide site-specific information that identifies actions necessary to restore offsite power and use available nearby power sources when offsite power is unavailable.	8.2.2.7
8.2-4	A COL applicant that references the U.S. EPR design certification will provide a site-specific grid stability	8.2.2.4

Item No.	Description	FSAR Tier 2 Section
	analysis.	
8.2-5	A COL applicant that references the U.S. EPR design certification will provide site-specific information for the protective devices that control the switchyard breakers and other switchyard relay devices.	8.2.1.2
8.2-6	A COL applicant that references the U.S. EPR design certification will provide site-specific information for the station switchyard equipment inspection and testing plan.	8.2.2.5
8.2-7	A COL applicant that references the U.S. EPR design certification will provide site-specific information regarding the communication agreements and protocols between the station and the transmission system operator, independent system operator, or reliability coordinator/ authority. Additionally, the applicant will provide a description of the analysis tool used by the transmission system operator to determine, in real time, the impact that the loss or unavailability of various transmission system elements will have on the condition of the transmission system to provide post-trip voltages at the switchyard. The information provided should be consistent with information requested in NRC Generic Letter 2006-02.	8.2.1.1
8.2-8	A COL applicant that references the U.S. EPR design certification will provide site-specific information regarding indication and control of switchyard components.	8.2.1.2
8.2-9	A COL applicant that references the U.S. EPR design certification will describe essential elements of a program for the operation, setpoint determination, and surveillance testing of the Phase Monitoring System for the GDC 17 offsite power feeds to address NRC Bulletin 2012-01.	8.2.2.4

8.2.6 Conclusions

As set forth above, the staff has reviewed all of the relevant information that is applicable to the U.S. EPR offsite power system design and evaluated its compliance with 10 CFR Part 50 General Design Criteria including GDC 5, GDC 17, and GDC 18, and conformance to RGs, standards, and BTPs committed to by the applicant. The staff also reviewed the COL information items in FSAR Tier 2, Table 1.8-2. Pending the closure of Confirmatory Items 8.2-1 and 8.2-2, the staff concludes that the applicant has provided sufficient information in the FSAR and identified necessary analyses to support the bases for their conclusions of their offsite power system design for the COL applicant. The staff concludes the design of the U.S. EPR offsite power system meets the appropriate regulatory requirements listed in Section 8.2.3, and shown in the staff technical evaluations in Section 8.2.4 and COL Information Items in Section 8.2.5 of this report.

8.3 Onsite Power System

8.3.1 Alternating Current Power Systems

The U.S. EPR onsite ac power system is designed to provide reliable electric power from the EPSS to provide for the safe shutdown of the reactor.

8.3.1.1 *Introduction*

The safety function of the onsite ac power system (assuming the offsite power system is not functioning) is to provide sufficient capacity and capability to ensure that the SSCs important to safety perform as intended. The onsite power system must satisfy the requirements of 10 CFR Part 50, Appendix A, GDC 5, GDC 17, and GDC 18, and must perform its design function during all plant operating and accident conditions.

8.3.1.2 *Summary of Application*

FSAR Tier 1: In FSAR Tier 1, Section 2.5.1, the applicant states that the EPSS provides electrical power for systems that are essential to reactor shutdown, containment isolation and heat removal, reactor core cooling, and preventing a significant release of radioactive material to the environment. The EPSS distributes power to safety-related and non-safety-related plant loads during normal and abnormal operations.

EPSS divisions are independent and physically separated during normal bus alignments. An alternate feed is provided between EPSS Divisions 1 and 2, and between Divisions 3 and 4 to provide the normal and standby source of power to safety systems, safety-related support systems, or components that do not have the required redundancy when one EDG is out of service. Independence is maintained between the EPSS divisions that have an alternate feed installed and the divisions that do not have an alternate feed installed. The divisions without the alternate feed installed are independent of each other.

In FSAR Tier 1, Section 2.5.4, the applicant states that the EDGs provide a standby source of Class 1E power to safety-related and non-safety-related loads during conditions that result in a loss of preferred power to EPSS buses.

FSAR Tier 1, Section 2.5.8, provides the lightning and grounding system information while Section 2.5.9 describes the plant lighting system. The containment electrical penetrations are provided in FSAR Tier 1, Section 3.5, to protect from fault currents that are greater than their continuous current rating.

FSAR Tier 2: The applicant has provided a FSAR Tier 2 system description of the onsite ac power system in Section 8.3.1, “Alternating Current Power Systems,” summarized here, in part, as follows:

The onsite ac power supply system supplies all electrical loads of the plant and is subdivided into the Class 1E EPSS and the non-Class 1E NPSS. The EPSS supplies electrical power to safety-related loads and a limited number of non-safety-related loads. The NPSS supplies electrical power to the remaining plant non-safety-related loads.

ITAAC: The ITAAC associated with FSAR Tier 2, Section 8.3.1, are given in FSAR Tier 1, Table 2.5.1-3, "Emergency Power Supply System ITAAC" Table 2.5.4-4, "Emergency Diesel Generator ITAAC", Table 2.5.8-1 "Lightning Protection and Grounding System ITAAC," Table 2.5.9-1,"Lighting System ITAAC," Table 2.5.10-2, "Normal Power Supply System ITAAC," and Table 3.5-1, "Containment Isolation ITAAC."

Technical Specifications: Technical Specifications applicable to the onsite ac power system can be found in FSAR Tier 2, Chapter 16, Sections 3.8.1, "AC Sources – Operating;" 3.8.2, "AC Sources – Shutdown;" 3.8.3, "Diesel Fuel Oil, Lube Oil, and Starting Air;" 3.8.9, "Distribution Systems – Operating;" and 3.8.10, "Distribution Systems – Shutdown." Bases for these TSs are in B3.8.1, "AC Sources – Operating;" B3.8.2, "AC Sources – Shutdown;" B3.8.3, "Diesel Fuel Oil, Lube Oil, and Starting Air;" B3.8.9, "Distribution Systems – Operating;" and B3.8.10, "Distribution Systems – Shutdown."

Conceptual Design: FSAR Tier 2 contains conceptual design information, delineated by double brackets ([[ ]]), which is outside the scope of the U.S. EPR certification related to the following systems:

- The Switchgear Building. Conceptual design information for this structure is included in Section 1.2, Section 8.3, and Section 8.4.
- The auxiliary power and generator transformer areas. Conceptual design information for these components is included in Section 8.2.
- The lightning protection and grounding system grid. Conceptual design information for this system is included in Section 8.3.1.
- The electrical distribution system equipment to the circulating water system outside of the Turbine Building. Conceptual design information for this equipment is included in Table 8.3-3 and Figure 8.3-3.

U.S. EPR Plant Interfaces: FSAR Tier 2, Table 1.8-1, "Summary of U.S. EPR Plant Interfaces with Remainder of Plant" contains information related to the following plant interfaces that will be addressed in the COL designs:

- Onsite ac power transmission system connections to the switchyard and the connection to the plant power distribution system (Item No. 8-2)
- Lightning protection and grounding system grid (Item No. 8-4)
- Design details for electrical distribution system for circulating water system components outside the turbine building (Item No. 8-5)

8.3.1.3 *Regulatory Basis*

The relevant requirements of NRC regulations for the onsite ac power system, and the associated acceptance criteria, are given in NUREG-0800, Section 8.3.1 and are summarized below.

1. GDC 2, "Design Basis for Protection against Natural Phenomena," as it relates to SSCs of the ac power system being capable of withstanding the effects of natural phenomena without the loss of the capability to perform their safety functions

2. GDC 4, “Environmental and Dynamic Effects Design Bases,” as it relates to SSCs of the ac power system being capable of withstanding the effects of missiles and environmental conditions associated with normal operation, maintenance, testing, and postulated accidents

3. GDC 5, as it relates to sharing of SSCs of the ac power systems of different nuclear power units

4. GDC 17, as it relates to the onsite ac power system's (1) capacity and capability to permit functioning of SSCs important to safety assuming no offsite power is available; (2) independence, redundancy, and testability to perform its safety function assuming a single failure; and (3) provisions to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit or the loss of power from the transmission network

5. GDC 18, as it relates to inspection and testing of the onsite power systems

6. GDC 50, “Containment Design Basis,” as it relates to the design of containment electrical penetrations containing circuits of the ac power system and the capability of electric penetration assemblies in containment structures to withstand a loss-of-coolant accident (LOCA) without loss of mechanical integrity and the external circuit protection for such penetrations

7. 10 CFR 50.55a(h), “Codes and Standards,” as it relates to the incorporation of IEEE Std 603-1991 (including the correction sheet dated January 30, 1995)

8. 10 CFR 50.63, as it relates to the redundancy and reliability of the emergency onsite ac power sources, as a factor in limiting the potential for SBO events

9. 10 CFR 50.65(a)(4), as it relates to the assessment and management of the increase in risk that may result from proposed maintenance activities before performing the maintenance activities for the onsite ac power system. These activities include, but are not limited to, surveillances, post-maintenance testing, and corrective and preventive maintenance. Compliance with the maintenance rule, including verification that appropriate maintenance activities are covered therein, is reviewed under SRP Chapter 17. Programs for incorporation of requirements into appropriate procedures are reviewed under SRP Chapter 13.

10. 10 CFR 50.34(f)(2), as it relates to; automatic MCR annunciation for bypassed or deliberately induced inoperability of safety-related systems, establishing and maintaining natural circulation in hot standby conditions during a LOOP, and providing power for pressurizer safety and relief valves, and the pressurizer level instrumentation.

Acceptance criteria adequate to meet the above requirements include:

1. RG 1.6, “Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems,” Regulatory Positions D.1, D.3, and D.4, as they relate to the independence between redundant onsite ac power sources and their respective ac load groups.

2. RG 1.9, “Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants,” as it relates to the design and testing of the onsite power supply.

3. RG 1.32, as it relates to the design, operation, and testing of the safety-related portions of the onsite ac power system. Except for sharing of safety-related ac power systems in multi-unit nuclear power plants, RG 1.32 endorses IEEE Std 308-2001.

4. RG 1.47, “Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems,” as it relates to the bypass and inoperable status of the onsite power supply.

5. RG 1.53, “Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems,” as it relates to the application of the single-failure criterion.

6. RG 1.63, “Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants,” as it relates to the capability of electric penetration assemblies in containment structures to withstand a loss of coolant accident without loss of mechanical integrity and the external circuit protection for such penetrations.

7. RG 1.75, “Physical Independence of Electrical Systems,” as it relates to the physical independence of the circuits and electrical equipment that comprise or are associated with the onsite ac power system.

8. RG 1.81, “Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants,” as it relates to the sharing of SSCs of the ac power system. Regulatory Position C.2a states that multi-unit sites that share ac systems should be limited to two units.

9. RG 1.118, “Periodic Testing of Electric Power and Protection Systems,” as it relates to the capability to periodically test the onsite ac power system.

10. RG 1.153, “Criteria for Safety Systems,” as it relates to the design, reliability, qualification, and testability of the power, instrumentation, and control portions of safety systems of nuclear plants, including the application of the single-failure criterion in the onsite dc power system.

11. RG 1.155, as it relates to the capability and the capacity of the onsite ac power system for an SBO, including the operation of the AAC power source(s).

12. RG 1.160, as it relates to the effectiveness of maintenance activities for ac power systems.

13. RG 1.182, as it relates to conformance to the requirements of 10 CFR 50.65(a)(4) for assessing and managing risk when performing maintenance.

14. RG 1.204, as it relates to the design, installation, and performance of station grounding systems and surge and lightning protection systems.

15. RG 1.206, as it relates to power system analytical studies and stability studies to verify the capability of the offsite power systems and their interfaces with the onsite power system.

16. Interim Staff Guidance (ISG) JLD-ISG-2012-01, “Compliance with Order EA-12-049 Order Modifying Licenses with regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events.”

8.3.1.4 *Technical Evaluation*

The staff has reviewed the onsite ac power system presented in FSAR Tier 2, Section 8.3.1. This section provides descriptive information, analyses, and referenced documents, including electrical single-line diagrams, tables, and physical arrangements. The review is to evaluate whether the U.S. EPR onsite ac power system satisfies applicable regulatory requirements to ensure its intended safety functions are met during all plant operating and accident conditions. The onsite ac power system for U.S. EPR consists of standby power sources, distribution systems, and auxiliary supporting systems provided to supply power to safety-related equipment or equipment important to safety for all normal operating and accident conditions.

NUREG-0800, Table 8-1, lists GDC, RGs, standards, and BTPs that are applicable for electrical power systems. The staff has reviewed the following U.S. EPR FSAR information that relates to compliance with requirements applicable to onsite ac power system design and conformance to applicable guidance as described below:

8.3.1.4.1 Compliance with GDC 2

GDC 2 requires that SSCs important to safety, which include the onsite ac power systems, be capable of withstanding the effects of natural phenomena without the loss of the capability to perform their safety functions.

The U.S. EPR onsite ac power distribution system consists of four redundant divisions. Each division of EPSS distribution equipment is located in Seismic Category I buildings. Each EPSS division is located in separate rooms in each of these buildings, which provide physical separation among the four redundant divisions. All Class 1E components such as switchgear buses, load centers, MCCs, and distribution transformers will meet the Seismic Category I requirements. The nature and magnitude of the natural phenomena considered in the U.S. EPR design are described in FSAR Tier 2, Chapter 2, “Site Characteristics.” The U.S. EPR design criteria for wind, tornado, flood, and earthquake have been evaluated in Sections 3.3, 3.4, and 3.7, respectively, of FSAR Tier 2, Chapter 3, “Design of Structures, Components, Equipment and Systems.”

All Class 1E components of the U.S. EPR onsite ac power system are located in Seismic Category I structures that are protected from the effects of natural phenomena such as wind, hurricane, tornadoes, tornado missiles, flood, and earthquake. 10 CFR Part 50, Appendix B, (Criterion III – Design Control) requires that this equipment, as installed, is seismically qualified in accordance with the COL applicant’s quality assurance (QA) program. The staff will evaluate the adequacy of a COL applicant’s QA program in Chapter 17 of this report. The location of the onsite ac power system inside Seismic Category I structures, the design of the onsite ac power system as Class 1E, and the seismic qualification of that equipment, will provide assurance that equipment and structures will be designed to withstand the effects associated with natural phenomena without loss of capability to perform their safety functions during an accident.

Based on the above discussion, the staff finds that the U.S. EPR onsite ac power system meets the requirements of GDC 2 and the onsite ac power system design is capable of withstanding the effect of natural phenomena without the loss of the capability to perform its safety functions.

8.3.1.4.2 Compliance with GDC 4

GDC 4 requires that SSCs important to safety, which include the onsite ac power system, be capable of withstanding the effects of missiles and environmental conditions associated with normal operation, maintenance, testing, and postulated accidents. Specifically, the onsite ac power system must be designed to accommodate the effects of and to be compatible with the environmental conditions, and to be appropriately protected against dynamic effects, including the effects of missiles that may result from equipment failures.

The staff has reviewed the applicant's onsite Class 1E ac distribution system components. These are located in Seismic Category I structures, and rooms constructed in such a manner that any internal hazard only affects their respective division. There are four such functionally independent and physically separated divisions. No high energy lines are routed through the dedicated electrical rooms containing Class 1E equipment such as switchgear, load centers, MCCs, and distribution transformers. These rooms are also provided conditioned air that maintains ambient environmental conditions during normal operations and DBEs.

In addition, for that equipment located in harsh environments, the environmental qualification program for electrical equipment provides reasonable assurance that equipment remains functional during and following exposure to harsh environmental conditions as a result of a DBE. Environmental qualification of mechanical and electrical equipment described in FSAR Tier 2, Section 3.11, "Environmental Qualification of Mechanical and Electrical Equipment," lists GDC 4 as one of the acceptance criteria. FSAR Tier 2, Table 3.11-1 of Section 3.11, lists safety-related electrical and instrumentation and control (I&C) equipment located in a harsh environment that must be qualified.

Based on the above, the staff finds the onsite ac power system design for U.S. EPR can perform safety-related functions following physical effects of an internal hazard. Thus, the onsite ac power system design for U.S. EPR meets the requirements of GDC 4.

8.3.1.4.3 Compliance with GDC 5

GDC 5 requires SSCs important to safety, which includes the dc power system, not be shared among other nuclear units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions. The SSCs of the onsite ac power system for the U.S. EPR are not shared between individual nuclear power units. Therefore, GDC 5 and RG 1.81 do not apply to the onsite ac power system.

8.3.1.4.4 Compliance with GDC 17

GDC 17 addresses, in part, that an onsite ac power system be provided to permit functioning of SSCs important to safety. GDC 17 requires that this system have the safety function to provide sufficient capacity and capability to assure that acceptable fuel design limits and design conditions of the RCS are not exceeded as a result of anticipated operational occurrences (AOOs), and that the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents. The systems to which the onsite ac power system supplies power that accomplishes these functions are governed by GDC 33, "Reactor coolant makeup," GDC 34, "Residual heat removal," GDC 35, "Emergency core cooling," GDC 38, "Containment heat removal," GDC 41, "Containment atmosphere cleanup," and GDC 44 "Cooling water for SSCs important to safety," during normal and accident conditions, as necessary for the specific system condition. GDC 17 requires further that this onsite ac power system have sufficient independence, redundancy, and testability to perform its safety functions assuming a single failure, and include provisions to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit or the loss of power from the transmission network.

As set forth below, the applicant has established the onsite ac power system's compliance with GDC 17 by demonstrating conformance to the applicable guidance. The staff's evaluation of whether the U.S. EPR onsite ac system design conforms to the applicable guidance that is set forth in RG 1.6, RG 1.9, RG 1.32, RG 1.53, RG 1.75, RG 1.153, RG 1.155, RG 1.204, NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability"; and SECY-91-078, as follows.

8.3.1.4.4.1 *Conformance to RG 1.6*

FSAR Tier 2, Section 8.3.1.2.4, states conformance to RG 1.6. The staff reviewed the onsite ac EPSS design that provides independence between the redundant standby power sources that supply the safety-related loads. The U.S. EPR EPSS has four divisions (31BDA, 32BDA, 33BDA, and 34BDA), each of which is normally powered from the preferred power source (i.e., offsite power) and can be powered by an independent and redundant EDG. The four EPSS divisions can be further divided into two divisional pairs (i.e., Divisions 1 and 2 into the first divisional pair, and Divisions 3 and 4 into the second divisional pair). A divisional pair supports safety-related function completion within that division taking into consideration the single failure criteria.

The four EPSS divisions are normally functionally independent and physically separated from each other. However, alternate feeds are provided between EPSS divisions to provide normal and standby power to safety-related systems or components that are not powered by four 100 percent redundant trains. During periods when a standby power source (i.e., EDG) is out of service, or other similar maintenance activities, an alternate feed is established between Divisions 1 and 2 or between Divisions 3 and 4 as appropriate for the out of service EDG.

In RAI 11, Question 08.03.01-2, the staff requested that the applicant provide a list of all engineered safety feature (ESF) loads on emergency power supply system buses. This is to understand how all ESF loads are distributed in each division of EPSS buses and to identify ESF equipment that is not powered by 100 percent redundant EPSS divisions. In an October 15, 2008, response to RAI 11, Question 08.03.01-2, the applicant provided the list of all safety-related systems and components, and also identified systems (e.g., ventilation, filtration, borating, and cooling systems) that are not powered by 100 percent redundant EPSS divisions. These systems are powered by only two EPSS divisions. However, the alternate feed maintains redundancy if an EDG in one of the two divisions is not available. While in this configuration, an additional single failure in any other division will not result in a loss of power to any safety-related system or component. Accordingly, the staff finds that the applicant's onsite ac system can still be considered as functionally independent when a full complement of equipment is available and operable in all four divisions, provided that the alternate feed is established. The staff considers this issue resolved.

In RAI 11, Question 08.03.01-3, the staff requested that the applicant for its rationale for using the alternate feed design over four independent divisions for safety-related functions and the risk insights represented by the alternate feed connection. In a July 16, 2008, response to RAI 11, Question 08.03.01-3, the applicant stated that each EPSS division is functionally independent when a full complement of equipment is available and operable in all four divisions. As stated in the above RAI question, not all safety-related equipment (e.g., ventilation, filtrations, borating, and cooling systems) are redundant in all divisions. If one EDG is out of service or otherwise inoperable the U.S. EPR onsite ac system allows for establishment of an alternate feed that connects two divisions of a divisional pair. The applicant responded that the alternate feed configuration reduces the risk associated with a single EDG being out of service, because certain safety-related components powered by the divisional pair would still be functional during a postulated DBE with an associated LOOP. The applicant's probabilistic risk assessment (PRA) has shown a very small (negligible, less than one percent) decrease in the total risk (core damage frequency) as a result of this lineup. The alternate feed lineup does not increase EDG trip frequency, and it provides additional protection when an EDG is in maintenance. Accordingly, the alternate feed lineup configuration is acceptable. The staff considers this issue resolved.

In RAI 11, Question 08.03.01-4, the staff requested that the applicant provide details of the onsite ac power system protection scheme and demonstrate that the alternate feed configuration does not result in unacceptable influences in the division that supplies ac and dc control power. In a July 17, 2008, response to RAI 11, Question 08.03.01-4, the applicant stated that the division supplying the alternate feed is protected from a fault in an alternate feed bus by two Class 1E breakers in series, while the alternate feed is in service. RG 1.6, Regulatory Position 3.b provides that two breakers in series and properly coordinated with each other will prevent an unacceptable influence from an alternate feed bus fault to the supply bus. Accordingly, the manual connection satisfies RG 1.6, Regulatory Position 3.b for connecting one load group to another group. In addition, the procedures for establishing such an alternate feed are the responsibility of the COL applicant. Developing the procedure will be addressed by FSAR Tier 2, Table 1.8-2, COL Information Item 13.5-1. Since an alternate feed bus fault will not have an unacceptable influence on a supply bus, the staff finds that the applicant adequately addressed the issue. The staff considers this issue resolved.

In RAI 9, Question 08.02-5, the staff requested that the applicant describe how the EDG output breaker lockout scheme will prevent energizing a faulted bus. In a July 11, 2008, response to RAI 9, Question 08.02-5, the applicant stated that contacts from the medium voltage bus lockout relay (86 device) are placed in the trip and close circuits of each associated EDG output source breaker as well as the other source breakers associated with the medium voltage bus. These contacts will trip open a closed EDG output breaker and prevent an EDG output breaker from closing until the lockout signal is manually reset. Accordingly, the staff finds that the applicant adequately addressed the issue. The staff considers this issue resolved.

Based on the above responses to RAI questions, the alternate feed that connects between two safety divisions maintains the plant capability to complete safety-related functions coincident with a single failure. The alternate feed design includes features that maintain independence between divisions by preventing automatic connections, two EDGs from operating in parallel, and a fault on one division from degrading the other division. The staff finds that these design features conform to RG 1.6, and that the U.S. EPR onsite power systems have sufficient independence in this respect to perform their safety functions assuming a single failure.

8.3.1.4.4.2 *Conformance to RG 1.9*

In FSAR Tier 2, Section 8.3.1.2.4, the applicant stated that EDGs for the onsite ac power system conform to the guidance of RG 1.9, "Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants," that endorses IEEE Std 387-1995, "Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations." The staff has reviewed the four safety-related EDGs that are provided as the standby onsite ac power source for the U.S. EPR plant and supply power to the station safety-related and selected non-safety-related loads in the event of a loss of offsite power or voltage degradation. Each EDG is assigned to its respective EPSS division. The four EDGs are located in two Diesel

Buildings. Each Diesel Building is separated into two sections, one for each EDG. Each building is a Seismic Category I structure, and is built to provide physical protection for the EDGs. Within each structure, the two EDGs and their support systems are physically separated by a reinforced concrete wall to protect against internal hazards. U.S. EPR EDGs include the following design features:

- Design properties (mechanical and electrical) for starting and loading while maintaining nominal frequency and voltage within limits specified
- Developing EDG load rating of 9,500 kW or greater. This represents: (1) Greater than the sum of the conservatively estimated connected loads that any EDG will power at any one time; (2) performance characteristics for motors calculated based on 90 percent efficiency and power factor of 85 percent or less, and (3) at least ten percent margin to account for future load growth
- Emergency start signal overrides the engine and generator protection trips
- When operating in emergency mode, bypassed conditions are annunciated in the main control room (MCR) and locally to alert the operators of the abnormal condition
- Controls and indications to start up, shut down, and parallel the generator with the preferred power source from the MCR and remote shutdown station (RSS)
- Motive and control power supplies to EDG auxiliary support components are from the EUPS system of the same division

In RAI 11, Question 08.03.01-5, the staff requested that the applicant provide a summary of the results of calculations and assumptions that support EDG sizing and voltage profiles for each load step change. The staff also requested that the applicant clarify why values for the above EDG output, voltage, and frequency are different from tested values in the proposed TS surveillance requirements (SRs). In a September 25, 2008, response to RAI 11, Question 08.03.01-5, the applicant stated that equipment has not been procured. Thus, the results of the calculations are unavailable for review at present. FSAR Tier 1, Section 2.5.4.5.3, will verify the EDG size to power the assigned loads. EDG dynamic load tests were included in FSAR Tier 2, Section 14.2.12.9.15, Test No. 105, "Emergency Diesel Generator Electrical." In addition, to provide consistency between the TS values and the values described in FSAR Tier 2, Section 8.3.1.1.5, the FSAR was revised to state "Load tests are performed to verify an EDG output of 9,500 kW or greater while maintaining steady-state frequency at 60 Hz ± 2 percent and steady-state output voltage between 6.555 kV and 7.260 kV." The proposed EDG design is capable of generating a minimum power within an acceptable range of voltages and frequencies as specified in RG 1.9. This capability will be verified by ITAAC (FSAR Tier 1, Table 2.5.4-4, Item 5.3), and is therefore acceptable to the staff. The staff confirmed that the revised FSAR contains the change as committed to in the RAI response. The staff considers this issue resolved.

In RAI 11, Question 08.03.01-16, the staff requested that the applicant provide an explanation of the difference between the power factor of 90 percent specified in the TS as opposed to the power factor of 85 percent or less described for developing the EDG load rating in the FSAR. In a July 16, 2008, response to RAI 11, Question 08.03.01-16, the applicant indicated that the TS power factor of 90 percent is a system design power factor that represents the total system inductive load, while the 85 percent power factor in the FSAR is used as a power factor for motors during the early phase of the design. The motor power factor is used during the initial sizing of the EDG as a conservative value in accordance with RG 1.9, Section C.1.2. The applicant revised FSAR Tier 2, Section 8.3.1.2.4 for clarification, as follows: "…in developing EDG load rating, performance characteristics for motors were calculated based on 90 percent efficiency and power factors of 85 percent or less." Since the assumption of lower motor power factor results in more conservative EDG sizing, the staff concludes that the applicant adequately addressed the issue and it is resolved. The staff confirmed that the revised FSAR contains the change as committed to in the RAI response.

In RAI 11, Question 08.03.01-14, the staff requested that the applicant clarify why the load sequencer is not required for the U.S. EPR TS in Limiting Condition for Operation (LCO) 3.8.1. In a July 16, 2008, response to RAI 11, Question 08.03.01-14, the applicant stated that a typical existing operating plant has a specific component called a load sequencer, which includes relays and time delay circuits. The U.S. EPR design does not contain such a component. The load sequencing function is performed by the I&C protection system (PS). Specifically, the software within the actuator logic units (ALU) will control the timing of electrical loads being sequenced on the EDGs after a LOOP. For satisfying LCO 3.8.1, SR 3.8.1.11 tests the as-designed operation of the standby power sources during the loss of the offsite power source. This test verifies actions associated with the LOOP, including shedding of the non-essential loads and energizing of the emergency buses and respective loads from the EDG. It further demonstrates the capability of the EDG to automatically achieve the required voltage and frequency within the specified time prescribed by Revision 4 of RG 1.9, "Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants," Section 2.2.5 - LOOP Test. Since the I&C PS will sequence the loads onto each EDG, and surveillance testing demonstrates the EDGs' capability to power those loads, the operator can perform actions associated with a LOOP, including the non-essential loads and energizing the emergency buses and respective loads from the EDG. Accordingly, the staff concludes that the applicant adequately addressed the issue, and therefore considers it resolved.

8.3.1.4.4.3 *Conformance to RG 1.32*

FSAR Tier 2, Section 8.3.1.2.4, states conformance to RG 1.32. The staff has reviewed the design criteria and design features for the U.S. EPR onsite ac power system to determine whether it will perform its safety functions under the conditions produced by the postulated DBE and whether methods for tests and surveillance of the safety-related power systems are adequate to verify this capability during the operational life of the plant. The staff has also reviewed electrical and physical separation of redundant power sources and distribution systems, initial plant startup test programs, electrical independence, and analyses described in the FSAR. The onsite EPSS ac power system is divided into four divisions. Each division is located in its respective separate location within a Seismic Category I building, which provides a physical separation from its redundant division. The staff determined that the onsite ac power system has been designed in accordance with IEEE Std 308-2001, "IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations," as endorsed by RG 1.32, "Criteria for Power Systems for Nuclear Power Plants." The boundary of Class 1E emergency power supply system for U.S. EPR is also consistent with IEEE Std 308 to perform its required safety function. As an example, the isolation and separation of the non-Class 1E components from the Class 1E system prevent degradation of the Class 1E system to an unacceptable level. The staff finds that this design feature ensures that the Class 1E power for the safety-related systems conform to their functional requirements, as the onsite ac power system has been designed in accordance with IEEE Std 308, as endorsed by RG 1.32 to provide Class 1E power of adequate quality, which enables the safety-related systems to perform their credited functions, and which the staff therefore finds acceptable.

8.3.1.4.4.4 *Conformance to RG 1.53*

FSAR Tier 2, Section 8.3.1.2.4, states that the EPSS onsite ac power systems have been designed to conform with RG 1.53, "Application of the Single-Failure Criterion to Safety Systems," which endorses IEEE Std 379-2000, "Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems." For the demonstration of the onsite ac distribution system capability in the presence of a single failure, the applicant has performed an analysis in FSAR Tier 2, Table 8.3-9, "Onsite ac Power System Failure Modes and Effects Analysis." The staff has reviewed the table and finds that independence and redundancy are maintained in these systems by using these features:

- Alternate feeds are limited to the redundant electrical divisional pairs of 1 and 2, or 3 and 4 which keep the safety load groups of Division 1 and 2 physically separate and electrically independent from the load groups of Division 3 and 4.

- At least one redundant train is supplied from Division 1 or 2 and the other is supplied from Division 3 or 4.

- Each divisional pair can power the full complement of safety-related systems and components. Thus, the applicant's safety-related systems have the necessary electrical normal and standby power sources to perform their safety-related function in the presence of a single failure.

The onsite ac distribution system capability to maintain its safety-related function in the presence of a single failure in conformance to RG 1.53 is demonstrated by onsite ac Power System Failure Modes and Effects Analysis, and the staff finds it acceptable.

8.3.1.4.4.5 *Conformance to RG 1.75*

FSAR Tier 2, Section 8.3.1.2.4, states conformance to RG 1.75. The staff has reviewed the isolation and separation of the non-Class 1E components from the Class 1E system that prevents degradation of the Class 1E system to an unacceptable level in accordance with RG 1.75, which endorses IEEE Std 384-1992, "Criteria for Independence of Class 1E Equipment and Circuits," and RG 1.32 which endorses IEEE Std 308-2001, for circuit breakers or fuses that are automatically opened by fault current. The FSAR describes criteria for cable routing for the U.S. EPR onsite ac power systems. These criteria include criteria for cable derating and cable tray fill, as well as cable independence and separation. The U.S. EPR onsite ac power distribution system consists of four redundant divisions. Each division of EPSS distribution equipment is located in Seismic Category I buildings. Each EPSS division is located in separate rooms in each of these buildings, which provide physical separation among the four redundant divisions. All Class 1E components such as switchgear buses, load centers, MCCs, and distribution transformers will meet the Seismic Category I requirements. Non-Class 1E circuits are electrically isolated from Class 1E circuits and associated circuits by the use of isolation devices, shielding, and wiring techniques, or separation distance. Thus, cable routing, derating, raceway fill, separation, identification of redundant Class 1E circuits, and isolation of non-Class 1E circuits from Class 1E circuits are in accordance with RG 1.75.

In RAI 9, Question 08.01-4, the staff requested that the applicant confirm whether periodic testing of circuit breakers in accordance with RG 1.75 is performed for isolation devices for the applicant's design. In a July 11, 2008, response to RAI 9, Question 08.01-4, the applicant confirmed that the recommendations in RG 1.75 were applicable and were considered in the design. However, it was not clearly stated whether the COL applicant would perform the periodic test or whether testing frequencies for isolation devices would be in accordance with RG 1.75. Since the staff needed clarification on the periodic testing of breakers, the staff issued a follow-up RAI. In RAI 183, Question 08.03.01-20, the staff requested that the applicant clarify periodic testing of circuit breakers under RG 1.75. In a March 27, 2009, response to RAI 183, Question 08.03.01-20, the applicant stated that FSAR Tier 2, Section 8.3.1.1.10, was revised as follows: "Periodic testing of circuit breakers (visual inspection of fuses and fuse holders) used as isolation devices are performed during every refueling to demonstrate that the overall coordination scheme under multiple faults of non-safety-related loads remains within the limits specified in the design criteria." Thus, periodic testing of circuit breakers used as isolation devices is verified and will conform to RG 1.75.

On the same subject, in RAI 183, Question 08.03.01-22, the staff requested that the applicant clarify how the overcurrent protection systems for safety-related and selected non-safety-related loads are designed for the 120 Vac panel board. In a March 27, 2009, response to RAI 183, Question 08.03.01-22, the applicant stated that the FSAR was revised to add separate panel boards for non-safety-related loads. This separation will prevent faults in non-safety-related circuits from affecting safety-related equipment through the panel board. Accordingly, the staff finds that the applicant has adequately addressed the issue. The staff considers this issue resolved. The above RAI questions resulted in revisions to FSAR Tier 2, Section 8.3.1.1.10, Section 8.3.1.3.5, and Section 8.3.2.1.1.7. The staff confirmed that the revised FSAR contains the changes as committed to in the RAI response. On the basis of its review, the staff concludes that the applicant adequately addressed these issues and they are resolved.

In RAI 11, Question 08.03.01-6, the staff requested that the applicant clarify whether the COL applicant should develop a testing program for those inaccessible power cables installed in duct banks, or underground (e.g., manholes located below ground water level), if degradation is detected or suspected, as described in NRC Generic Letter (GL) 2007-01, "Inaccessible or Underground Power Cable Failures that Disable Accident Mitigation Systems or Cause Plant Transients". In a September 26, 2008, response to RAI 11, Question 08.03.01-6, the applicant revised FSAR Tier 2, Section 8.3.1.1.9 and Table 1.8-2, Item 8.3-2, by adding, "A COL applicant that references the U.S. EPR design certification will describe inspection, testing and monitoring programs to detect the degradation of inaccessible or underground power cables that support EDGs, offsite power, emergency service water (ESW) and other systems that are within the scope of 10 CFR 50.65." Since a COL applicant will address this issue as specified in FSAR Tier 2, Table 1.8-2, COL Information Item 8.3-2, the staff finds that the applicant adequately addressed the issue. The staff confirmed that the revised FSAR contains the changes as committed to in the RAI response. The staff considers this issue closed.

Based on the above discussion, the staff finds that the applicant satisfies the criteria or establishing and maintaining the independence of safety-related equipment and circuits, and auxiliary supporting features by physical separation and electrical isolation in conformance to RG 1.75, and the proposed design is acceptable in regard to independence.

8.3.1.4.4.6 *Conformance to RG 1.153*

RG 1.153, "Criteria for Safety Systems," addresses the need for functional and design independence and separation requirements for onsite ac power system distribution for nuclear power plants. FSAR Tier 2, Section 8.3.1.2.4, states conformance to RG 1.153. Meeting the detailed requirements of IEEE Std 603-1991 "Criteria for Safety Systems for Nuclear Power Generating Stations," with respect to independence and separation of the ac power distribution system divisions, will achieve the goals stated in RG 1.153. FSAR Tier 2, Section 7.1.3 discusses the compliance of the U.S. EPR design to IEEE Std 603-1998. FSAR Tier 2, Revision 5, Section 7.1.3.6, cites this reference as IEEE Std 603-1998 in lieu of IEEE Std 603-1991. FSAR Tier 2, Section 7.1 Reference 45 (a May 24, 2011, letter from AREVA), states a Request for Alternatives to IEEE Std 603-1991. A technical comparison of IEEE Std 603-1991 to IEEE Std 603-1998 shows that the requirements of IEEE Std 603-1998 meet or exceed those of the 1991 version. More information on the staff's review of this technical comparison is set forth in Section 7.1.4.1 of this report.

The staff has reviewed the applicant's onsite ac electrical distribution safety-related configuration and its functions to determine whether divisional pair functional independence and physical separation are in accordance with IEEE Std 603-1991 and IEEE Std 603-1998 for safety-related system independence. The IEEE standard addresses independence between redundant portions of a safety system and effects of a design basis event. In the U.S. EPR design, this is accomplished by the separation of safety-related components between divisional pairs. The physical separation assures that a single failure or internal hazard, or both, in one divisional pair can only affect that one divisional pair. Therefore, during design-basis accidents coincident with a single failure to any electrical component in a divisional pair, the second divisional pair will support safety-related function completion. The onsite ac power electrical distribution equipment (switchgear, load centers, MCCs, transformers, feeder breakers, load breakers) is sized to provide sufficient power to start and operate the connected loads.

The staff finds that the U.S. EPR onsite ac electrical distribution system is designed in accordance with the independence and separation requirements of RG 1.153.

8.3.1.4.4.7 *Conformance to RG 1.155*

FSAR Tier 2, Section 8.3.1.2.4, states conformance to RG 1.155 "Station Blackout." The SBO for the applicant's onsite ac power system conformance to RG 1.155 and its conformance to SECY 90-016, "Evolutionary Light Water Reactor Certification Issues and Their Relationship to Current Regulatory Requirements", January 1990, are addressed in Section 8.4 of this report.

8.3.1.4.4.8 *Conformance to RG 1.204*

In FSAR Tier 2, Section 8.3.1.2.4, the applicant has stated that its onsite ac grounding and lightning protection system conforms to RG 1.204, "Guidelines for Lightning Protection of Nuclear Power Plants," which endorses IEEE Std 665-1995, (Reaffirmed 2001), "Guide for Generating Station Grounding;" IEEE Std 666-1991 (Reaffirmed 1996), "Design Guide for Electric Power Service Systems for Generating Stations;" IEEE Std 1050-1996, "Guide for Instrumentation and Control Equipment Grounding in Generating Stations;" and IEEE Std C62.23-1995 (Reaffirmed 2001), "Application Guide for Surge Protection of Electric Generating Plants." Also, the applicant stated that insulation coordination studies will be performed to provide for proper insulation levels of electrical equipment with overvoltage protective devices such as surge arresters and transient voltage surge suppressors. Achieving insulation coordination depends on site-specific parameters such as voltage transients, characteristics of equipment such as transformers, and the operating characteristics of surge arresters. These studies will ensure maximum protection to the insulation of equipment.

The staff reviewed the lightning protection provided for the MSU transformers, EATs, NATs, and structures containing safety-related equipment. The applicant stated that: (1) Surge arresters are installed on each phase of the primary and secondary windings of the transformers, are connected as close as possible to the terminals of the equipment to be protected, and have a path to the ground grid as short and direct as practicable; (2) the path from the surge arrester to the ground grid is one continuous run without splices; and (3) each surge arrester has its own ground conductor for bonding to the ground grid. The surge arresters for lightning and surge protection are shown on FSAR Tier 2, Figures 8.3–2 and 8.3–3. Since these design features protect the transformers against the effects of lightning, and the COL applicant will perform the insulation coordination analyses under Item 2.6 in FSAR Tier 1 Table, 2.5.8-1, "Lightning Protection and Grounding System Inspections, Tests, Analyses, and Acceptance Criteria," the staff finds that the onsite ac grounding and lightning protection system for the U.S. EPR conforms to RG 1.204.

In RAI 70, Question 08.03.01-17, the staff requested that the applicant provide the calculations for surge and lightning protection on insulation coordination and power quality limits (harmonic distortion) as cited in the RG 1.204 and also asked whether such calculations should be performed and provided by the COL applicant, as the calculations may depend on site-specific grid (interface) information. In an October 3, 2008, response to RAI 70, Question 08.03.01-17, the applicant stated that surge and lightning protection aim to minimize insulation failures (to reduce the frequency of interruptions to service and expensive repairs) by achieving insulation coordination, depending on site-specific parameters such as the size of voltage transients, characteristics of equipment such as transformers, and the operating characteristics of surge arresters. The applicant's initial evaluation determined there is no need to install surge arresters in both the primary and secondary windings. As a result, FSAR Tier 2, Section 8.3.1.3.5, was revised and Figures 8.3-2 and 8.3-3 were revised to remove the surge arresters from the secondary windings of the above transformers, as the secondary connections will not be overhead. Also, FSAR Tier 1, Section 2.5.8.2.6, was revised to indicate that "Insulation coordination is achieved on surge arresters on MSU transformers, NATs, and EATs." In addition, the staff concurs with these changes because the COL applicant will need to verify the adequacy of the surge and lightning protection devices through the insulation coordination studies described above. The staff confirmed that the revised FSAR contains the change as committed to in the RAI response, and therefore considers this issue resolved.

As for the total harmonic distortion (THD), the COL applicant will analyze all procured equipment to verify the system THD is within the guidelines of IEEE Std 519-1992, "IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems." To verify that the as-built distribution system THD is within acceptable limits, FSAR Tier 1, Section 2.5.2, ITAAC Item 5.19 has been added to indicate that analysis will be performed to show that THD does not exceed five percent on the Class 1E buses. FSAR Tier 2, Section 8.3.1.3.6, was also revised to state, "An analysis will be performed to verify the THD present on the Class 1E buses is less than or equal to five percent." Since this ITAAC verifies that the THD is within acceptable limits, the staff finds that the applicant has adequately addressed the issue. The staff considers this issue resolved.

8.3.1.4.4.9 *Conformance to NUREG/CR-0660*

FSAR Tier 2, Section 8.3.1.2.4, states conformance to NUREG/CR-0660. The staff has reviewed whether the EDG that will be procured meets the recommendations of RG 1.9 and of NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability," February 1979. NUREG/CR 0660 recommends that EDG systems include the following design features: (1) Starting system air dryer; (2) continuous lube oil pre-heat system with a set temperature when the diesel generator is in standby; and (3) local instrument panels in the diesel rooms at the engine are isolated from engine vibration. Since the EPR design includes all the above features, the staff finds that the EDG to be procured for the U.S. EPR design will incorporate the recommendations of NUREG/CR-0660 accordingly.

8.3.1.4.4.10 *Conformance to SECY-91-078*

FSAR Tier 2, Section 8.3.1.2.4, states conformance to SECY-91-078, "Chapter 11 of the Electric Power Research Institute's (EPRI's) Requirements Document and Additional Evolutionary Light Water Reactor (LWR) Certification Issues." This SECY discusses the inclusion of an alternate power source to non-safety-related loads and recommends that all the offsite sources should be directly connected to the Class 1E buses with no intervening non-safety buses for evolutionary plant designs. The U.S. EPR offsite preferred power is directly supplied to the onsite EPSS without intervening non-Class 1E buses. In addition, EPSS switchgear buses do not share windings from the preferred power EATs with the non-Class 1E switchgear. Since the normal power supply to the non-Class 1E buses receives offsite power from the station switchyard via NATs, the station remains connected to the offsite power sources without any need for transferring buses or power sources during startup, full power operation, or shutdown. Since SECY-91-078 recommends exactly these features, the staff finds that the applicant's onsite ac power supply system design conforms to SECY-91-078.

During this review, the staff noticed that the EPSS distributes power to safety-related and selected non-safety-related plant loads (i.e., severe accident heat removal pumps, emergency lighting, and emergency pressurizer heaters) during normal and abnormal operations. Electrical separation of non-safety plant loads from safety loads is discussed in Section 8.3.1.4.4.5 of this report.

To understand the interactions of the loads presented by this equipment with the safety-related loads (e.g., failure of non-safety-related electrical equipment that could directly affect safety-related equipment operation), in RAI 9, Question 08.01-2, the staff requested that the applicant provide a list of the major (13.8 kV and 6.9 kV) non-safety-related electrical equipment that will be installed on the onsite electrical distribution system and its pertinent electrical characteristics (e.g., nominal ratings of output, load factor, efficiency, power factors, etc.). In a July 11, 2008, response to RAI 9, Question 08.01-2, the applicant provided a list of the major non-safety-related electrical equipment and its pertinent electrical characteristics (U.S. EPR large non-safety-related load information). This information included sizes of non-safety-related electrical equipment that will be in the electrical transient analysis for the U.S. EPR system. The staff reviewed this information in the context of evaluating the design's conformance to BTP 8-6. (See Section 8.3.1.4.15 of this report.) The staff considers this issue resolved.

Based on the above discussion, the staff finds that the applicant's onsite ac power supply system design conforms to SECY-91-078, as offsite preferred power is directly supplied to the onsite EPSS without intervening non-Class 1E buses, and is acceptable.

8.3.1.4.5 Compliance with GDC 18

GDC 18 requires that electric power systems important to safety, which include the onsite ac power system, be designed to permit appropriate periodic inspection and testing of important areas and features to assess the continuity of the systems and the condition of their components. These systems shall be designed with a capability to test periodically: (1) The operability and functional performance of the components of the systems, such as onsite power sources, relays, switches, and buses; and (2) the operability of the systems as a whole and under conditions as close to design as practical.

The four EPSS divisions of the U.S. EPR permit the testing of one division without affecting safety-related functions because two remaining divisions will be available to provide power for Emergency Core Cooling System (ECCS) injection, assuming a single failure of the third division. Additionally, the generic Technical Specifications would require a licensee to test the EDGs periodically to verify their capability to start and accept load. The plant procedures to implement these SRs will be developed to test portions of the logic circuitry, including any parallel logic, interlocks, bypasses, and inhibit circuits as indicated in NRC GL 96-01, "Testing of Safety-Related Logic Circuits," so that safety-related functions are verified as designed when actuated. GL 96-01 addresses the need for adequate testing of safety-related actuation logic circuitry to assure the operability and functional performance of safety significant essential electric components required for automatic actuation during an event.

The staff has evaluated whether the onsite ac power system provides the capability to perform integral testing of Class 1E systems on a periodic basis. Accordingly, the following RGs applicable to testing of the U.S. EPR onsite ac power system were reviewed.

8.3.1.4.5.1 *Conformance to RG 1.47*

FSAR Tier 2, Section 8.3.1.2.5, states conformance to RG 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems." The current design of the protection systems (PS) and engineered safety feature systems are such that certain safety-related functions of a nuclear power plant may be bypassed or made inoperable during the performance of periodic tests or maintenance. RG 1.47 describes an acceptable method of complying with the requirements to indicate the inoperable or bypassed status of Class 1E systems or portions of such systems. The applicant's FSAR states that indication of a bypassed or deliberately induced inoperable component is automatically annunciated in the MCR to indicate the system or component condition. Since EPSS provides power to the PS for I&C equipment status, the plant operator can identify systems actuated or controlled by the PS in accordance with RG 1.47. FSAR Tier 2, Section 7.5.2.2.4, "Conformance to RG 1.47," provides additional information on testability of bypassed or inoperable status indicators that are displayed.

The staff's review was limited to the power supply for the PS for the U.S. EPR design. The staff reviewed the ac onsite power system and confirmed that it is available to power the PS and its auxiliary or supporting safety-related systems and, therefore, finds the application conforms to RG 1.47.

8.3.1.4.5.2 *Conformance to RG 1.118*

FSAR Tier 2, Section 8.3.1.2.5, states conformance to RG 1.118. RG 1.118 provides guidance on the capability for periodic surveillance testing and calibration of safety-related equipment to be provided while retaining the capability of the safety-related systems to accomplish their safety-related functions in accordance with IEEE Std 338-1987, "Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems." FSAR Tier 2, Chapter 16 sets forth TS that would require testing and calibration of safety-related system equipment at the U.S. EPR during power operation. This testing duplicates, as close as practical, the demonstration that safety-related equipment can perform its specified functions.

In RAI 11, Question 08.03.01-15, the staff requested that the applicant clarify whether each EDG can reach rated speed and whether the voltage/output breaker closes in 15 seconds.
In a July 16, 2008, response to RAI 11, Question 08.03.01-15, the applicant responded that the start-up time of an unloaded diesel generator, from the emergency start signal to nominal

speed, rated generator frequency and voltage, is less than or equal to 15 seconds, and the EDG output breaker nominal closing time of 15 seconds following EDG start on a LOOP signal is accurately reflected in FSAR Tier 2, Section 8.3, Tables 8.3-4 through 8.3-7, Note 13, and TS SR 3.8.1.11. This value is assumed in the applicant's transient and accident analyses as appropriate and bounds the credited safety function performance requirements. In addition, the applicant responded that the timing of EDG will be verified with FSAR Tier 1, Section 2.5.4, ITAAC Item 2.5.4.6.1. Since this performance characteristic will be verified by the above referenced TS and ITAAC, the staff concludes that the applicant adequately addressed the issue and therefore is resolved.

Based on the above, the applicant's onsite ac power system will be designed to be testable during operation of the nuclear power generating station, as well as during those intervals when the station is shut down. The staff finds this conforms to the positions of RG 1.118.

8.3.1.4.6 Compliance with GDC 50

GDC 50 requires, in part, that the design of containment penetrations, including electrical penetrations containing circuits of the ac power system in containment structures, must withstand a LOCA without loss of mechanical integrity. In order to satisfy this requirement, the penetration assemblies in containment structures must be capable to withstand all ranges of overload and short circuit currents up to the maximum fault current vs. time conditions that could occur given single random failures of circuit protective devices.

As described below, U.S. EPR containment electrical penetration assemblies are Class 1E devices and are designed, constructed, and qualified in accordance with IEEE Std 317-2003, "IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations," and penetration assembly protection from fault currents inside containment is in accordance with the guidance in IEEE Std 741-1986, "IEEE Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations," as endorsed by RG 1.63, "Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants." Containment structures are classified as Seismic Category I in accordance with RG 1.29, "Seismic Design Classification," to withstand a design basis seismic event without the loss of safety function. Additionally, the penetration assemblies are qualified for a harsh environment, as described in FSAR Tier 2, Section 8.3.1.1.11.

FSAR Tier 2, Section 8.3.1.1.11 states that the containment electrical penetration assemblies are designed as follows: (1) Redundant, series connected, overcurrent interrupting devices are provided for electrical circuits going through the containment electrical penetration assemblies where the maximum available fault current is greater than the continuous rating of the penetration assembly; (2) Class 1E protection devices are used for Class 1E circuits; (3) overcurrent protection devices are designed, selected, and coordinated (i.e., containment electrical penetration assembly fault current clearing time curves for the current interrupting device are coordinated with the thermal capability curve of the containment electrical penetration assembly); (4) protective devices located in separate panels or separated by barriers are independent so that failure of one device would not adversely affect the other; (5) penetrations would withstand the full range of fault current (minimum to maximum) available at the penetration; and (6) protection devices are capable of being tested, calibrated, and inspected.

In RAI 183, Question 08.03.01-20, the staff requested that the applicant provide the periodic inspection and testing program for containment penetration assembly protective devices. In a March 27, 2009, response to RAI 183, Question 08.03.01-20, the applicant revised FSAR

Tier 2, Section 8.3.1.1.11, to indicate that circuit breakers used as containment penetration conductor overcurrent protection devices will be periodically tested and provided with specific periodic testing requirements. Since these circuit breakers will be tested periodically, the staff finds that the applicant has adequately addressed the issue and therefore is resolved. The staff confirmed that the revised FSAR contains the change as committed to in the RAI response.

The staff finds that the design of the applicant's containment electrical penetrations will satisfy GDC 50 to withstand a LOCA without loss of mechanical integrity because the design includes appropriate external circuit protection.

8.3.1.4.7 Compliance with 10 CFR 50.55a(h)

10 CFR 50.55a(h) requires compliance with the relevant positions for plant protection and safety systems on design, reliability, qualification, and testability of the power and I&C portions of the protection and safety systems outlined in IEEE Std 603-1991.

The safety and protection systems of the applicant's onsite ac power system design are based on IEEE Std 603, which will be confirmed by the electrical distribution system protection and coordination studies, and verified via ITAAC in FSAR Tier 1, Table 2.5.1-3, "Class IE Emergency Power Supply System ITAAC," Item 5.13. Accordingly, the staff finds that the U.S. EPR onsite ac power system design will meet the requirements of 10 CFR 50.55a(h). The aspects of IEEE Std 603 that apply to the adequacy of I&C are evaluated in Chapter 7 of this report.

8.3.1.4.8 Compliance with 10 CFR 50.63

Applicant compliance with 10 CFR 50.63 relates to use of the redundancy and reliability of diesel generator units as a factor in limiting the potential for SBO events. RG 1.9, "Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants" will be used to set the target reliability levels of emergency onsite ac power sources (i.e., EDG) as a factor in determining the coping duration for SBO and establishment of a reliability program for attaining and maintaining source target reliability levels. Operating experience shows that EDGs of requisite reliability to support a specified coping duration are available. In accordance with RG 1.9, as part of the initial test program, the testing includes 25 valid start and load tests without failure on each EDG to demonstrate reliability. If the testing meets the above mentioned requirement, the EDGs will be considered sufficiently reliable to support the coping duration and will meet the requirements of 10 CFR 50.63. Further evaluation of this issue is contained in Section 8.4.4.1.1 of this report.

8.3.1.4.9 Compliance with 10 CFR 50.65(a)(4)

Under 10 CFR 50.65(a)(4), COL applicants assess and manage the increase in risk that may result from proposed maintenance activities for onsite ac power equipment before performing the maintenance activities. These activities include surveillances, post maintenance testing, and corrective and preventive maintenance. The FSAR states that compliance and acceptability with the maintenance rule according to RG 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," and RG 1.182, "Assessing and Managing Risk before Maintenance Activities at Nuclear Power Plants," is characterized under FSAR Tier 2, Chapter 17.

In RAI 183, Question 08.03.01-20, the staff requested that the applicant provide the description of the program that implements 10 CFR 50.65 in FSAR Section 17.6. In a March 27, 2009, response to RAI 183, Question 08.03.01-20, the applicant referenced FSAR Tier 2, Table 1.8-2, COL Information Item 17.6-5, which states: "A COL applicant that references the U.S. EPR design certification will describe the program for maintenance risk assessment and management in accordance with 10 CFR 50.65(a)(4). Since the removal of multiple SSCs from service can lead to a loss of Maintenance Rule functions, the program description will address how removing SSCs from service will be affected. For qualitative risk assessments, the program description will explain how the risk assessment and management program will preserve plant specific key safety functions." Since the description of a Maintenance Rule program is the COL applicant's responsibility, the staff finds that the applicant adequately addressed the issue by providing a COL Information Item that provides for a COL applicant to address the requirements of 10 CFR 50.65(a)(4). Therefore, the staff considers this issue resolved.

8.3.1.4.10 Compliance with 10 CFR 50.34(f) on Three Mile Island Action Plan Requirements

The applicant provided information on compliance with of 10 CFR 50.34(f) regarding the following three items:

- 10 CFR 50.34(f)(2)(v) [Three Mile Island (TMI) Action Item I.D.3]: Bypassed or deliberately induced inoperability of safety-related systems is automatically annunciated in the MCR per RG 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems." This satisfies the recommendation of TMI Item I.D.3 for safety-related system status monitoring.

- 10 CFR 50.34(f)(2)(xiii) [TMI Action Item II.E.3.1]: The EDG provides standby power to a number of pressurizer heaters in each EPSS division. The heaters are capable of establishing and maintaining natural circulation at hot standby conditions during a LOOP, and they are also capable of being powered from offsite power or the EDG. This satisfies the redundancy recommended by TMI Action Item II.E.3.1.

- 10 CFR 50.34(f)(2)(xx) [TMI Action Item II.G.1]: The EDG provides power for pressurizer safety and relief valves, and the pressurizer level instrumentation, as recommended by TMI Action Item II.G.1.

The staff verified that if the onsite ac power system bypassed or deliberately rendered inoperable, such a condition is automatically annunciated in the MCR, as recommended by RG 1.47. Accordingly, the staff finds that the U.S. EPR design complies with the requirements of 10 CFR 50.34(f)(2)(v) in regard to the onsite ac power system. Additionally, the staff verified that the U.S. EPR design provides EDG standby power to a number of pressurizer heaters in each EPSS division, and provides EDG power for pressurizer safety and relief valves, including the pressurizer level instrumentation and, therefore, the staff finds that the applicant complies with 10 CFR 50.34(f)(2)(xx).

8.3.1.4.11 Conformance to BTP 8-1

FSAR Tier 2, Section 8.3.1.2.11 states conformance to BTP 8-1, "Requirements on Motor-Operated Valves in the Emergency Core Cooling System (ECCS) Accumulator Lines." BTP 8-1 recommends that the motor operated isolation valves in the ECCS should be designed to facilitate automatic opening of the valve with visual indication and alarm in the control room. The staff has reviewed FSAR Tier 2, Sections 7.5.2.2.5 and 7.6.1.2.2, which describe features for safety injection (SI) system accumulator motor operated isolation valves, and verified that the power supplied by the EPSS to those valves provides for their indications, alarm features, and control features in accordance with BTP 8-1. The staff's review finds these features acceptable.

8.3.1.4.12 Conformance to BTP 8-2

BTP 8-2, "Use of Diesel Generator Sets for Peaking," recommends that emergency power DG sets should not be used for peaking service, as frequent interconnection of the preferred and standby power supplies increases the probability of their common failure. FSAR Tier 2, Section 8.3.1.2.11 states that EDGs will not be used for peaking service. The EDGs provide only standby power in the event of a loss of the offsite preferred power source(s). They are periodically connected to the offsite power source, one at a time, only for surveillance testing in accordance with station TS SRs and post maintenance testing. FSAR Tier 2, Section 8.3.1.2.11, states conformance to BTP 8-2. Accordingly, the staff finds that the U.S. EPR EDGs will not be used for peaking service, in accordance with BTP 8-2.

8.3.1.4.13 Conformance to BTP 8-4

BTP 8-4, "Application of the Single-Failure Criterion to Manually Controlled Electrically Operated Valves," establishes the acceptability of disconnecting power to electrical components of a fluid system as one means of designing against a single failure that might cause an undesirable component action. FSAR Tier 2, Section 8.3.1.2.11, states conformance to BTP 8-4, "Application of the Single-Failure Criterion to Manually Controlled Electrically Operated Valves." The FSAR explains that a systematic evaluation of the safe shutdown systems was performed for potential inadvertent movement of manually controlled electrically operated valves that could result in the loss of system safety-related functions. The evaluation included motor-operated valves, solenoid-operated valves, and those valves operated indirectly by an electrical device for failures in both the "fail to function" and "undesirable function" condition.

The U.S. EPR safe shutdown systems include system redundancy sufficient to provide 100 percent of the cooling capacity with one system train disabled as a result of a misaligned electrically operated valve, with the exception of the SI accumulator tank discharge motor operated isolation valve. To prevent inadvertent movement of this valve from isolating the SI accumulator when it is required to be operable, power is removed from the valve motor. This action will be performed under administrative controls and periodically verified in accordance with plant TS SRs as indicated in FSAR Tier 2, Chapter 16, Section 3.5.1. The applicant revised FSAR Tier 2, Section 8.3.1.2.11 to add the passive flooding line isolation valves and Steam Generator Blowdown Transfer Valves as indicated in FSAR Tier 2, Chapter 16, Sections 3.5.4 and 3.7.22, respectively.

The capability to restore power to the SI accumulator tank discharge isolation valve is in accordance with BTP 8-4, as the valve is not operated in the safety system operational sequence and does not need to be rapidly restored during plant shutdown. A redundant accumulator isolation valve position indication in the MCR is provided for verification of valve position. Accordingly, the staff finds this design conforms to BTP 8-4.

8.3.1.4.14 Conformance to BTP 8-5

In addition to conforming to RG 1.47, FSAR Tier 2, Section 8.3.1.2.11 states that additional guidance from BTP 8-5, "Supplemental Guidance for Bypass and Inoperable Status Indication for Engineered Safety Features Systems," has been incorporated into the design of the bypassed and inoperable status indicators. The purpose of this BTP is to provide supplemental guidance for implementing RG 1.47 and establish design criteria for bypass and inoperable status indication for engineered safety feature systems, thus providing accurate information for the operator and reducing the possibility for the indicating equipment to adversely affect the monitored safety systems. Since EPSS provides power to the PS for I&C equipment status, the plant operator can identify systems actuated or controlled by the PS in accordance with RG 1.47 and all bypassed or inoperable status indicators that are displayed are indicated in FSAR Tier 2, Section 7.5.2, thus satisfying BTP 8-5.

8.3.1.4.15 Conformance to BTP 8-6

FSAR Tier 2, Section 8.3.1.2.11, states conformance to BTP 8-6, "Adequacy of Station Electric Distribution System Voltages." BTP 8-6 prescribes that nuclear power plants implement a degraded voltage monitoring scheme to protect safety-related equipment on Class 1E buses from degraded voltage conditions. The applicant has performed an analysis and provided setpoints for degraded voltage and time delays in accordance with BTP 8-6, and the setpoints are in FSAR Tier 2, Chapter 16, Table 3.3.8-1 of the TS. In addition, the results of electrical analysis will be verified by bus voltage measurements taken during startup tests. Accordingly, the staff finds that the U.S. EPR design conforms to the BTP 8-6.

In RAI 9, Question 08.01-3, the staff informed the applicant that FSAR Tier 2, Table 1.8-2 should include the COL applicant's site-specific degraded grid voltage (DGV) set point values (Class 1E 6.9 kV buses), which are determined by detailed analysis based on the expected worst grid voltages (min/max). In a July 17, 2008, response to RAI 9, Question 08.01-3, the applicant stated that this could be a COL information item, but those values have been identified as TS items in FSAR Tier 2, Chapter 16 (TS). The applicant revised FSAR Tier 2, Section 8.2.2.4, to reference FSAR Tier 2, Chapter 16 Table 3.3.1-2. Since these values will be specified in the plant TS, the staff concurs with the applicant that this information is not necessary to be listed as a COL information item in FSAR Tier 2, Table 1.8-2. The staff confirmed that Revision 1 of the FSAR, dated May 29, 2009, contains the change as committed to in the RAI response. In addition, in RAI 216, Question 08.03.01-24, the staff requested that the applicant clarify whether the above trip setpoint values should be adjusted when the alternate feed is established. In an April 16, 2009, response to RAI 216, Question 08.03.01-24, the applicant stated that the upper and lower setting band limits for the DGV and loss of voltage (LOV) time and voltage set point values include consideration of the alternate feed connection, and do not require revised set point values when the alternate feed connection is implemented. Since the degraded grid voltage setpoints already reflect consideration of the alternate feed configuration, the staff considers these issues resolved. However, the staff will track this as **Confirmatory Item 8.3-1,** which will be confirmed during the review of Chapter 16.

In RAI 11, Question 08.03.01-7, the staff requested that the applicant clarify when electrical analysis results will be verified by bus voltage measurements (Position B.4) per BTP 8-6. In a September 26, 2008, response to RAI 11, Question 08.03.01-7, the applicant stated that the hot functional test was revised to include this verification test under FSAR Tier 2, Section 14.2.12.13 and the BTP 8-6 voltage measurements, and the verification test will be performed as required by ITAAC Item 2.5.1.6.3 in FSAR Tier 1, Table 2.5.1-3, Item 6.3. This test will also be included under FSAR Tier 2, Section 14.2.12.13.19, "Pre-Core Electrical Distribution System Voltage Verification Test No. 226," as part of the Initial Testing Program. In addition, the applicant revised FSAR Tier 2, Section 14.2.12.13.19, as part of the Initial Testing Program, which includes bus voltage measurements in accordance with BTP 8-6, Position B.4. The staff confirmed the revised FSAR contains the changes as committed to in the RAI responses. Since the voltage measurement per BTP 8-6 and verification will be performed during the initial testing program, and as required by the ITAAC, the staff finds that the analysis in the U.S. EPR FSAR conforms to BTP 8-6. Based on the above, the staff finds that the applicant's revisions have adequately addressed these issues and considers these issues resolved.

8.3.1.4.16 Conformance to BTP 8-7

FSAR Tier 2, Section 8.3.1.2.11, states conformance to BTP 8-7, "Criteria for Alarms and Indications Associated with Diesel Generator Unit Bypassed and Inoperable Status." BTP 8-7 recommends that the alarms should be displayed in the control room and at the diesel-generator unit for all disabling conditions, which will indicate the DG unit's capability to adequately respond to an emergency demand. To allow operators to respond to emergency demand, FSAR Tier 2, Section 8.3.1.1.5, describes how EDG bypass or inoperable conditions are automatically alarmed in the MCR and provide operators with accurate information about the status of each EDG. EDG indications and alarms are listed in FSAR Tier 2, Table 8.3-8. This listing is consistent with RG 1.9, "Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants," Regulatory Positions 1.6 through 1.9. BTP 8-7, Section B, Item 6, states, "RG 1.9, Positions C.1.6 through C.1.8, set forth further guidance to be addressed regarding status and anomalous conditions indication and alarms for diesel-generators." Therefore, the staff finds the FSAR conforms to BTP 8-7 in this regard.

8.3.1.4.17 Conformance to RG 1.206

RG 1.206, "Combined License Applications for Nuclear Power Plants," provides guidance regarding the information to be submitted in an application for a combined license for a nuclear power plant. Under RG 1.206, Section C.I.8.3.1.3, the applicant has performed the following electrical power system calculations and distribution system studies for onsite ac power systems, described in FSAR Tier 2, Section 8.3.1.3:

- Load Flow/Voltage Regulation Studies and Under/Overvoltage Protection
- Short-Circuit Studies
- Equipment Sizing Studies
- Equipment Protection and Coordination Studies
- Insulation Coordination (Surge and Lightning Protection)
- Power Quality Limits
- Grounding

The electrical power system calculations and distribution system studies utilized ETAP, Nuclear Version 5.5.6N, to analyze the ac distribution system for load flow and voltage regulation, short-circuit studies, and motor starting studies. The applicant stated that ETAP is qualified to 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," American Society of Mechanical Engineers (ASME) NQA-1, "Quality Assurance Requirements for Nuclear Facility Applications," and International Organization for Standardization (ISO)-9001, "Quality Management Systems – Requirements." It is also subject to 10 CFR Part 21, "Reporting of Defects and Noncompliance."

In RAI 11, Questions 08.03.01-8, 9 and 08.03.01-10, the staff requested that the applicant provide summaries and assumptions for the above studies. In a November 11, 2008, response to Questions 08.03.01-8, 9, and 10, the applicant provided the requested information. Since the ETAP was used to perform the calculations for all the above studies, the staff performed an audit on April 2, 2009, on how the applicant built those ETAP models for each calculation and what inputs were used to support the above analyses. During the audit, the staff observed that all electrical calculations are comprehensive, extensive, and detailed enough to identify foreseeable problems (see audit summary in Agencywide Documents Access and Managements System (ADAMS) Accession No. ML092080011). The staff concludes that the applicant adequately addressed the issue and it is resolved.

In RAI 9, Question 08.01-1, the staff requested that the applicant clarify why the sizing of the main generator, the EDGs, and the SBODG is left for the COL applicant to decide based on site-specific information. In a July 14, 2008, response to RAI 9, Question 08.01-1, the applicant responded that the actual rated size of the main generator, the EDGs, and the SBODG is dependent on which manufacturer is selected to provide the equipment and the nominal values of the associated equipment. Since the equipment sizes are indicated to provide a minimum equipment size to satisfy the function of the equipment, a COL applicant that references the applicant design certification will identify site-specific loading differences that raise generator loading, and demonstrate the electrical distribution system is adequately sized for the additional load. (see COL Information Item 8.1-2). The staff considers this issue resolved.

In RAI 11, Question 08.03.01-11, the staff requested that the applicant provide a summary of the results of the electrical distribution system protection and coordination studies performed in accordance with IEEE Std 242-2001 to develop a selectively coordinated system. In a July 16, 2008, response to RAI 11, Question 08.03.01-11, the applicant stated that the information needed to perform these studies comes from as-procured equipment and, thus, the results of the studies are unavailable for review. The applicant responded that IEEE Std 242-2001 will be used as an acceptance standard for the performance of the study. The studies will be completed prior to placing the electrical equipment in service and will be demonstrated via an ITAAC as described in FSAR Tier 1, Table 2.5.1-3 (Commitment Wording 5.13). Accordingly, the staff concludes that the applicant has adequately addressed the issue and, therefore, considers it resolved.

As described above, the staff finds that the applicant has performed the preliminary electrical power system calculations and distribution system studies for the onsite ac power systems, described in FSAR Tier 2, Section 8.3.1.3, in accordance with RG 1.206 and, therefore, the onsite power system is acceptable.

8.3.1.4.18 Conformance to the NRC Interim Staff Guidance JLD-ISG-2012-01 for mitigation strategies for beyond-design-basis external events

Following the earthquake and tsunami at the Fukushima Dai-ichi nuclear power plant in March 2011, the NRC established a senior-level task force referred to as the Near-Term Task Force (NTTF) to review NRC processes and regulations and to make recommendations to the Commission for its policy direction, among other things. The NTTF recommended, among other things, that the NRC revise 10 CFR 50.63 to impose additional requirements with respect to the loss of ac power at a reactor, including requirements to preplan and prestage offsite resources to support uninterrupted core and spent fuel pool cooling, and reactor coolant system and containment integrity (NTTF Recommendation 4.1). The NTTF also recommended that the NRC require licensees to protect equipment currently provided pursuant to 10 CFR 50.54(hh)(2) from the effects of design-basis external events and to add equipment to address multi-unit events (NTTF Recommendation 4.2). On March 12, 2012, the NRC issued Order EA-12-049, “Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events,” to power reactor licensees to address the issues raised in NTTF Recommendations 4.1 and 4.2. The NRC then issued the interim staff guidance (ISG) in JLD-ISG-2012-01 to assist power reactor licensees in developing measures needed to comply with the requirements of EA-12-049. In order to address the issues raised in NTTF Recommendations 4.1 and 4.2, as restated in EA-12-049, the applicant developed ANP-10329, Revision 0, “U.S. EPR Mitigation Strategies for an Extended Loss of AC Power Event Technical Report.” In accordance with ANP-10329, Revision 0, the applicant has revised FSAR Tier 2, Sections 8.3.1.1.1, “Emergency Power Supply System,” and 8.3.1.1.7, “Extended Loss of AC Power Diesel Generator,” and FSAR Tier 2, Section 8.3, “Onsite Power System.” In the Report ANP-10329, the applicant states that an ELAP assumes a simultaneous loss of all ac power (LOOP, loss of EDGs, and loss of alternate source). The applicant further states that dc power is required for operation of electrical switchgear and the I&C systems for operation of essential ac motor-operated valves that are battery backed. The applicant indicates that during Phase 1 of an ELAP event, the EUPS design feature supports extension of the battery cycle capability beyond the 2 hours credited for the safety-related batteries in the safety analysis. This issue is further discussed in Section 8.3.2.4.11 of this report.

The U.S. EPR design includes a diesel generator (ELAP DG) for use during Phase 2 of an ELAP event as described in FSAR Tier 2, Section 8.3.1.1.7. FSAR Tier 2, Section 8.3.1.1.7 states that using manual transfer switches, the ELAP DG can power Divisions 1 and 2 equipment via EPSS 480V buses 31 BMB and 32 BMB. The staff has reviewed the description of the ELAP DG and confirmed that it has the capacity adequate to power a minimum set of two divisions (Divisions 1 and 2) of safety-related equipment to maintain core cooling, containment, and spent fuel pool cooling. Further, the staff confirmed that the connection configurations for this DG shown on FSAR Tier 2, Figure 8.3-2 allow it to supply power to the minimum set of Division 1 and 2 equipment. Since the ELAP DG has adequate capacity and capability to power equipment sufficient to maintain core cooling, containment, and spent fuel pool cooling capabilities for mitigating a beyond design basis event, the staff concludes that use of the ELAP DG in this fashion is an acceptable mitigation strategy in accordance with JLD-ISG-2012-01.

The staff’s comprehensive review of the applicant’s proposals in conformance to JLD-ISG-2012-01 will be documented in Chapter 20 of this report. Chapter 20 of this report will describe the staff’s evaluation and findings regarding the NTTF recommendations that are applicable to the AREVA U.S. EPR design. The applicable recommendations will address three topics: mitigation strategies for beyond-design-basis external events (related to Recommendations 4.1 and 4.2); spent fuel pool (SFP) instrumentation (related to Recommendation 7.1); and emergency preparedness staffing and communications (related to Recommendation 9.3). For more information on this review topic, see Chapter 20 of this report.

8.3.1.5 *Combined License Information Items*

Table 8.3.1-1 provided below lists all of the ac onsite power system COL information items and descriptions from FSAR Tier 2, Chapter 8, Section 8.3.1 and Chapter 1, Table 1.8-2:

Table 8.3-1 U.S. EPR Combined License Information Items for Onsite ac Power System

Item No.	Description	FSAR Tier 2 Section
8.1-2	A COL applicant that references the U.S. EPR design certification will identify site-specific loading differences that raise EDG loading or Class 1E battery loading, and demonstrate the electrical distribution system is adequately sized for the additional load.	8.1.3
8.3-1	A COL applicant that references the U.S. EPR design certification will establish procedures to monitor and maintain EDG reliability during plant operations to verify the selected reliability level target is being achieved as intended by RG 1.155.	8.3.1.1.5
8.3-2	A COL applicant that references the U.S. EPR design certification will describe inspection, testing and monitoring programs to detect the degradation of inaccessible or underground power cables that support EDGs, offsite power, ESW and other systems that are within the scope of 10 CFR 50.65.	8.3.1.1.9

8.3.1.6 *Conclusions*

As set forth above, the staff has reviewed all of the relevant information that is applicable to the U.S. EPR onsite ac power system design and evaluated is compliance with GDC 17, GDC 18, and GDC 50, and conformance to RGs, standards, and BTPs committed to by the applicant. The staff also reviewed the COL information items in FSAR Tier 2, Table 1.8-2. Pending the closure of Confirmatory Item 8.3-1, the staff concludes that the applicant has provided sufficient information in the FSAR and identified necessary analyses to support the bases for their conclusions of their onsite ac power system design for the COL applicant. The staff concludes the design of the U.S. EPR onsite ac power system design meets the appropriate regulatory requirements listed in Section 8.3.1.3, and shown in the staff's technical evaluations in Section 8.3.1.4 and COL Information Items in Section 8.3.1.5 of this report.

8.3.2 Direct Current Power Systems

The U.S. EPR onsite dc power system is designed to provide reliable electric power from the EPSS to provide for the safe shutdown of the reactor.

8.3.2.1 *Introduction*

The safety function of the onsite dc power system, assuming the offsite power system is not functioning, is to provide sufficient capacity and capability to ensure that the SSCs important to safety perform as intended. The objective of the staff's review is to determine whether the onsite dc power system satisfies the requirements of 10 CFR Part 50, Appendix A, and GDC 2, GDC 4, GDC 5, GDC 17, GDC 18, and GDC 50 and will perform its design function during all plant operating and accident conditions.

8.3.2.2 *Summary of Application*

FSAR Tier 1: In FSAR Tier 1, Section 2.5.2, the applicant states that the EUPS system provides Class 1E power to safety-related dc loads and uninterruptible ac power to safety-related and select non-safety-related loads during normal and abnormal operations.

In FSAR Tier 1, Section 2.5.7, the applicant states the non-Class 1E uninterruptible power supply system (NUPS) provides non-Class 1E uninterruptible power during normal and abnormal operations to non-safety-related Turbine Island and Nuclear Island loads, which include the control rod drive mechanism (CRDM) operating coils. Interruption of power to the CRDM operating coils in a reactor trip condition is a safety-related function accomplished by opening the reactor trip breakers. The reactor trip breakers have a non-safety-related function of opening when the shunt trip coil is energized as a diverse means of opening the breakers.

In FSAR Tier 1, Section 2.5.11, the applicant states the 12-hour uninterruptible power supply (12UPS) system provides non-Class 1E uninterruptible power during normal and abnormal operations to Nuclear Island and Turbine Island loads including alternate ac support features.

FSAR Tier 2: The applicant has provided an FSAR Tier 2 system description in Section 8.3.2, which is summarized here, in part, as follows:

The dc power system includes a EUPS system, a non-Class 1E 12UPS system, and a NUPS system. In general, the EUPS system provides uninterruptible dc control power for safety-related switchgear and load centers, I&C systems, and uninterruptible ac motive power for safety-related motor operated valves. The 12UPS system provides uninterruptible dc control power and ac motive power for similar non-safety-related equipment during normal operation and selected equipment for at least 12 hours. The NUPS provides uninterruptible dc control power and ac motive power for various non-safety-related balance of plant equipment.

ITAAC: The ITAAC associated with FSAR Tier 2, Section 8.3.2, are given in FSAR Tier 1, Section 2.5.2, Table 2.5.2-3, "Class 1E Uninterruptible Power Supply ITAAC"; Table 2.5.7-2, "Non-Class 1E Uninterruptible Power Supply ITAAC"; and Table 2.5.11-1, "12 Hour Uninterruptible Power Supply ITAAC."

Technical Specifications: Technical Specifications applicable to the onsite ac power system can be found in FSAR Tier 2, Chapter 16, Sections 3.8.4, "DC Sources – Operating"; 3.8.5, "DC Sources – Shutdown"; 3.8.6, "Battery Parameters"; 3.8.7, "Inverters – Operating"; 3.8.8, "Inverters – Shutdown"; 3.8.9, "Distribution Systems – Operating"; 3.8.10, "Distribution Systems – Shutdown"; Bases for these TSs are in B3.8.4, "DC Sources – Operating"; B3.8.5, "DC Sources – Shutdown"; B3.8.6, "Battery Parameters"; B3.8.7, "Inverters – Operating"; B3.8.8, "Inverters – Shutdown"; B3.8.9, "Distribution Systems – Operating"; and B3.8.10, "Distribution Systems – Shutdown."

8.3.2.3 *Regulatory Basis*

The relevant requirements of NRC regulations for the onsite dc power system, and the associated acceptance criteria, are given in NUREG-0800, Section 8.3.2, and are summarized below.

1. GDC 2, as it relates to SSCs of the dc power system being capable of withstanding the effects of natural phenomena without the loss of the capability to perform their safety functions.

2. GDC 4, as it relates to SSCs of the dc power system being capable of withstanding the effects of missiles and environmental conditions associated with normal operation, maintenance, testing, and postulated accidents.

3. GDC 5, as it relates to sharing of SSCs of the dc power systems of different nuclear power units.

4. GDC 17, as it relates to the onsite dc power system's (1) capacity and capability to permit functioning of SSCs important to safety; (2) independence, redundancy, and testability to perform its safety function assuming a single failure; and (3) provisions to minimize the probability of losing electric power from any of the remaining supplies as a result of or coincident with the loss of power generated by the nuclear power unit or the loss of power from the transmission network.

5. GDC 18, as it relates to inspection and testing of the onsite power systems.

6. GDC 50, as it relates to the design of containment electrical penetrations containing circuits of the dc power system and the capability of electric penetration assemblies in containment structures to withstand a LOCA without loss of mechanical integrity and the external circuit protection for such penetrations.

7. 10 CFR 50.63, as it relates to the redundancy and reliability of the emergency onsite dc power sources, as a factor in limiting the potential for SBO events.

8. 10 CFR 50.65(a)(4), as it relates to the assessment and management of the increase in risk that may result from proposed maintenance activities before performing the maintenance activities for the onsite dc power system. These activities include, but are not limited to, surveillances, post-maintenance testing, and corrective and preventive maintenance. Compliance with the maintenance rule, including verification that appropriate maintenance activities are covered therein, is reviewed under SRP Chapter 17. Programs for incorporation of requirements into appropriate procedures are reviewed under SRP Chapter 13.

9. 10 CFR 50.55(a)(h), as it relates to the incorporation of IEEE Std 603-1991 (including the correction sheet dated January 30, 1995).

Acceptance criteria adequate to meet the above requirements include:

1. RG 1.6, Regulatory Positions D.1, D.3, and D.4, as they relate to the independence between redundant onsite dc power sources and their respective dc load groups.

2. RG 1.32, as it relates to the design, operation, and testing of the safety-related portions of the onsite dc power system. Except for sharing of safety-related dc power systems in multi-unit nuclear power plants, RG 1.32 endorses IEEE Std 308-2001.

3. RG 1.47, as it relates to the bypass and inoperable status of the onsite dc power supply system.

4. RG 1.53, as it relates to the application of the single-failure criterion of the onsite dc power system.

5. RG 1.63, as it relates to the capability of electric penetration assemblies in containment structures to withstand a loss of coolant accident without loss of mechanical integrity and the external circuit protection for such penetrations.

6. RG 1.75, as it relates to the physical independence of the circuits and electrical equipment that comprise or are associated with the onsite dc power system.

7. RG 1.81, as it relates to the sharing of SSCs of the dc power system. Regulatory Position C.1 states that multi-unit sites should not share dc systems.

8. RG 1.118, as it relates to the capability to periodically test the onsite dc power system.

9. RG 1.128, “Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants,” as it relates to the installation of vented lead-acid storage batteries in the onsite dc power system.

10. RG 1.129, “Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Nuclear Power Plants,” as it relates to maintenance, testing, and replacement of vented lead-acid storage batteries in the onsite dc power system.

11. RG 1.153, as it relates to the design, reliability, qualification, and testability of the power, instrumentation, and control portions of safety systems of nuclear plants, including the application of the single-failure criterion in the onsite dc power system.

12. RG 1.155, as it relates to the capability and the capacity of the onsite dc power system for a SBO, including batteries associated with the operation of the AAC power source(s).

13. RG 1.160, as it relates to the effectiveness of maintenance activities for dc power systems. Compliance with the maintenance rule, including verification that appropriate maintenance activities are covered therein, is reviewed under SRP Chapter 17.

14. RG 1.182, as it relates to conformance to the requirements of 10 CFR 50.65(a)(4) for assessing and managing risk when performing maintenance.

15. RG 1.206, as it relates to power system analytical studies and stability studies to verify the capability of the offsite power systems and their interfaces with the onsite power system.

16. ISG JLD-ISG-2012-01, “Compliance with Order EA-12-049 Order Modifying Licenses with regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events,”

8.3.2.4 *Technical Evaluation*

The staff has reviewed the onsite dc power system of the FSAR. The FSAR provides descriptive information, analyses, and referenced documents, including electrical single-line diagrams, tables, and physical arrangements. The onsite dc power system of the FSAR includes a EUPS system, a 12UPS system, and a NUPS system. This review evaluates whether the U.S. EPR onsite dc power system satisfies the applicable regulations to ensure its intended safety functions are met during all plant operating and accident conditions.

NUREG-0800, Table 8-1 lists GDC, RGs, IEEE standards, and BTPs that are applicable for the onsite dc power systems. The staff has reviewed the following areas that are applicable to the U.S. EPR onsite dc power system design:

8.3.2.4.1 Compliance with GDC 2

GDC 2 requires that SSCs important to safety, which include the onsite dc power systems, be capable of withstanding the effects of natural phenomena without the loss of the capability to perform their safety functions.

The U.S. EPR onsite dc power distribution system consists of four redundant divisions. Each division of EUPS distribution equipment is located in Seismic Category I buildings. Each EUPS division is located in separate rooms in each of these buildings, which provide physical separation among the four redundant divisions. All Class 1E components such as batteries, battery chargers, inverters, switch boards, and other components will meet the Seismic Category I requirements. The nature and magnitude of the natural phenomena considered in the U.S. EPR design are described in FSAR Tier 2, Chapter 2, “Site Characteristics.” The U.S. EPR design criteria for wind, hurricane, tornado, flood, and earthquake have been evaluated in Sections 3.3, 3.4, and 3.7, respectively, of FSAR Tier 2, Chapter 3, “Design of Structures, Components, Equipment and Systems.”

All Class 1E components of the U.S. EPR onsite dc power system are located in Seismic Category I structures, protected from the effects of natural phenomena such as tornadoes, tornado missiles, and flood. 10 CFR Part 50, Appendix B, Criterion III, “Design Control,” requires that this equipment, as installed, is seismically qualified in accordance with the COL applicant’s QA program. The staff will evaluate the adequacy of a COL applicant’s QA program in this regard.

The onsite dc power system is located inside Seismic Category I structures, the onsite dc power system is a Class 1E system, and is seismically qualified, Therefore, the staff finds that the dc power system equipment will be designed to withstand the effects associated with natural phenomena without loss of capability to perform their safety functions during an accident or will be protected from such phenomena by the structures within which that equipment is located. Based on the above, the staff finds that the U.S. EPR onsite dc power system meets the requirements of GDC 2.

8.3.2.4.2 Compliance with GDC 4

GDC 4 requires that SSCs important to safety, which include the onsite dc power systems for the U.S. EPR, be capable of withstanding the effects of missiles and environmental conditions associated with normal operation, maintenance, testing, and postulated accidents.

The U.S. EPR EUPS components are located in Seismic Category I structures and buildings in an area absent of high energy lines, and in rooms constructed in such a manner that any internal hazard only affects the respective division. The staff’s review of the design details and construction of safety-related structures indicates that no high energy lines are routed through the dedicated electrical rooms containing batteries, battery chargers, inverters, MCCs, panel boards, or switch boards. In addition, these rooms are also provided conditioned air that maintains ambient environmental conditions within the equipment qualification limits during normal operations, DBEs, and SBO.

In addition, for that equipment located in harsh environments, the environmental qualification program for electrical equipment provides reasonable assurance that equipment remains functional during and following exposure to harsh environmental conditions as a result of a DBE. Environmental qualification of mechanical and electrical equipment described in FSAR Tier 2, Section 3.11, "Environmental Qualification of Mechanical and Electrical Equipment," lists GDC 4 as one of the acceptance criteria. FSAR Tier 2, Table 3.11-1 of Section 3.11, lists safety-related electrical and I&C equipment located in a harsh environment that must be qualified. Based on the above, the staff finds the onsite dc power system design for U.S. EPR can perform safety-related functions following physical effects of an internal hazard.

Considering the ambient temperature controls and plant design described above, the onsite dc power system components of the U.S. EPR are capable of withstanding the effects of missiles and environmental conditions associated with normal operation and postulated accidents. Accordingly, the staff finds that the U.S. EPR dc power systems meet the requirements of GDC 4.

8.3.2.4.3 Compliance with GDC 5

GDC 5 requires SSCs important to safety, which includes the dc power system, not be shared among other nuclear units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions. The safety-related EUPS systems and components (i.e., batteries, chargers, or inverters) for the U.S. EPR are not shared between individual nuclear power units. Thus, the staff finds that GDC 5 and RG 1.81 are not applicable to the dc power system of U.S. EPR.

8.3.2.4.4 Compliance with GDC 17

GDC 17 requires that the onsite power supplies, including the dc power supplies, and the associated electrical distribution system, have sufficient capacity, capability, independence, redundancy, and testability to perform their safety functions, assuming a single failure. Thus, no single failure should prevent the onsite power system from supplying electric power, thereby enabling safety functions and other vital functions.

The onsite dc power system for the U.S. EPR includes an EUPS system, a 12UPS system, and a NUPS system. The EUPS system provides uninterruptible dc control power for safety-related switchgear and load centers, I&C systems, and uninterruptible ac motive power for certain safety-related motor operated valves. The 12UPS system provides uninterruptible dc control power and ac motive power for non-safety-related equipment during normal operation and selected equipment for at least 12 hours. The NUPS provides uninterruptible dc control power and ac motive power for various non-safety-related balance of plant equipment.

The U.S. EPR onsite dc power distribution system consists of four independent and redundant EUPS divisions. EUPS divisions are in a Seismic Category I Safeguard Building and Diesel Building, and each division is located in a separate room in each building, providing physical separation among the four redundant divisions. Each division includes inverters, batteries, battery chargers, MCCs, distribution panels, and converters, and they are redundant and physically separated from each other. Each EUPS system battery and battery charger provides power to the dc switchboard, which provides power to the 250 Vdc loads and inverter of each division. The inverter powers the 480 Vac loads that require uninterruptible power and multiple ac/dc converters that are operated in parallel to supply dc power to redundant safety-related loads and selected non-safety-related loads. This independence among redundant EUPS divisions includes control power (250 Vdc) for circuit breakers for EUPS switchgear and load centers, EDG control power, and power for the converter cubicles that is supplied to I&C systems (24 Vdc) in the related division. Therefore, the U.S. EPR onsite dc power system components have the independence and redundancy required by GDC 17 to perform their safety-related functions in the presence of a single failure.

Battery size is determined in accordance with the methodology in IEEE Std 485-1997 (R2003), "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications," endorsed by RG 1.212, "Sizing of Large Lead-Acid Storage Batteries." The battery sizing takes into account the worst-case battery load conditions to develop the duty cycle and includes specific load characteristics such as in-rush current. Battery cell discharge performance characteristic curves are used to calculate the cell capacity necessary for satisfactory battery performance based on the worst-case duty cycle. Duty cycle development and load characteristics are shown in FSAR Tier 2, Table 8.3-13, Table 8.3-14, Table 8.3-15, and Table 8.3-16. Other considerations included in the cell size are a 10 percent design margin, a minimum battery temperature of 18 °C (65 °F), and 25 percent margin as an aging factor.

In RAI 11, Question 08.03.02-1, the staff requested that the applicant identify those selected non-safety-related loads, and explain how they were accounted for in the sizing of EUPS batteries. In a July 16, 2008, response to RAI 11, Question 08.03.02-1, the applicant identified those non-safety-related loads as special emergency lighting systems in Divisions 2 and 3, and post accident monitoring (PAM) equipment in Divisions 1 through 4 that powers the radiation monitoring system. In FSAR Revision 2, the applicant identified additional communication system loads. The special emergency lighting, radiation monitoring, communication system loads for which power needs to be maintained for a minimum of 2 hours in the event of an SBO, are accounted for in the EUPS battery sizing calculation by factoring these loads as continuous loads throughout the battery loading scenario. Therefore, the staff finds that the applicant has adequately addressed the issue. Accordingly, the staff considers this issue resolved.

GDC 17 specifies the safety function of the electric power systems as providing sufficient capacity and capability to assure that: (1) Specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences; and (2) the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents. The systems to which the onsite dc power system supplies control power that accomplishes these functions are governed by GDC 33, "Reactor coolant makeup," GDC 34, "Residual heat removal," GDC 35, "Emergency core cooling," GDC 38, "Containment heat removal," GDC 41, "Containment atmosphere cleanup," and GDC 44 "Cooling water," for SSCs important to safety during normal and accident conditions, as necessary for the specific system condition.

Compliance with GDC 17 is accomplished through the design of the onsite power dc distribution system capacity, capability, independence, and redundancy along with meeting the single-failure criteria. As described below, the staff finds that the applicant's onsite dc system design conforms to the following Regulatory Guides: RG 1.6, RG 1.32, RG 1.53, RG 1.75, RG 1.128, RG 1.129, and RG 1.153.

8.3.2.4.4.1 *Conformance to RG 1.6*

FSAR Tier 2, Section 8.3.2.2.4 states conformance to RG 1.6. RG 1.6 relates, in part, to the independence between redundant onsite dc power sources and between their distribution systems. Each U.S. EPR EUPS division contains a battery, two battery chargers, an inverter with a static bypass switch, and converters. There are no (automatic or manual) connections between EUPS divisions. During normal EPSS bus alignments, four redundant divisions are physically separated and electrically independent preventing failure in one division from having a detrimental effect on another division that would prevent performance of a safety function. Accordingly, the staff finds that the EUPS provides uninterruptible Class 1E dc and ac power to the redundant safety-related load groups and conforms to the guidance provided in RG 1.6.

8.3.2.4.4.2 *Conformance to RG 1.32*

FSAR Tier 2, Section 8.3.2.2.4 states conformance to RG 1.32. RG 1.32 relates, in part, to the design, operation, and testing of the safety-related portions of the onsite dc power system. It provides the principle design criteria and design features for onsite dc power systems. RG 1.32 endorses IEEE Std 308-2001, "Criteria for Class 1E Power Systems for Nuclear Power Generating Stations." The U.S. EPR EUPS batteries, battery chargers, inverters and distribution equipment are designed to: (1) Operate with sufficient power at the quality necessary for the safety systems to meet their functional requirements; (2) conform to the restrictions on sharing of the safety-related dc power system between multiple units; and (3) permit periodic inspection and testing of important parameters and features. Accordingly, the staff finds that the applicant's onsite dc power system conforms to the guidance provided in RG 1.32.

8.3.2.4.4.3 *Conformance to RG 1.53*

The applicant has stated that in FSAR Tier 2, Section 8.3.2.2.4, the EUPS has been designed in conformance to RG 1.53, which provides that safety-related systems will have the power to perform their safety-related function in the presence of a single failure. The applicant has provided onsite dc distribution system capability to maintain safety function in the presence of a single failure as discussed in FSAR Tier 2, Table 8.3-12, "Class 1E Uninterruptible Power Supply System FMEA." In order to detect the presence of a single failure and to permit dc system monitoring, the EUPS system components have local battery charger and inverter indications. For example, dc switchboard and 480 Vac MCC voltage, battery charger output current and battery charge or discharge rate are indicated in the MCR and RSS. In addition, a dc switchboard undervoltage alarm indicates that the battery is being discharged, and a dc system ground alarm is provided in the MCR. Since the safety-related functions can be performed in the presence of single failure, the staff finds that the U.S. EPR onsite dc power system conforms to the guidance provided in RG 1.53.

8.3.2.4.4.4 *Conformance to RG 1.75*

FSAR Tier 2, Section 8.3.2.2.4 states conformance to RG 1.75. RG 1.75 addresses the physical independence of the circuits and electrical equipment that comprise or are associated with the onsite dc power system. Station routing of Class 1E and non-Class 1E raceways, cable trays and cables has been designed to meet independence, separation criteria, routing, fire protection, and identification requirements of IEEE Std 384-1992, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits," as endorsed by RG 1.75. The FSAR describes raceway and cable routing for the applicant's onsite power systems and includes information on cable derating, cable tray fill, cable independence, and necessary separation. Each EUPS division for U.S. EPR is located in separate Seismic Category 1 safeguard buildings and diesel buildings. This arrangement provides physical separation through the use of safety class structures for the majority of the electrical equipment and circuits. Administrative programs were developed to distinguish cable routing, derating, raceway fill, separation, and cable identification of redundant Class 1E circuits, and the independence of non-Class 1E circuits from Class 1E circuits is in accordance with RG 1.75. RG 1.75 does not distinguish between ac and dc power system cables. The function and voltage class of the cables includes 24 and 250 Vdc control and low voltage power cables. The staff finds that the physical independence of the circuits and electrical equipment for the onsite dc power system satisfies RG 1.75. However, the staff informed the applicant that COL applicants must develop a periodic testing program with a test frequency for fuses or circuit breakers that are used as isolation devices under RG 1.75.

In RAI 183, Question 08.03.01-20, the staff requested that the applicant clarify the periodic testing of circuit breaker recommendations in RG 1.75. In a March 27, 2009, response to RAI 183, Question 08.03.01-20, the applicant stated that FSAR Tier 2, Section 8.3.1.1.10, will be revised as follows: "Periodic testing of circuit breakers (visual inspection of fuses and fuse holders) used as isolation devices are performed during every refueling to demonstrate that the overall coordination scheme under multiple faults of non-safety-related loads remains within the limits specified in the design criteria." This RAI question resulted in a revision of FSAR Tier 2, Section 8.3.1.1.10, to include periodic testing of circuit breakers. The staff confirmed that the revised FSAR contains the change as committed to in the RAI response. Accordingly, the staff finds that the applicant has adequately addressed the issue. The staff considers this issue resolved.

In RAI 183, Question 08.03.01-21, the staff requested that the applicant clarify whether the output of each 24 Vdc converter module has a fuse or circuit breaker installed for individual component protection, as FSAR Tier 2, Figure 8.3.5 did not show a fuse or circuit breaker installed. In a January 28, 2009, response to RAI 183, Question 08.03.01-21, the applicant stated that the output circuit breaker is an integral component of the converter, thus a circuit breaker is not shown on FSAR Tier 2, Figure 8.3.5. The staff finds that adequate isolation is provided for each 24 Vdc converter module through the integral circuit breaker, and that the applicant adequately addressed the issue; therefore, the issue is resolved.

Based on the above, the staff finds that the U.S. EPR onsite dc power system conforms to the guidance of RG 1.75, as the design provides physical independence of the circuits and electrical equipment that comprise or are associated with the onsite dc power system.

8.3.2.4.4.5 *Conformance to RGs 1.128 and 1.129*

FSAR Tier 2, Section 8.3.2.2.4, states that the design and installation of EUPS batteries conforms to IEEE Std 484-2002, "Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications," as endorsed by RG 1.128, for proper design and installation for large lead-acid storage batteries. Stationary lead-acid batteries provide normal response and instrument power and backup energy for emergencies. IEEE Std 484-2002 recommends common or standard practices for the design of battery installations and the battery installation procedures. The methods described are applicable to installations and battery sizes using vented lead-acid batteries designed for float operation with a battery charger serving to maintain the battery in a charged condition as well as to supply the normal dc load. Testing related to initial design and installation of EUPS batteries for the U.S. EPR is described in FSAR Tier 1, Table 2.5.2-3, "Class 1E Uninterruptible Power Supply System ITAAC."

In addition, FSAR Tier 2, Section 8.3.2.2.4 also states that the maintenance and testing of EUPS batteries conforms to RG 1.129. RG 1.129 relates to maintenance, testing, and replacement of the batteries for the onsite power system. It also indicates that maintenance and testing of EUPS batteries for the U.S. EPR is in accordance with IEEE Std 450-2002, "Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications," as endorsed by RG 1.129. Detailed battery surveillance testing would be required in the TS FSAR Tier 2, Chapter 16, Section 3.8.4. Accordingly, the staff finds that the installation, testing and maintenance methods of vented lead-acid storage batteries in the EUPS, including the ITAAC, conform to the guidance in RG 1.128 and RG 1.129.

8.3.2.4.4.6 *Conformance to RG 1.153*

RG 1.153 relates to the design, reliability, qualification, and testability of the power, instrumentation, and control portions of safety systems of nuclear plants, including the application of the single-failure criterion in the onsite dc power system. It also addresses the need for functional and design independence and separation requirements for onsite dc power system distribution for nuclear power plants. FSAR Tier 2, Section 8.3.2.2.4 states conformance to RG 1.153. Meeting the detailed requirements of IEEE Std 603-1991, and IEEE Std 603-1998, "Criteria for Safety Systems for Nuclear Power Generating Stations," with respect to independence and separation of the dc power distribution system divisions, will achieve the goals stated in RG 1.153.

The staff has reviewed the applicant's onsite dc electrical distribution safety-related configuration and its functions to determine whether functional independence and physical separation of each division is in accordance with IEEE Std 603-1991 and IEEE Std 603-1998 for safety-related system independence. The IEEE standard addresses independence between redundant portions of a safety system and effects of a design basis event. In the U.S. EPR design, this is accomplished by the separation of safety-related components among divisions. The physical separation assures that a single failure or internal hazard, or both, in one division can only affect that division (see Section 8.3.2.4.1 of this report). Therefore, during design basis accidents coincident with a single failure to any electrical component in a division, the remaining divisions will support safety-related function completion. The onsite dc power electrical distribution equipment (i.e., batteries, battery chargers, MCCs, switchboards, inverters, and panel boards) is sized to provide sufficient power to start and operate the connected loads. Accordingly, the staff finds that the U.S. EPR onsite dc electrical distribution system is designed in accordance with the independence and separation requirements of RG 1.153.

The redundancy of the EUPS divisions maintains power to the safety-related loads so that equipment may complete its safety-related functions in the event of a single failure. Electrical independence and physical separation is provided between redundant onsite distribution divisions, so a failure in one division does not prevent the accomplishment of safety-related functions.

The EUPS batteries are sized to provide power for 2 hours to loads connected to the Class 1E distribution equipment, when the ac supply to the battery charger is lost. The EUPS battery cells are the vented lead-acid type. Division 1, 2, 3, and 4 EUPS batteries are each rated at 2,400 amp hours (Ah), at an eight hour rate, to 1.75 V/cell at 25 °C (77 °F). (See FSAR Tier 2, Table 8.3-11, "Onsite DC Power System Component Data Nominal Values.") Each EUPS division contains two 100 percent capacity chargers. Each EUPS battery charger is sized to supply continuous steady-state loads while recharging its respective battery. These battery charger parameters are alarmed in the MCR to alert operators of abnormal conditions.

The power supply for the I&C system is comprised of four Class 1E inverters (one inverter per division) providing power at a nominal 480 Vac, three-phase, 60 Hz to the four independent divisions (480 Vac vital ac distribution MCCs). The inverter limits the output voltage waveform THD to below maximum recommended limits (5 percent) as recommended in IEEE Std 519-1992. Each inverter includes a static bypass switch to transfer power from the inverter to the EDG backed bypass source. The static bypass switch automatically transfers to the bypass source on inverter failure, inverter overload, inverter output undervoltage or overvoltage, or manually. The transfer is a make-before-break transfer to the respective division voltage regulated MCCs, which occurs with minimal change in voltage, frequency, or phase displacement. Transfer to the bypass source is only possible when the bypass source is available. During inverter maintenance and tests, the vital ac distribution MCC supply is provided directly from the bypass source.

In addition, each EUPS division supplies the respective division I&C equipment with 24 Vdc converters via both 480 Vac and 250 Vdc power supplies. The converter cubicles are operated in parallel to provide two power supply feeds to each specific I&C cabinet group. Both the ac/dc and dc/dc converters are sized to supply the entire I&C cabinet group so that on failure of one converter cubicle, the other converter cubicle can supply the power demand of the entire I&C cabinet group. The output of each converter module has a fuse or circuit breaker installed for individual component protection. Electrical isolation between the converter cubicles is provided by blocking diodes.

Based on the above, the staff finds that the U.S. EPR dc power supply has the capacity and capability to provide power to all safety loads needed to assure that fuel design limits and reactor coolant system pressure boundary design conditions are not exceeded and the core is cooled and containment integrity and other vital functions are maintained during all facility operating modes, including anticipated operational occurrences and design-basis accidents, even in the event of a single failure. Based on the above, the staff finds that the dc power distribution system divisions conform to the guidance in RG 1.153 pertaining to the independence and separation of the dc power distribution system divisions, and accordingly comply with the requirements in GDC 17 in regard to those matters.

8.3.2.4.5 Compliance with GDC 18

GDC 18 requires that electric power systems important to safety, which include the onsite dc power system, be designed to permit appropriate periodic inspection and testing of important areas and features to assess the continuity of the systems and the condition of their components. These systems shall be designed with a capability to test periodically: (1) The operability and functional performance of the components of the systems, such as onsite dc power sources, inverters, battery chargers, switchboards, and buses; and (2) the operability of the systems as a whole and under conditions as close to design as practical.

All EUPS components are periodically tested in accordance with the Technical Specifications as detailed in FSAR Tier 2, Chapter 16. Also, the dc switchboard and 480 Vac MCC voltage, battery charger output current, and battery charge or discharge rate are indicated in the MCR and the RSS. For example, a dc switchboard undervoltage alarm will indicate when the battery is being discharged, and a dc system ground alarm is provided in the MCR. FSAR Tier 1, Table 2.5.2-2, “Class 1E Uninterruptible Power Supply Electrical Equipment Design,” verifies the design of electrical display parameters that will be monitored in the MCR and RSS.

FSAR Tier 2, Section 8.3.2.2.5 states that the EUPS has been designed to permit periodic inspection and testing of important areas and features to assess the operability and functionality of the dc systems and the condition of their components. The staff finds that the battery and battery charger capacities can be periodically tested in accordance with technical specifications detailed in FSAR Chapter 16 and complies with GDC 18 in this regard.

8.3.2.4.5.1 *Conformance to RG 1.47*

FSAR Tier 2, Section 8.3.2.2.5 states conformance to RG 1.47, as it relates to the bypass and inoperable status of the onsite dc power system. The FSAR states that bypassed or deliberately induced inoperability of the EUPS batteries, battery chargers, and UPS inverters is automatically annunciated in the MCR to indicate the bypassed system or component in accordance with RG 1.47. The FSAR also states that additional guidance provided in BTP 8-5 has been used in the design of the bypass and inoperable status indicators for the engineered safety feature systems (see FSAR Tier 2, Section 7.5.2). As discussed above, the staff finds that dc system equipment and components are monitored, and if the system or its components are bypassed or deliberately rendered inoperable, that condition is annunciated in the MCR in accordance with RG 1.47, which is acceptable.

8.3.2.4.5.2 *Conformance to RG 1.118*

Battery and battery charger capacities at U.S. EPR are periodically tested in accordance with technical specifications detailed in FSAR Tier 2, Chapter 16 in accordance with RG 1.118. RG 1.118 provides guidance on the capability for periodic surveillance testing and calibration of safety-related equipment to be provided while retaining the capability of the safety-related systems to accomplish their safety-related functions in accordance with IEEE Std 338-1987, "Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems." Periodic dc system component testing in accordance with RG 1.129 is performed based on the component manufacturer recommendations and IEEE Std 450-2002. There are two battery chargers installed, one operational and the other in standby mode. Battery charger maintenance and testing is performed during power operation through use of the standby battery charger. Testing that could cause perturbations to the dc electrical distribution systems or challenge continued steady-state operation of safety-related systems is normally performed during plant shutdown. Testing performed during plant shutdown includes battery performance or modified performance discharge tests. Inverter maintenance that involves removing the inverter from service is also performed during plant shutdown. Additional specific testing of the EUPS components during shutdown is detailed in FSAR Tier 2, Chapter 16.

Based on the above, the staff finds that the applicant's onsite dc power system can be appropriately accessed for required periodic inspection and testing, enabling verification of important system parameters, performance characteristics, and features, as well as detection of degradation and/or impending failure under controlled conditions. The U.S. EPR EUPS has been designed to permit periodic inspection and testing to assess the operability and functionality of the systems and the condition of their components. Therefore, the staff finds that the U.S. EPR onsite dc power system meets the the guidance in RG 1.118 and the requirements of GDC 18.

8.3.2.4.6 Compliance with GDC 50

GDC 50 requires, in part, that the design of containment penetrations, including electrical penetrations containing circuits of the dc power system in containment structures, must withstand a LOCA without loss of mechanical integrity. In order to satisfy this requirement, the penetration assemblies in containment structures must be capable to withstand all ranges of overload and short circuit currents up to the maximum fault current vs. time conditions that could occur given single random failures of circuit protective devices. The compliance of containment electrical penetration assembly design, qualification, and protection has been reviewed and evaluated under Section 8.3.1 of this report. The design provisions described in that section apply to the onsite dc power circuits. All U.S. EPR containment electrical penetration assemblies for onsite Class 1E ac and dc systems are designed, constructed, and qualified in accordance with IEEE Std 242-1986, "IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems," IEEE Std 317-2003, "IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations," and IEEE Std 741-1986, "IEEE Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations." These IEEE Standards are endorsed by RG 1.63, and the staff finds that the applicant's commitment to follow these standards in the design of electric penetration assemblies provides assurance that a LOCA will not cause the electrical penetrations of a containment structure to exceed the design leakage rate, thus limiting the consequences of a LOCA as prescribed by GDC 50.

8.3.2.4.7 Compliance with 10 CFR 50.55a(h)

10 CFR 50.55a(h) requires compliance with the relevant positions for plant protection and safety systems on design, reliability, qualification, and testability of the power and I&C portions of the protection and safety systems outlined in IEEE Std 603-1991 and IEEE Std 603-1998. The safety and protection systems of the applicant's onsite dc power system design are based on IEEE Std 603, which will be confirmed by the electrical distribution system protection and coordination studies, and verified via ITAAC (see FSAR Tier 1, Table 2.5.2-3, "Class IE Uninterruptible Power Supply ITAAC"). Accordingly, the staff finds that the U.S. EPR onsite dc power system design will meet the requirements of 10 CFR 50.55a(h). The aspects of IEEE Std 603 that apply to the adequacy of I&C are evaluated in Chapter 7 of this report.

8.3.2.4.8 Compliance with 10 CFR 50.63

As discussed below, the applicant has met the requirements of 10 CFR 50.63 with respect to the onsite dc power system. In particular, 10 CFR 50.63 requires, in part, that the specified station blackout duration be based on the redundancy and reliability of the emergency onsite dc power sources. The dc power systems have adequate capability and capacity to enable the plant to withstand and recover from an SBO event of specified duration. See Section 8.4.4.1 of this report for the staffs' evaluation of this matter, with the exception of battery capacity and capability, which is discussed below.

8.3.2.4.8.1 *Conformance to RG 1.155*

FSAR Tier 2, Section 8.3.2.2.8 states conformance to RG 1.155. RG 1.155 relates to the capability and the capacity of the applicant's onsite dc power system for an SBO, including batteries associated with the operation of the AAC power source(s). At the start of an SBO, the U.S. EPR design provides 2-hour rated safety-related batteries to supply dc power to safety-related inverters and their critical loads including I&C and dc control power. During the onset of SBO, the EUPS and 12UPS maintain control power to I&C systems and distribution system equipment that is used for SBO mitigation where: (1) The EUPS provides power to the main steam relief isolation valves, main steam relief control valves, and containment isolation valves that are operated during an SBO event; (2) the EUPS provides power to the RCP standstill seal system and seal leak off line isolation valves once the RCPs have coasted to a stop (to reduce reactor coolant system inventory loss); and (3) the 12UPS also provides control power for SBODG starting and alignment to EPSS buses to establish power to those systems necessary for safe shutdown. EUPS battery chargers are loaded onto the SBODGs when EPSS buses are re-energized. Therefore, the U.S. EPR EUPS system maintains power to the EUPS loads throughout the SBO event.

The FSAR states that IEEE Std 485-1997, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications" will be used for sizing EUPS and 12UPS batteries. IEEE Std 485 calls for consideration of SBO loads along with the lowest expected battery temperature under normal conditions. Since batteries provide the least power at their lowest operating temperature, they will be appropriately sized if this guidance is followed. This is verified in FSAR Tier 1, Section 2.5.2, "Class 1E Uninterruptible Power Supply," and Section 2.5.11, "12-Hour Uninterruptible Power Supply System." These ITAAC will verify that the applicant's onsite dc power system, as related to batteries, as installed, will ensure the U.S. EPR standard design will be able to withstand or cope with, and recover from, an SBO by providing capability for maintaining core cooling and an appropriate level of containment integrity.

Based on the above, the capacity of any onsite dc sources used for SBO response is adequate to address the SBO load profile and specified duration to meet the requirements of 10 CFR 50.63. Therefore, the staff finds that the U.S. EPR onsite dc power system batteries conform to RG 1.155.

8.3.2.4.9 Compliance with 10 CFR 50.65(a)(4)

Under 10 CFR 50.65(a)(4), COL applicants assess and manage the increase in risk that may result from proposed maintenance activities for onsite dc power equipment before performing the maintenance activities. These activities include surveillances, post maintenance testing, and corrective and preventive maintenance. The FSAR states that compliance and acceptability with the maintenance rule according to RG 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," and RG 1.182, "Assessing and Managing Risk before Maintenance Activities at Nuclear Power Plants," is characterized under FSAR Tier 2, Chapter 17.

In RAI 183, Question 08.03.01-20, the staff requested that the applicant provide the description of the program that implements 10 CFR 50.65 in FSAR Tier 2, Section 17.6. In a March 27, 2009, response to RAI 183, Question 08.03.01-20, the applicant referenced FSAR Tier 2, Table 1.8-2, COL Information Item 17.6-5, which states: "A COL applicant that references the U.S. EPR design certification will describe the program for maintenance risk assessment and management in accordance with 10 CFR 50.65(a)(4). Since the removal of multiple SSCs from service can lead to a loss of Maintenance Rule functions, the program description will address how removing SSCs from service will be affected. For qualitative risk assessments, the program description will explain how the risk assessment and management program will preserve plant specific key safety functions." Since the description of a Maintenance Rule program is the COL applicant's responsibility, and the COL information item is referenced in FSAR Tier 2, Table 1.8-2, COL Information Item 17.6-5, the staff finds that the applicant addressed adequately the issue and, therefore, considers this issue resolved.

8.3.2.4.10 Conformance to RG 1.206

This regulatory guide provides guidance regarding the information to be submitted in an application for a nuclear power plant. The applicant has performed numerous electrical power system calculations and distribution system studies for dc systems, described in FSAR Tier 2, Section 8.3.2.3. The electrical power system calculations and distribution system studies utilized ETAP, Nuclear Version 5.5.6N to analyze the dc distribution system for load flow and voltage regulation, short-circuit studies and motor starting studies. ETAP has been qualified to 10 CFR Part 50, Appendix B; 10 CFR Part 21; and ASME NQA-1, ISO 9001. The following are the dc electrical power system calculations and distribution system studies performed for the U.S. EPR:

- Load flow and Under/Overvoltage Protection
- Short-Circuit Studies
- Equipment Sizing Studies
- Equipment Protection and Coordination Studies

In RAI 11, Question 08.03.02-3, the staff requested that the applicant provide the results of dc load flow calculations and the assumptions used to demonstrate the adequacy of bus voltage values with these system loads. In an October 15, 2008, response to RAI 11, Question 08.03.02-3, the applicant provided the load flow calculation results that determine the voltage level at the battery terminals, dc switchboards, and inverters during the largest loading demand, as determined by the EUPS battery duty cycle developed in accordance with IEEE Std 485-1997(R2003). Final dc load flow calculations show that adequate voltage is available throughout the EUPS two hour battery duty cycle duration (based on safety analysis assumptions) and battery charging conditions are within the design rating. The final dc load flow analysis that supports the adequacy of the dc onsite power system will be provided in FSAR Tier 1, Section 2.5.2, ITAAC Item 5.12. Accordingly, the staff finds that the applicant has adequately addressed the issue. The staff considers this issue resolved.

In RAI 11, Question 08.03.02-4, the staff requested that the applicant provide the results of the dc short circuit calculations to determine the applicable circuit breaker interrupting ratings, and maximum bus bracing current capabilities. The staff also asked why the dc protection and coordination studies were not performed. In a July 16, 2008, response to RAI 11, Question 08.03.02-4, the applicant responded that the Class 1E EUPS dc short-circuit analysis was performed to determine dc equipment ratings based upon available short-circuit fault current. The available short-circuit current fault values are 38.73 kA for 31BUC and 34BUC and 29.25 kA for 32BUC and 33BUC as per preliminary design calculations. Final short-circuit current fault values will be determined with parameters obtained from procured equipment when any loads are changed. As described in FSAR Tier 2, Section 8.3.1.1.3, coordination studies will be conducted in accordance with IEEE Std 242-2001 to verify the protection feature coordination capability to limit the loss of equipment due to postulated fault conditions. Since the equipment is not yet procured, the results are unavailable. The applicant responded that the protection feature coordination capability guidance of IEEE Std 242-2001 will be used to perform the equipment protection and coordination studies, in conformance to RG 1.206. The studies will be completed prior to placing the electrical equipment in service and will be verified by FSAR Tier 1, Table 2.5.2-3, Item 5.16. Since performance of the ITAAC will ensure the studies are completed in accordance with acceptable methodology, the staff finds that the applicant has adequately addressed the issue. The staff considers this issue resolved.

In RAI 11, Question 08.03.02-5, the staff requested that the applicant provide a summary of the sizing calculations for battery, charger, inverter, switchgear bus, breakers, panels, and cables, and assumptions used. In a September 30, 2008, response to RAI 11, Question 08.03.02-5, the applicant responded that battery sizing assumptions and calculation summaries for the EUPS and the 12UPS were performed in accordance with IEEE Std 485-1997(R2003). The battery charger sizing calculation was performed in accordance with IEEE Std 946-2004, “IEEE Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations.”

The applicant also provided sizing calculations for the inverters, switchgear buses, breakers, panels and cables. Accordingly, the staff finds that the applicant has adequately addressed the sizing calculation issues. In FSAR Tier 2, Sections 8.3.2.1 and 8.3.2.3.3, and Table 8.3-11, the applicant also provided revisions to correct the time considered to recharge the battery from a fully discharged state and the number of cells for the 12UPS batteries. The staff finds that the applicant has adequately addressed this issue. The staff confirmed that the revised FSAR contains the change as committed to in the RAI response. The staff considers these issues resolved.

In accordance with RG 1.206, FSAR Tier 2, Section 8.3.2.3 adequately addressed the dc system studies and analyses. As discussed above, the staff finds that the studies will be completed prior to placing the electrical equipment in service and will be verified by FSAR Tier 1, Table 2.5.2-3, Item 5.16. Since performance of the ITAAC will ensure the studies are completed in accordance with acceptable methodology, the staff considers this acceptable.

8.3.2.4.11 Conformance to the NRC Interim Staff Guidance JLD ISG 2012-01 for mitigation strategies for beyond design-basis external events

The background to JLD-ISG-2012-01 is set forth above in Section 8.3.1.4.17 of this report. To address the issues raised in NTTF Recommendations 4.1 and 4.2, as restated in EA-12-049, the applicant developed ANP-10329, Revision 0, "U.S. EPR Mitigation Strategies for an Extended Loss of AC Power Event Technical Report." In accordance with ANP-10329, Revision 0, the applicant has revised FSAR Tier 2, Section 8.3.2.1.1.1 "General," under Section 8.3.2.1.1, "Class 1E Uninterruptible Power Supply System." In FSAR Tier 2, Section 8.3.1.1.1, the applicant describes the capability of the EUPS design to remotely isolate non-essential loads during an ELAP event and to extend battery cycle capability beyond the 2 hours credited in the safety analysis for the safety-related batteries. The applicant states that the cycle extension provides adequate time to repower the EUPS electrical division(s) relied upon during an ELAP through alternate means. FSAR Tier 2, Figure 8.3-5, "Class 1E Uninterruptible Power Supply System Single Line Drawing," depicts the ac and dc load shed buses that are provided for each EUPS division. The staff verified that the system depicted on FSAR Tier 2, Figure 8.3-5 is capable of accomplishing the load shed relied upon in this proposed mitigation strategy, and confirmed through an August 2013 audit that the design feature supports extension of battery cycle capability beyond the 2 hours credited in the safety analysis for the safety-related batteries (see Audit Report ADAMS ML14153A517).

The staff's comprehensive review of the applicant's proposals in conformance to JLD-ISG-2012-01 will be documented in Chapter 20 of this report. Chapter 20 of this report will describe the staff's evaluation and findings regarding the NTTF recommendations that are applicable to the AREVA U.S. EPR design. The applicable recommendations will address three topics: mitigation strategies for beyond-design-basis external events (related to Recommendations 4.1 and 4.2); SFP instrumentation (related to Recommendation 7.1); and emergency preparedness staffing and communications (related to Recommendation 9.3). For more information on this review topic please see Chapter 20 of this report.

8.3.2.5 *Combined License Information Items*

Table 8.3.2-1 provided below lists the dc onsite power system COL information item numbers and descriptions from FSAR Tier 2, Chapter 8, Section 8.3.2 and Chapter 1, Table 1.8-2:

Table 8.3-2 U.S. EPR Combined License Information Items for Onsite dc Power System

Item No.	Description	FSAR Tier 2 Section
8.1-2	A COL applicant that references the U.S. EPR design certification will identify site-specific loading differences that raise Class 1E battery loading, and demonstrate the electrical distribution system is adequately sized for the additional load.	8.1.3

8.3.2.6 *Conclusions*

As set forth above, the staff has reviewed all of the relevant information that is applicable to the U.S. EPR onsite dc power system design and evaluated is compliance with GDC 2, GDC 4, GDC 5, GDC 17, GDC 18, and GDC 50, and conformance to RGs, standards, and BTPs committed to by the applicant. The staff also reviewed the COL information items in FSAR Tier 2, Table 1.8-2. The staff concludes that the applicant has provided sufficient information in the FSAR and identified necessary analyses to support the bases for their conclusions of their onsite dc power system design for the COL applicant. The staff concludes that the design of the U.S. EPR onsite dc power system meets the appropriate regulatory requirements listed in Section 8.3.2.3 of this report, and shown in the staff technical evaluations in Sections 8.3.2.4 and combined license information items in Section 8.3.2.5 of this report.

8.4 Station Blackout

As described below, the U.S. EPR electric power system is designed to provide reliable electric power from the AAC source to provide for the safe shutdown of the reactor.

8.4.1 Introduction

The applicant has provided an introductory system description in FSAR Tier 2, Section 8.4, “Station Blackout,” provided here, in part, as follows:

> The term SBO refers to a complete loss of ac electric power to the non-safety-related and safety-related switchgear buses. An SBO involves a loss of the offsite electric power system (preferred power system) occurring at the same time the EDGs are unavailable. An SBO does not include loss of available ac power to buses fed by station batteries through inverters or by AAC sources specifically provided for SBO mitigation.

8.4.2 Summary of Application

FSAR Tier 1: The FSAR Tier 1 information associated with this section is found in FSAR Tier 1, Section 2.5.3. The applicant states that the two station SBODGs are provided as the AAC source to provide power to station loads necessary to bring the plant to and maintain the plant in a safe shutdown condition during SBO conditions.

FSAR Tier 2: The applicant has provided an FSAR Tier 2 system description in Section 8.4 provided here, in part, as follows:

The U.S. EPR includes an AAC source that has been designed in accordance with 10 CFR 50.63 and RG 1.155. NUMARC 87-00, “Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors” was used for clarification, as permitted by RG 1.155. Specifically, two separate and independent non-safety-related SBODGs are provided to mitigate a postulated SBO. The SBODGs have the capacity and capability to bring the plant to and maintain the power plant in a non-DBA safe shutdown condition without any support systems powered from the preferred power supply (offsite grid) or EPSS. Safe shutdown (non-DBA) means bringing the plant to those shutdown conditions specified in the U.S. EPR technical specifications as “hot standby.”

ITAAC: The ITAAC associated with FSAR Tier 2, Section 8.4, are given in FSAR Tier 1, Section 2.5.3, Table 2.5.3-2, “Station Blackout Alternate AC Source Inspections, Tests, Analyses, and Acceptance Criteria.”

Technical Specifications: There are no Technical Specifications for this area of review.

Conceptual Design: FSAR Tier 2, Section 1.8 contains conceptual design information that is outside the scope of the EPR certification related to the following systems:

- The Switchgear Building. Conceptual design information for this structure is included in Section 1.2, Section 8.3, and Section 8.4.

U.S. EPR Plant Interfaces: FSAR Tier 2, Table 1.8-1 contains information related to the following plant interfaces that will be addressed in the COL designs:

- A COL applicant that references the U.S. EPR design certification will provide site-specific information that identifies any additional local power sources and transmission paths that could be made available to re-supply the power plant following a loss of offsite power (LOOP).

8.4.3 Regulatory Basis

The relevant requirements of NRC regulations related to station blackout, and the associated acceptance criteria are given in NUREG-0800, Section 8.4, and are summarized below.

1. 10 CFR 50.63, as it relates to the establishment of a reliability program for emergency onsite ac power sources and the use of the redundancy and reliability of DG units as a factor in limiting the potential for SBO events.

2. 10 CFR 50.65 (a)(4), as it relates to the assessment and management of the increase in risk that may result from proposed maintenance activities before performing the maintenance activities for the SBO equipment. These activities include, but are not limited to, surveillances, post-maintenance testing, and corrective and preventive maintenance. Compliance with the maintenance rule, including verification that appropriate maintenance activities are covered therein, is reviewed under NUREG-0800, Chapter 17. Programs for incorporation of requirements into appropriate procedures are reviewed under NUREG-0800, Chapter 13.

Acceptance criteria adequate to meet the above requirements include:

1. RG 1.155, as it relates to compliance with 10 CFR 50.63. NUMARC 87-00, Revision 0, also provides guidance acceptable to the staff for meeting these requirements. RG 1.155, Table 1 provides a cross-reference to NUMARC 87-00, Revision 0, and notes when the RG takes precedence.

2. RG 1.9 and RG 1.155, as they relate to the reliability program implemented to ensure that the target reliability goals for onsite EDG power sources are adequately maintained.

3. RG 1.160, as it relates to the effectiveness of maintenance activities for onsite EDG power sources, including grid-risk-sensitive maintenance activities (i.e., activities that tend to increase the likelihood of a plant trip, increase LOOP frequency, or reduce the capability to cope with a LOOP or SBO). Compliance with the maintenance rule, including verification that appropriate maintenance activities are covered therein, is reviewed under SRP Chapter 17.

4. RG 1.182, as it relates to conformance to the requirements of 10 CFR 50.65(a)(4) for assessing and managing risk when performing maintenance.

8.4.4 Technical Evaluation

The staff has reviewed whether the applicant's design complies with 10 CFR 50.63, which relates to the capability to withstand and recover from an SBO. The term SBO refers to the complete loss of ac electric power to the essential and nonessential switchgear buses in a nuclear power plant. An SBO does not include the loss of available ac power to buses fed by station batteries through inverters or by AAC sources specifically provided for SBO mitigation.

8.4.4.1 *Compliance with 10 CFR 50.63*

The SBO Rule (10 CFR 50.63) requires nuclear power plants to withstand and recover from an SBO condition lasting for a specified duration. As explained below, the U.S. EPR includes an AAC source that has been designed to perform this function in accordance with 10 CFR 50.63 based on the guidance provided in RG 1.155. FSAR Tier 2, Section 8.4.2.6, states conformance to RG 1.155. The applicant demonstrates conformance to RG 1.155 as follows:

8.4.4.1.1 SBO Coping Duration

The SBO Rule requires each plant to maintain adequate core cooling and appropriate containment integrity during an SBO. RG 1.155, Section C.3.1, presents a method acceptable for determining the specified duration for which a plant should be able to withstand an SBO.

The maximum SBO coping duration for the U.S. EPR was determined using RG 1.155, Section C.3.1, Table 2, "Acceptable Station Blackout Duration Capability Hours." Three factors were considered for the evaluation: (1) Redundancy of the onsite emergency ac (EAC) power sources, since the applicant's design relies on one of four emergency power sources for decay heat removal, and Emergency ac Power Configuration Group A is selected from RG 1.155, Table 3; (2) selection of the EDG reliability target, where two EDG reliability targets (0.95, or 0.975) are available from RG 1.155, Section C.1.1, and the lower EDG reliability target value of 0.95 is selected for U.S. EPR; and (3) site-specific expected frequency of LOOP events, where the applicant selected the most conservative offsite power design characteristic group, P3, from RG 1.155, Table 4, "Offsite Power Design Characteristic Groups." Therefore, the probable time needed to restore offsite power, based on using RG 1.155, Table 2, results in a worst-case duration of 8 hours. Thus, the applicant's design has enveloped an 8-hour coping duration based on the worst case site conditions. Since the applicant chose the most conservative analytical assumptions recommended in RG 1.155, the staff finds that the 8-hour SBO coping duration for the U.S. EPR design conforms to the guidance provided in RG 1.155, Section C.3.1. However, this does not prevent a COL applicant from proposing a different SBO coping duration based on site-specific information. A COL applicant seeking to use a shorter coping duration would have to justify the duration sought in its COL application, in accordance with the applicable change process.

In RAI 70, Question 08.04-5, the staff questioned whether consideration of the redundancy of the onsite Class 1E emergency power supply system (i.e., EAC) was appropriate in determining the SBO coping duration. Since the onsite power distribution system is not 100 percent redundant among four divisions, the staff asked whether the selection of the EAC Power Configuration Group should be “B,” instead of “A,” under RG 1.155, Section C.3.1. In a November 3, 2008, response to RAI 70, Question 08.04-5, and during a meeting on April 2, 2009, the applicant clarified that each EDG can power equipment capable of removing decay heat to achieve and maintain safe shutdown. On this basis, the staff concurs with the applicant that the correct EAC Power Configuration Group should remain “A,” as provided in FSAR Tier 2, Section 8.4.2.6.1. Therefore, the staff has determined that the applicant’s selected 8-hour coping duration for the applicant’s design conforms to the guidance in RG 1.155, Section C.3.1. Accordingly, the staff finds that the applicant has adequately addressed the issue, since the applicant’s design has enveloped an 8-hour coping duration based on the guidance provided in RG 1.155. The staff considers this issue resolved.

8.4.4.1.2 SBO Coping Capability

In determining that the capability to cope with an SBO lasting for the specified 8- hour duration conforms to the guidance in RG 1.155, Section C.3.2, the applicant has selected the AAC approach. This involves installing an independent AAC power source, where it will be available in a timely manner after the onset of SBO and can be manually connected to one or all of the redundant safety buses as necessary to power all equipment to achieve and maintain safe shutdown. Pursuant to RG 1.155, the time necessary for making this equipment available should not exceed 1 hour and should be demonstrated by test. In addition, if tests can show the AAC power source will be available in less than 10 minutes, no coping analysis is needed.

The applicant selected two SBODGs for the AAC power source. Both SBODGs will automatically start and manually align to their respective buses from the MCR within 10 minutes. Also, sufficient controls, indications, and alarms are available in the MCR and at the local control panel to start the SBODGs from each of those locations. Lists of alarms and indications are provided in FSAR Tier 2, Table 8.4-3. Since the AAC power source can be available in less than 10 minutes, no SBO coping analysis is needed.

In RAI 70, Question 08.04-7, the staff requested that the applicant clarify whether operator action alone during an SBO event is adequate to maintain coolant inventory without the makeup water system, as shown on SBO timeline event No. 4. In a December 18, 2009, response to RAI 70, Question 08.04-7, the applicant provided details that show the operator actions to be taken to limit the reactor coolant inventory losses are: (1) Terminating letdown flow at the onset of the SBO event by automatic action; and (2) maintaining RCS sampling and pressurizer degasification flows for the eight-hour SBO coping period. The applicant responded that these flows will maintain coolant inventory without the makeup water system for an SBO event and will not adversely affect successful mitigation of the SBO. In addition, FSAR Tier 2, Section 8.4.2.6.2, was revised to indicate the letdown flow is terminated automatically at the beginning of the SBO event. Since coolant inventory without the makeup water would not adversely affect successful mitigation of SBO, the staff finds that the applicant has adequately addressed the issue. The staff confirmed that the revised FSAR contains the change as committed to in the RAI response. The staff considers this issue resolved.

The staff also requested that the applicant clarify whether brief temperature exceedance (briefly exceeding 50 °C (122 °F) before heating, ventilation, and air conditioning [HVAC] is restored) in the Safeguard Building (SB) areas would damage any equipment. In a December 18, 2008, response to RAI 70, Question 08.04-7, the applicant also indicated that no equipment damage will result from the referenced temperature excursion. This temperature excursion will take place during the assumed 15 minutes for HVAC restoration in Divisions 1 and 4, and 21 minutes in Divisions 2 and 3, respectively. The limited time without HVAC in these areas limits the potential temperature rise and equipment heat up, and this would prevent equipment damage. To ensure adequate protection of the equipment from heat up, the SB room heat up model was used to evaluate a bounding worst-case condition. The result from the use of conservative estimates by the applicant, based on heat loss from lighting, external ambient temperature, zero radiation heat transfer, and zero equipment heat capacity, indicates that over-temperature conditions occur only in selected areas and for a brief period of time, therefore equipment damage is not expected to occur. Accordingly, the staff finds that the applicant has adequately addressed the issue. The staff considers this issue resolved.

The staff finds that SBO coping capability for the U.S. EPR conforms to the guidance provided in RG 1.155, Section C.3.2, since the design includes an independent AAC power source that will be available in a timely manner (10 minutes as discussed below in Section 8.4.4.1.3) after the onset of an SBO.

8.4.4.1.3 AAC Power Sources

The U.S. EPR AAC power sources for SBO are diesel generators with continuous ratings of 3,900 kW (or greater). The design provides two full capacity AAC power sources of diverse design, capable of powering at least one complete set of normal safe shutdown loads. Each SBODG has sufficient capacity to power equipment capable of bringing the plant to and maintaining the plant in a safe shutdown (i.e., hot standby) condition so as to continue core cooling and to maintain containment integrity during an SBO. The staff's reviewed the loads and calculated the total load represented by this equipment. The total estimated load is less than 3,900 kW, which is less than the continuous rated capacity of a single AAC diesel. In addition, the AAC power sources selected (i.e., SBODG) for the U.S. EPR conform to the following guidance provided in RG 1.155, Section C.3.3:

- The AAC power sources are not normally directly connected to the preferred or the onsite emergency power system. The SBODGs are normally not running. Two breakers exist between each SBODG and the nearest Class 1E bus.

- There is a minimum potential for common cause failure with the preferred or the onsite EDG power sources. No single-point vulnerability exists whereby a weather-related event or single active failure could disable any portion of the blacked-out unit's onsite sources and simultaneously fail the AAC power sources. The SBODGs are installed in a non-seismically designed building, housing non-safety-related components. The SBODG failures cannot affect systems required for a DBA. Also, there is no sharing of AAC power sources between a U.S. EPR plant and other units on the same site.

- The AAC power sources can be connected to their associated EPSS buses within 10 minutes after the onset of SBO. When an SBO condition occurs, load and source breakers will be opened on the SBODG bus to separate the SBODG from other power sources and to reduce the possibility of immediately connecting the non-Class 1E load to less than the machine rating (loads are typically 25 to 30 percent of the machine continuous rating). The SBODGs will then start automatically. If the SBODGs fail to start automatically, they can be manually started from the MCR. One AAC power source is capable of manual connection to the Division 1 and Division 2 safety buses. The other AAC power source is capable of manual connection to the Division 3 and Division 4 safety buses. After the generators are connected to their respective Class 1E 6.9 kV buses, safe shutdown loads are added manually.

- The AAC power source has sufficient capacity and will be maintained with a minimum fuel supply to operate the systems necessary for 24 hours of continuous operation, adequate to cope with an SBO for the eight hour coping duration to bring the plant to and maintain the plant in a safe shutdown condition.

FSAR Tier 2, Section 8.4.2.6.3 stated that the AAC power source conforms to diversity guidance in RG 1.155, Regulatory Position 3.3.5. This is accomplished by specifying and selecting equipment, including the engine, generator, and primary support equipment, that is different from the corresponding EDG equipment. Programs exist to periodically inspect, test, and maintain the AAC power system to ensure that it meets or exceeds the 0.95 AAC power source reliability target. RG 1.9 refers to safety-related EDGs, but is not directly applicable to the SBODGs. However, the reliability program implemented to ensure that target reliability goals for onsite EDGs prescribed in RG 1.9 will be used as guidance in the SBODG testing program described in FSAR Tier 2, Section 8.4.2.5.

In RAI 11, Question 08.04-3, the staff requested that the applicant elaborate on how engine, generator, and primary support equipment for the SBODG and EDG types are diversely designed to avoid a common mode failure. In a July 16, 2008, response to RAI 11, Question 08.04-3, the applicant responded with differences between the SBODG and the EDGs, such as engine sizes (9,500 kW vs. 3,900 kW), models, and physical locations, and described that they do not share control power, heating, ventilation, air conditioning, engine cooling, or fuel systems. Most importantly, the cooling system for EDG heat transfer utilizes a water-to-water heat exchanger, while the corresponding system for the SBODG transfers heat from water-to-air through a radiator. The response concluded that there are no weather-related events or single active failures that can simultaneously disable both SBODG and EDG. Since the SBODGs and EDGs are diversely designed, their susceptibility to a common mode failure is reduced. Accordingly, the staff finds that the applicant adequately addressed the issue. The staff considers this issue resolved.

With respect to evolutionary advanced light-water (ALWR) or evolutionary reactors, the staff discussed issues relating to SBO in SECY-90-016, "Evolutionary Light Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements," and SECY-94-084, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs." In these SECY papers, the staff proposed a policy that such plants should have an AAC power source of diverse design and capable of powering at least one complete set of normal shutdown loads. SECY-94-084 indicated that the AAC power source should be of full capacity, and be able to bring the plant to a cold shutdown. The AAC power source (SBODG) proposed by the applicant is not a full capacity AAC source, and is not capable of bringing the plant to a cold shutdown.

This position is formalized in SECY 91-078, on Chapter 11 “Electric Power Systems” of EPRI Utility Requirements Document for the evolutionary ALWR. The EPRI Utility Requirements Document includes a combustion turbine (CT) for non-safety loads as an alternate power source. The CT would provide additional margin for abnormal events based on operational experience. Thus, the evolutionary ALWR onsite power system under the EPRI document design consists of: (1) Two EDGs to support two divisions of safety loads, and (2) a large CT generator for all non-safety loads. The bases for adding a CT for the evolutionary ALWR are: (1) Feeding permanent non-safety loads during LOOP events; (2) coping with an SBO (AAC); and (3) backing up the EDGs in case they fail or are unavailable. Therefore, the CT capacity for the evolutionary ALWR would be large enough to bring the plant to a cold shutdown.

In RAI 11, Question 08.04-1 and RAI 70, Question 08.04-8, the staff requested that the applicant clarify their plans to address the above SECY guidance with respect to SBODG sizing. In a July 16, 2008, response to RAI 11, Question 08.04-1 and a December 18, 2008, response to RAI 70, Question 08.04-8, the applicant stated that SECY 94-084 is for passive plant design, and the ALWR onsite power system configuration system (i.e., two divisions) is not applicable to the U.S. EPR plant. It further stated that the above SECY guidance is for the evolutionary ALWR and the above normal shutdown loads do not clearly define the desired end state operating mode (i.e., cold shutdown). 10 CFR 50.2 defines AAC power source and safe shutdown for SBO. The applicant follows the safe shutdown definition for SBO which means bringing the plant to hot standby or hot shut down, defined by the plant technical specifications. In addition, in a December 18, 2008, response the applicant stated that the SBO core damage frequency for the U.S. EPR (i.e., 3.0 E-8/yr) is lower than the industry average of 3.0 E-6/yr. The response also noted that there are no updates to NRC regulations or guidance documents for SBO, as a result of the above SECY position. The staff has determined that a full capacity AAC source (i.e., capable of bringing the plant to cold shutdown) is not required by 10 CFR 50.63. Accordingly, the staff finds that the applicant had adequately addressed the issue. The staff considers this issue resolved.

In addition, for the reasons described above, the staff finds that the diversity in engine size, model, and cooling system for the U.S. EPR SBODG (3,900 kW) AAC power sources conforms to the diversity guidance in RG 1.155, Section 3.3.5.

8.4.4.1.4 Procedures and Training to Cope with SBO

The FSAR includes a statement, “A COL applicant that references U.S. EPR design certification will address the RG 1.155 position related to procedures and training to cope with SBO.” It is reflected as FSAR Tier 2, Table 1.8-2, COL Information Item 8.4-2.

In RAI 11, Question 08.04-4, the staff requested that the applicant clarify whether the procedures and training shown as Item 8.4-2 of FSAR Tier 2, Table 1.8-2, should, in coping with an SBO, include Regulatory Position C.1.3 for EDG emergency power restoration, Regulatory Position C.2 for offsite power restoration, and Regulatory Position C.3.4 guidance on operator actions to cope with SBO. In RAI 216, Question 08.04-9, the staff requested that the applicant also clarify whether FSAR Tier 2, Table 1.8-2 should include C.1.3 and C.2, or provide justification for any exception. In an April 16, 2009, response to RAI 11, Question 08.04-4, the applicant revised FSAR Tier 2, Section 8.4.2.6.4 and FSAR Tier 2, Table 1.8-2 to add those two positions. This response resulted in revisions to FSAR Tier 2, Section 8.4.2.6.4 and FSAR Tier 2, Table 1.8-2 to state RG 1.155 guidance that includes the above three RG Positions. Since the COL applicant will address restoration of the onsite and offsite power sources, the staff finds that the applicant adequately addressed the issue. The staff confirmed that the revised FSAR contains the change as committed to in the RAI response. Accordingly, the staff considers this issue resolved.

Based on the analyses performed according to the guidance of RG 1.155 as it relates to compliance with 10 CFR 50.63, as explained above, the staff finds the U.S. EPR design will be capable to withstand and recover from an SBO event, and therefore complies with 10 CFR 50.63.

8.4.4.2 *10 CFR 50.65(a)(4) –Requirements for Monitoring the Effectiveness of Maintenance of Nuclear Power Plants*

10 CFR 50.65(a)(4) relates to the assessment and management of the increase in risk that may result before performing the SBO maintenance activities. These activities include surveillances, post maintenance testing, and corrective and preventive maintenance. The applicant states that 10 CFR 50.65(a)(4) is applicable to systems provided to mitigate an SBO. Compliance with the maintenance rule according to RG 1.160, including verification that appropriate maintenance activities are covered, is reviewed under NUREG-0800, Chapter 17. Acceptability of the program is based on meeting the relevant positions of RG 1.182, "Assessing and Managing Risk before Maintenance Activities at Nuclear Power Plants." Since the applicant's risk-informed evaluation process has shown the SBO equipment to be significant to public health and safety, it will be monitored as part of the reliability assessment program described in Section 17.4 of this report and the maintenance rule implementation program described in Section 17.6 of this report.

The staff has reviewed the above two sections and finds it acceptable for a COL applicant that references the U.S. EPR to provide the programs for maintenance risk assessment and for maintenance rule implementation in accordance with 10 CFR 50.65(a)(4). A similar response to RAI 183, Question 08.03.01-20, for onsite ac power system for 10 CFR 50.65(a)(4) compliance applies for SBO equipment. The staff's review is discussed in Section 8.2.4.5 of this report.

8.4.4.3 *Quality Assurance and Specifications for Non-Safety-Related Equipment*

RG 1.155, Regulatory Position C.3.5, Appendices A and B provide guidance on QA activities and specifications, respectively, for non-safety-related equipment used to meet the requirements of 10 CFR 50.63. The specific QA guidance is described in FSAR Tier 2, Chapter 17, "Quality Assurance and Reliability Assurance." Quality assurance measures applied to SBO equipment will be addressed by COL applicants. In addition, equipment installed to meet the SBO rule should not degrade the existing safety-related systems. This is accomplished by making the non-safety-related equipment as independent as practical from existing safety-related systems. As discussed in Section 8.3.1.4.4.5 of this report, regarding conformance to RG 1.75, SBO equipment is separated from safety-related equipment by isolation devices. Accordingly, the SBO equipment is independent from safety equipment in accordance with RG 1.155, Regulatory Position C.3.5 and RG 1.155, Appendix B.

8.4.5 Combined License Information Items

Table 8.4-1 provided below lists SBO COL information item numbers and descriptions from FSAR Tier 2, Chapter 8, Section 8.4.1 and Chapter 1, Table 1.8-2:

Table 8.4-1 U.S. EPR Combined License Information Items for Station Blackout

Item No.	Description	FASR Tier 2 Section
8.4-1	A COL applicant that references the U.S. EPR design certification will provide site-specific information that identifies any additional local power sources and transmission paths that could be made available to resupply the power plant following a loss of offsite power (LOOP).	8.4.1.3
8.4-2	A COL applicant that references the U.S. EPR design certification will address the RG 1.155 guidance related to procedures and training to cope with SBO.	8.4.2.6.4

8.4.6 Conclusions

The staff has evaluated the design of U.S. EPR with respect to station blackout against the guidelines of RG 1.155. For the reasons described above, the staff has determined that the U.S. EPR plant is capable of withstanding and recovering from a complete loss of ac electric power to essential and nonessential buses for the eight hours worst case coping period. The staff also reviewed the COL information items in FSAR Tier 2, Table 1.8-2. The staff concludes that the applicant has provided sufficient information in the FSAR and identified necessary analyses to support the bases for their conclusions of their SBO system design for the COL applicant. Accordingly, the staff finds that the FSAR demonstrates that the plant design is in compliance with the provisions of 10 CFR 50.63, and 10 CFR 50.65, as they relate to the capability to achieve and maintain safe shutdown in the event of an SBO, as shown in the staff technical evaluations in Section 8.4.4 and Combined License Information Items in Section 8.4.5 of this report.