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MFN 08-917

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U.S. Nuclear Regulatory Commission
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Rockville, MD 20852

Subject: **Response to Portion of NRC Request for Additional Information Letter 249 - Related to ESBWR Design Certification Application - RAI Number 14.3-394 S01**

The purpose of this letter is to submit the response to Nuclear Regulatory Commission (NRC) Request Additional Information (RAI) number 14.3-394 S01.

The response to RAI 14.3-394 S01 is provided in Enclosure 1, based on the request in NRC Letter 249 (Reference 1). The original response was submitted in Reference 2, as requested by the NRC in Reference 3.

Please contact me should you have any questions concerning this submittal.

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

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NRO

References:

1. MFN 08-723 – Letter from Nuclear Regulatory Commission to Robert E. Brown (GEH) "*Request for Additional Information Letter No. 249 Related to ESBWR Design Certification Application,*" dated September 16, 2008

2. MFN 08-086 Supplement 67 - Response to Portion of NRC Request for Additional Information Letter No. 202 Related to ESBWR Design Certification Application ESBWR RAI Number 14.3-394, dated August 27, 2008

3. MFN 08-486 - Letter from Nuclear Regulatory Commission to Robert E. Brown (GEH) "*Request for Additional Information Letter No. 202 Related to ESBWR Design Certification Application,*" dated May 21, 2008

Enclosure:

1. MFN 08-917 – Response to Portion of NRC Request for Additional Information Letter No. 249 Related to ESBWR Design Certification Application - DCD Tier 1 - RAI Number 14.3-394 S01

cc:

AE Cubbage	USNRC (with enclosure)
RE Brown	GEH/Wilmington (with enclosure)
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eDRF	0000-0089-2282, Revision 2

Enclosure 1

MFN 08-917

Response to Portion of NRC Request for

Additional Information Letter No. 249
Related to ESBWR Design Certification Application
DCD Tier 1

RAI Number 14.3-394 S01

* Verified DCD changes associated with this RAI response are identified in the enclosed DCD markups by enclosing the text within a black box. The marked-up pages may contain unverified changes in addition to the verified changes resulting from this RAI response. Other changes shown in the markup(s) may not be fully developed and approved for inclusion in DCD Revision 6.

For historical purposes, the original text of RAI 14.3-394 and any previous supplemental text and GE/GEH responses are included preceding each supplemental response. Any original attachments or DCD mark-ups are not included to prevent confusion.

NRC RAI 14.3-394

NRC Summary:

Interface requirements for offsite power

Full Text:

Section 4, "Interface Material" of DCD, Tier 1, Rev. 4 of ESBWR design states that an applicant for a combined license (COL) that references the ESBWR certified design must provide design feature or characteristics that comply with the interface requirements for the plant design and inspections, tests, analyses, and acceptance criteria (ITAAC) for the site specific portion of the facility design, in accordance with 10 CFR 52.79(c). However, no interface requirements were identified for the offsite power system in the certified design. RG 1.206, CIII.7.2, Site-Specific ITAAC, recommends that applicants should develop ITAAC for the site-specific systems that are designed to meet the significant interface requirements of the standard certified design, that is, the site-specific systems that are needed for operation of the plant (e.g., offsite power).

As indicated in Section 8.1.5.2.4 of DCD, the ESBWR standard design complies with the requirements of GDC 17 with respect to two independent and separate offsite power sources. Therefore, an ITAAC is needed so that the NRC staff can verify that the required circuits from the transmission network satisfy the requirements of GDC 17 with regards to its capacity and capability regardless of its low risk significance in ESBWR design.

Revise Section 4 of DCD, Tier 1 to include interface requirements for the offsite power system. It is expected that site-specific ITAAC for offsite power will be provided by the COL applicants to satisfy the interface requirements.

GEH RESPONSE

ITAAC are provided in Tier 1, Section 2.13, "Electrical Systems," for safety-related / risk significant aspects of the electrical system for the ESBWR standard plant design. ITAAC 1 in Table 2.13.1-2 verifies the functional arrangement of the onsite AC power system according to Subsection 2.13.1, Table 2.13.1-1, and Figure 2.13.1-1. Figure 2.13.1-1 depicts the connections of the ESBWR standard plant design to the offsite power system. Thus, no plant-specific

ITAAC would be necessary for these design features covered by Tier 1, Section 2.13.

As discussed in DCD Tier 2, Section 3.1.2.8, "Criterion 17 – Electric Power Systems," the design of the offsite power systems is outside the scope of the ESBWR standard plant design. However, this section notes that DCD Tier 2, Section 8.2, "Offsite Power Systems," discusses which specific portions of GDC-17 apply to the offsite power system and how these are implemented to the design.

The ESBWR is a passive plant and does not rely on actively generated power for design basis event mitigation and therefore both onsite AC power and offsite power are provided by nonsafety-related system In NRC SRM 94-084, the Commission agreed with the staff recommendation that any regulatory oversight for the offsite power systems of passive advanced light water reactors would be determined using the RTNSS process. As part of the GEH ESBWR DCD development, Chapter 19 (PRA and Severe Accidents) determined that the offsite power system for the ESBWR does not meet the criteria to be considered as RTNSS.

Thus, with regards to GDC 17, the ESBWR reference plant design does not require offsite or diesel-generated AC power for 72 hours after an abnormal event. Safety-related DC power supports passive core cooling and containment safety-related functions. Accordingly, GDC-17 is not applicable to the offsite power system that interfaces with the ESBWR standard plant as related to the need to be available within a few seconds following a loss-of-coolant accident. Nor is offsite power necessary after anticipated operational occurrences to assure that specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded, as would be required by GDC-17 for non-passive plants.[1] Accordingly, there is no need for an interface requirement for demonstrating the capacity and capability of the offsite power systems.

However, as described in DCD Tier 2, the ESBWR offsite power system complies with the provisions in GDC-17 for the existence of two separate and independent offsite circuits. Also, as described in DCD Tier 2, these circuits are

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[1] As discussed in the preamble to 10 CFR Part 50, Appendix A, the General Design Criteria were established for the types of plants that were "similar in design and location to plants for which construction permits have been issued by the Commission." The preamble notes that "there may be water-cooled nuclear power units for which fulfillment of some of the General Design Criteria may not be necessary or appropriate." In the ESBWR design, some elements of the GDC are not directly applicable. For example, when GDC 17 was established by the 1971 rulemaking (36 Fed. Reg. 3255 (Febr. 20, 1971)), light-water reactors required a significant source of AC power within a few seconds following AOOs or accidents. Accordingly, the capability and capacity of the offsite power system needed to be evaluated in light of the significant transient placed on the grid (i.e. loss of a major baseload supply). That is not the case for the ESBWR design.

capable of providing power to the plant during plant operation and during plant shutdown conditions. In addition, DCD Tier 2, Section 8.2.4, specifies the COL Information that will be provided by the COL applicant in regards to the transmission system and the offsite power sources, including the following COL Information, as delineated in Tier 2, Section 8.2, Revision 5:

- The COL applicant will describe the transmission system.
- The COL applicant will describe the switchyard.
- The COL applicant will specify the normal preferred power voltage.
- The COL applicant will specify the alternate preferred power voltage.
- The COL applicant is responsible for switchyard protective relaying and will ensure such relaying is coordinated, reviewed, and accepted by the applicable grid reliability organization.
- The COL applicant will address switchyard DC power.
- The COL applicant will address switchyard AC power.
- The COL applicant will address switchyard transformer protection.
- The COL applicant will address the stability and reliability of the offsite transmission system.
- The COL applicant is responsible for the interface protocol requirements.

In accordance with NRC regulatory guidance (as referenced in the RAI), Section C.III.7.2 of RG 1.206, site-specific ITAAC should be included in a COL for site-specific systems that are needed "for operation of the plant (e.g., offsite power, circulating water system)." The guidance goes on to state that Tier 1 should include an interface requirement to "describe the significant design provisions for interfaces between the certified design and SSCs of the facility that are wholly or partially outside the scope of the certified design" and that the "interface requirements also define the significant attributes and performance characteristics that the portion of the facility that is outside the scope of the design certification must have in order to support the in-scope (standard) portion of the design." In addition, the NRC guidance explains that "the AP1000 DCD does not contain any interface requirements for site-specific elements of the facility outside the scope of the certified design because the AP1000 has passive safety functions and does not rely upon systems outside the scope of the certified design to perform any safety-related or safety-significant functions." As previously stated, the ESBWR is also a passive plant, thus the same approach was implemented for DCD Tier 1.

As stated in GEH response to RAI 16.0-1, the ESBWR offsite power system does not meet the criterion of 10 CFR 50.36, thus this system will not be included in plant technical specifications. No Technical Specification required surveillances or associated Limiting Condition for Operation will exist for the ESBWR plant offsite power supplies.

As stated in the DCD Tier 2, Subsection 8.2.3, 2nd bullet, "The normal preferred circuit and the alternate preferred circuit are electrically independent and are physically separated from each other."

Because the ESBWR design did not request an exemption to GDC 17, an interface item for the offsite power system features as related to GDC-17 will be added to Tier 1. This new section will reflect that – similar to the AP1000 – the offsite power connection is neither safety-related nor safety significant because the ESWBR is a passive plant.

Plant-specific ITAAC will be required that verifies the ESBWR plants comply with GDC 17 with regard to offsite power being supplied by two physically separated electrically independent circuits.

DCD Impact

DCD Tier # 1, Section 4 will be revised as noted in the attached markup.

NRC RAI 14.3-394 S01

In response to RAI 14.3-394, GEH revised DCD, Tier 1, Section 4, "Interface Material," to add a new Section 4.2, "Offsite Power," which included requirements for COL applicant to develop an ITAAC to verify by inspection that two physically independent circuits will supply electric power from transmission network to the onsite electric distribution system. GEH stated that "In the ESBWR, which is a passive plant, the offsite power system provides no safety-related function and there is no direct interface with any safety-related component." GEH concluded that there is no need for an interface requirement for demonstrating the capacity and capability of the offsite power system. The NRC staff disagrees. The offsite power system has a direct interface with safety-related battery chargers and UPS components as it supplies them power during normal, abnormal and accident conditions. Since ESBWR design is committed to the requirements of GDC 17, the capacity and capability of the offsite power source must be demonstrated. Based on the above, the COL applicant needs to assure the NRC staff that adequate voltages are available at the input terminals of safety-related UPS, battery chargers and at the 120 volt load terminals for proper operation of the safety-related equipments by performance of analyses of the onsite distribution system when powered from offsite power sources. Therefore, an interface requirement for demonstrating the capacity and capability of the offsite power system should be provided. Revise DCD, Tier 1, Section 4.2 accordingly.

GEH Response

GEH agrees the offsite power system has a direct interface with safety-related battery chargers and UPS components as it supplies them power during normal, abnormal and accident conditions.

New ITAAC for demonstrating the capacity and capability of the normal and alternate preferred power supplies have been added to DCD Tier 1, Subsection 2.13.1. Interface requirements for demonstrating the capacity and capability of the site-specific portions of the normal and alternate preferred power supplies have been added to Tier 1, new Section 4.2. Additional supporting information has been added to Tier 2, Chapter 8.

NUREG 0800 Standard Review Plan Sections 8.2 and 8.3 dictate the discussion of offsite power in DCD Tier 2, Section 8.2 and onsite power in DCD Tier 2, Section 8.3. This forms a natural break between offsite and onsite power as it is discussed in DCD Tier 2 Chapter 8, however it confuses the discussion related to the applicability of GDC-17.

To make the applicability of GDC-17 clearer, GEH has incorporated the Preferred Power Supply (PPS) definition into DCD Tier 2 Chapter 8 per IEEE 765. The PPS consists of the normal preferred and alternate preferred power sources and includes those portions of the offsite power system and the onsite power system

required for power flow from the offsite transmission system to the safety-related Isolation Power Centers (IPC) incoming line breakers. The DCD Tier 2, Chapter 8 text has also been revised to clarify that GDC-17 applies to the entire PPS and ITAAC in Tier 1 Subsection 2.13.1 have been added to address capacity, capability and the physical and electrical separation of the normal preferred and alternate preferred power supplies.

Separate ITAAC have been provided for the onsite portion of the PPS and the feeders between the Plant Investment Protection (PIP) buses and the IPC safety-related incoming line breakers. This distinction has been made since the normal preferred and alternate preferred power supplies end at the PIP buses. The IPC bus supplies are referred to as normal and alternate supplies, not normal preferred and alternate preferred supplies. Note the IPC bus normal and alternate supply safety-related incoming line breakers are considered part of the same division and independence and separation is not required.

The interface between the ESBWR certified design and site-specific design is defined as being the same location as the interface between the on site power system and the off site power system. The Normal Preferred Power Supply interface between the ESBWR certified onsite design and site-specific offsite design is at the switchyard side terminals of the high side Motor Operated Disconnect (MOD) of the Unit Auxiliary Transformer (UAT) circuit breakers and main generator circuit breaker. The Alternate Preferred Power Supply interface between the ESBWR certified onsite design and the site-specific offsite design is at the switchyard side terminals of the Reserve Auxiliary transformer (RAT) high side MODs. This interface is defined to form the basis for the new interface requirements that are added to DCD Tier 1. The new interface requirements address the capacity, capability and the physical and electrical separation of the site-specific portions of the normal preferred and alternate preferred power supplies.

The bypass transformers for the safety-related Uninterruptible Power Supplies (UPS) have been removed from the ESBWR design as described in the response to RAI 8.2-14 Supplement 1 (MFN-08-844, dated 11-17-08) to prevent disruptive voltages from feeding through to the safety-related loads on the UPS buses. As a result, the safety-related 120-volt UPS buses are isolated from voltage and frequency fluctuations from off site power.

The new ITAAC added in response to this RAI will ensure the PPS equipment is capable of supplying power to the IPC buses and input to the safety related UPS and battery chargers. Adequate voltage at the terminals of utilization equipment on the safety-related 120-volt UPS buses is addressed by new ITAAC added in response to RAI 14.3-431 (MFN-08-897, dated 11-18-08).

DCD Impact

DCD Tier 1, Subsection 2.13.1 will be revised, new Section 4.2 will be added and Tier 2 Chapter 8 Subsections 8.1.1, 8.1.2.2, 8.1.5.2.4, 8.2.2.2, 8.3.1.1, 8.3.1.1.2, 8.3.1.2.1 will be revised in Revision 6 as noted in the attached markup.

MFN 08-917

Markups for

RAI 14.3-394 S01

DCD, Revision 6
Tier 1 and 2

4. INTERFACE MATERIAL

An applicant for a combined license (COL) that references the ESBWR certified design must provide design features or characteristics that comply with the interface requirements for the plant design and inspections, tests, analyses, and acceptance criteria (ITAAC) for the site-specific portion of the facility design, in accordance with 10 CFR 52.79 (c).

Tier 1 interfaces were identified for the conceptual design portion of the Plant Service Water System for the certified design.

4.1 PLANT SERVICE WATER SYSTEM

Design Description

The Plant Service Water System (PSWS) is the heat sink for the Reactor Component Cooling Water System. PSWS does not perform any safety-related function. There is no interface with any safety-related component.

The PSWS cooling towers and basins are not within the scope of the certified design. A specific design for this portion of the PSWS shall be selected for any facility, which has adopted the certified design. The plant-specific portion of the PSWS shall meet the interface requirements defined below.

Interface Requirements

The interface requirements are necessary for supporting the post-72-hour cooling function of the PSWS. The PSWS is required to remove 2.02×10^7 MJ (1.92×10^{10} BTU) over a period of 7 days without active makeup. Consequently, verification of compliance with the interface requirements shall be achieved by inspections, tests, and analyses that are similar to those provided for the certified design. The combined license applicant referencing the certified design shall develop these inspections, tests, and analyses, together with their associated acceptance criteria.

4.2 OFFSITE POWER

Design Description

The offsite portion of the Preferred Power Supply (PPS) consists of at least two electrical circuits and associated equipment that are used to interconnect the offsite transmission system with the plant main generator and the onsite portions of the PPS. The PPS consists of the normal preferred and alternate preferred power sources and includes those portions of the offsite power system and the onsite power system required for power flow from the offsite transmission system to the safety-related Isolation Power Centers (IPC) incoming line breakers.

The interface between the normal preferred ESBWR certified plant onsite portion of the PPS and the site-specific offsite portion of the PPS is at the switchyard side terminals of the high side MOD of the UAT circuit breaker and main generator circuit breaker. The interface between the alternate preferred ESBWR certified plant onsite portion of the PPS and the site specific offsite portion of the PPS is at the switchyard side terminals of the RAT high side MODs.

Interface Requirements

A combined license applicant referencing the ESBWR certified design shall develop an ITAAC to verify that the as-built offsite portion of the PPS from the transmission network to the interface with the onsite portions of the PPS satisfy the applicable provisions of GDC 17. Specifically, the ITAAC shall verify:

(1) At least two independent circuits supply electric power from the transmission network to the interface with the onsite portions of the PPS.

(2) Each offsite circuit interfacing with the onsite portions of the PPS is adequately rated to supply the load requirements during design basis operating modes (refer to ITAAC 2.13.1-2, Item 9).

(3) During steady state operation, the offsite portion of the PPS is capable of supplying voltage at the interface with the onsite portions of the PPS that will support operation of safety related loads during design basis operating modes.

(4) During steady state operation, the offsite portion of the PPS is capable of supplying required frequency at the interface with the onsite portions of the PPS that will support operation of safety related loads during design basis operating modes.

(5) The fault current contribution of the offsite portion of the PPS is compatible with the interrupting capability of the onsite fault current interrupting devices.

2.13 ELECTRICAL SYSTEMS

2.13.1 Onsite AC Power System

Design Description

The purpose of the Onsite AC Power System is to provide power to the power generation nonsafety-related loads and the plant's investment protection (PIP) nonsafety-related loads. The PIP buses also supply power to the four (4) safety-related, 480VAC, Isolation Power Center buses and the two (2) ancillary diesel buses. The nonsafety-related PIP buses and ancillary diesel buses have a ~~Regulatory Treatment of Non-Safety Systems (RTNSS)~~ function to supply power to RTNSS credited loads.

(1) The functional arrangement of Onsite AC Power System is as described in the Design Description of subsection 2.13.1 and Table 2.13.1-1, and as shown on Figure 2.13.1-1.

(2) The safety-related 480 VAC Isolation Power Center equipment identified in Table 2.13.1-1 conforms to Seismic Category I requirements and is housed in Seismic Category I structures.

(3) a. Independence is provided between safety-related divisions as required by Regulatory Guide 1.75.

b. Separation is provided between safety-related divisions, and between safety-related divisions and nonsafety-related equipment as required by Regulatory Guide 1.75.

(4) Each safety-related Isolation Power Center supplies power to safety-related loads in its respective division.

(5) Isolation Power Centers and their associated loads are protected against undervoltage, degraded voltage and under-frequency conditions.

(6) The Onsite AC Power System provides the following nonsafety-related functions:

a. The Onsite AC Power System provides the capability for distributing nonsafety-related AC power from onsite sources to nonsafety-related RTNSS loads.

b. The Onsite AC Power System provides a PIP bus undervoltage signal to trip the PIP bus normal and alternate preferred power supply breakers.

(7) The onsite AC Power System minimum inventory of alarms, displays, controls, and status indications in the main control room are addressed in Section 3.3.

(8) Environmental qualification of safety-related 480 VAC Isolation Power Center equipment is addressed in Tier 1 Section 3.8.

(9) Equipment within the onsite portion of the Preferred Power Supply (PPS) is rated to supply necessary load requirements, including power, voltage, and frequency, during design basis operating modes.

(10) Equipment within the onsite portion of the PPS is rated to interrupt analyzed fault currents, including the fault current contribution from the offsite portion of the PPS.

(11) a. The onsite portions of the normal preferred power supply circuits are physically separate from the onsite portions of the alternate preferred power supply circuits from the UAT and RAT to the PIP bus incoming line breakers.

b. The onsite portions of the normal preferred power supply circuits are electrically independent from the onsite portions of the alternate preferred power supply circuits from the UAT and RAT to the PIP bus incoming line breakers.

c. The onsite portions of the normal preferred power supply circuit breaker control power, instrumentation, and control circuits are electrically independent from the alternate preferred power supply circuit breaker control power, instrumentation, and control circuits from the UAT and RAT to the PIP bus incoming line breakers.

d. The onsite portions of the normal preferred power supply circuit breaker control power, instrumentation, and control circuits are physically separated from the alternate preferred power supply circuit breaker control power, instrumentation, and control circuits from the UAT and RAT to the PIP bus incoming line breakers.

(12) a. The normal power supply circuits are physically separate from the alternate power supply circuits from the PIP buses to the IPC bus incoming line breakers.

b. The normal power supply circuits are electrically independent from the alternate power supply circuits from the PIP buses to the IPC bus incoming line breakers.

c. The normal power supply circuit breaker control power, instrumentation, and control circuits are electrically independent from the alternate power supply circuit breaker control power, instrumentation, and control circuits from the PIP buses to the IPC bus incoming line breakers.

d. The onsite portions of the normal power supply circuit breaker control power, instrumentation, and control circuits are physically separated from the alternate power supply circuit breaker control power, instrumentation, and control circuits from the PIP buses to the IPC bus incoming line breakers.

Inspections, Tests, Analyses and Acceptance Criteria

Table 2.13.1-2 provides a definition of the inspections, tests, and/or analyses, together with associated acceptance criteria for the Electrical Power Distribution System.

Table 2.13.1-2

ITAAC For The Onsite AC Power System

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
7. The Onsite AC Power System minimum inventory of alarms, displays, controls, and status indications in the main control room are addressed in Section 3.3	See Section 3.3.	See Section 3.3.
8. Environmental qualification of safety-related 480 VAC Isolation Power Center equipment is addressed in Section 3.8.	See Section 3.8.	See Section 3.8.
9. Equipment within the onsite portion of the Preferred Power Supply (PPS) is rated to supply necessary load requirements, including power, voltage, and frequency, during design basis operating modes.	Analysis of the as-built onsite portion of the PPS will be performed to determine load requirements during design basis operating modes. This analysis will, in part, specify required power, voltage, and frequency at the interface between the onsite and offsite portions of the PPS in order to provide adequate power, voltage, and frequency to the safety-related IPC buses to support safety-related load operation.	Report(s) exist and conclude that the as-built equipment within the onsite portion of the PPS, as determined by its ratings, exceeds the analyzed load requirements, including power, voltage, and frequency, during design basis operating modes.
10. Equipment within the onsite portion of the PPS is rated to interrupt analyzed fault currents, including the fault current contribution from the offsite portion of the PPS.	Analysis of the as-built onsite portion of the PPS will be performed to determine the fault current interrupting requirements during design basis operating modes including the fault current contribution from the offsite portion of the PPS.	Report(s) exist and conclude that the as-built equipment within the onsite portion of the PPS, as determined by its ratings, exceeds the analyzed fault currents, including the fault current contribution from the offsite portion of the PPS.

Table 2.13.1-2

ITAAC For The Onsite AC Power System

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
11a. The onsite portions of the normal preferred power supply circuits are physically separate from the onsite portions of the alternate preferred power supply circuits from the UAT and RAT to the PIP bus incoming line breakers.	Inspections of the as-built onsite normal preferred power supply circuits and alternate preferred power supply circuits will be performed.	Report(s) exist and conclude the following for the as-built onsite portion of the PPS: • The UAT and RAT are physically separated by distance or physical barriers so as to minimize to the extent practical the likelihood of their simultaneous failure under design basis conditions. • The non-segregated phase bus duct provided for the electrical interconnection between the RAT and 6.9 kV switchgear buses are physically separated from the bus ducts provided for the interconnection of the UAT and the switchgear by distance or physical barriers so as to minimize to the extent practical the likelihood of their simultaneous failure under design basis conditions.
11b. The onsite portions of the normal preferred power supply circuits are electrically independent from the onsite portions of the alternate preferred power supply circuits from the UAT and RAT to the PIP bus incoming line breakers.	Tests of the as-built onsite portions of the PPS normal preferred and alternate preferred power supply circuits will be conducted by providing a test signal in only one preferred power circuit at a time.	Report(s) exist and conclude that a test signal exists in only the circuit under test.

Table 2.13.1-2

ITAAC For The Onsite AC Power System

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
11c. The onsite portions of the normal preferred power supply circuit breaker control power, instrumentation, and control circuits are electrically independent from the alternate preferred power supply circuit breaker control power, instrumentation, and control circuits from the UAT and RAT to the PIP bus incoming line breakers.	Tests of the as-built onsite portions of the normal preferred and alternate preferred power supply circuit breaker control power, instrumentation, and control circuits will be conducted by providing a test signal in only one circuit at a time.	Report(s) exist and conclude that a test signal exists in only the circuit under test.
11d. The onsite portions of the normal preferred power supply circuit breaker control power, instrumentation, and control circuits are physically separated from the alternate preferred power supply circuit breaker control power, instrumentation, and control circuits from the UAT and RAT to the PIP bus incoming line breakers.	Inspections of the as-built onsite portions of the normal preferred and alternate preferred power supply circuit breaker control power, instrumentation, and control circuits will be performed.	Report(s) exist and conclude that the as-built onsite portions of the normal preferred power supply circuit breaker control power, instrumentation, and control circuits are physically separated from the alternate preferred power supply circuit breaker control power, instrumentation, and control circuits by distance or physical barriers so as to minimize to the extent practical the likelihood of their simultaneous failure under design basis conditions.

Table 2.13.1-2

ITAAC For The Onsite AC Power System

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
12a. The normal power supply circuits are physically separate from the alternate power supply circuits from the PIP buses to the IPC bus incoming line breakers.	Inspections of the as-built normal power supply circuits and alternate power supply circuits will be performed.	Report(s) exist and conclude the normal power supply circuits are physically separate from the alternate power supply circuits by distance or physical barriers so as to minimize to the extent practical the likelihood of their simultaneous failure under design basis conditions.
12b. The normal power supply circuits are electrically independent from the alternate power supply circuits from the PIP buses to the IPC bus incoming line breakers.	Tests of the as-built normal and alternate power supply circuits will be conducted by providing a test signal in only one power circuit at a time.	Report(s) exist and conclude that a test signal exists in only the circuit under test.
12c. The normal power supply circuit breaker control power, instrumentation, and control circuits are electrically independent from the alternate power supply circuit breaker control power, instrumentation, and control circuits from the PIP buses to the IPC bus incoming line breakers.	Tests of the as-built normal and alternate power supply circuit breaker control power, instrumentation, and control circuits will be conducted by providing a test signal in only one circuit at a time.	Report(s) exist and conclude that a test signal exists in only the circuit under test.

Table 2.13.1-2

ITAAC For The Onsite AC Power System

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
12d.The onsite portions of the normal power supply circuit breaker control power, instrumentation, and control circuits are physically separated from the alternate power supply circuit breaker control power, instrumentation, and control circuits from the PIP buses to the IPC bus incoming line breakers.	Inspections of the as-built normal and alternate power supply circuit breaker control power, instrumentation, and control circuits will be performed.	Report(s) exist and conclude that the as-built normal power supply circuit breaker control power, instrumentation, and control circuits are physically separated from the alternate power supply circuit breaker control power, instrumentation, and control circuits by distance or physical barriers so as to minimize to the extent practical the likelihood of their simultaneous failure under design basis conditions.

8. ELECTRIC POWER

8.1 INTRODUCTION

8.1.1 General

Power is supplied to the plant from two independent offsite power sources, the "Normal Preferred" power source and the "Alternate Preferred" power source. The loss of both preferred sources may be referred to as a Loss of Preferred Power (LOPP) or a Loss of Offsite Power (LOOP). The terms may be used interchangeably. These power sources are designed to provide reliable power for the plant auxiliary loads, such that any single active failure can affect only one power source and cannot propagate to the alternate power source. The Preferred Power Supply (PPS) consists of the normal preferred and alternate preferred power sources and includes those portions of the offsite power system and the onsite power system required for power flow from the offsite transmission system to the safety-related Isolation Power Centers (IPC) incoming line breakers.

The onsite AC power system consists of safety-related and nonsafety-related power systems. The two offsite power sources provide the normal preferred and alternate preferred AC power to safety-related and nonsafety-related loads. In the event of total loss of offsite power sources and loss of main generator island mode operation (main generator continues to provide AC power to site loads upon loss of offsite power sources), two onsite independent nonsafety-related standby diesel generators are provided to power the Plant Investment Protection (PIP) nonsafety-related loads and safety-related loads through battery chargers, and rectifiers~~, or regulating transformers~~. Two nonsafety-related ancillary diesel generators are capable of supplying power to the ancillary buses when no other sources of AC power are available (see Subsection 8.3.1.1.9). There are four independent safety-related DC divisions to provide power for the safety-related loads.

Onsite safety-related and nonsafety-related DC systems supply all the DC power requirements of the plant.

8.1.2 Utility Power Grid and Offsite Power System Descriptions

8.1.2.1 Utility Power Grid Description

The utility power grid description is provided in Subsection 8.2.1.

8.1.2.2 Offsite Power System Description

The offsite power system consists of the set of electrical circuits and associated equipment that are used to interconnect the offsite transmission system with the plant main generator and the onsite electrical power distribution system~~, as indicated on the one-line diagram, Figure 8.1-1~~.

The system includes the switchyard and the high voltage tie lines to the high-side Motor Operated Disconnects (MODs) of the main generator circuit breaker, the high-side MODs of the Unit Auxiliary Transformers (UATs) circuit breakers, and the high-side MODs of the Reserve Auxiliary Transformers (RATs).

The Normal Preferred Power Supply interface between the ESBWR certified onsite design and site specific offsite design is at ~~The offsite power system begins at the terminals on the transmission system side of the circuit breakers that connect the switchyard to the offsite~~

~~transmission systems. It ends at~~ the switchyard side terminals of the high side MOD of the UAT circuit breaker and main generator circuit breaker. The Alternate Preferred Power Supply interface between the ESBWR certified onsite design and the site specific offsite design is at the switchyard side terminals of the RAT high side MODs ~~the connection to the input terminals of the MODs of the UATs, RATs, and main generator circuit breaker,~~ as indicated on Figure 8.1-1 and Note 4 of sheet 1 of 3 of subject figure.

During plant startup, emergency shutdown, or during plant outages, the offsite power system serves to supply power from the offsite transmission system to the plant auxiliary and service loads. Offsite power sources are as follows:

- "Normal Preferred" source through the UATs; and
- "Alternate Preferred" source through the RATs.

During normal operation, the main generator transmits generated power to the offsite transmission system through the main transformers and to the plant auxiliary and service loads through the UATs.

The onsite power distribution system is powered continuously by the normal preferred power source during shutdown and throughout plant startup. When the onsite main generator breaker is tripped, power to the plant continues to be fed from the normal preferred power source to the UATs or directly to the RATs through the alternate preferred power source line.

A detailed description of the offsite power system is provided in Subsection 8.2.1.

8.1.3 Onsite Electric Power System

8.1.3.1 Onsite AC Power System

The onsite AC power system includes the main generator, the main transformers, the main generator circuit breaker and high side MODs, the UAT input MODs and circuit breakers, the RAT input MODs, and the unit and reserve auxiliary transformers, as indicated on Figure 8.1-1.

The onsite power system is divided into two medium voltage power levels of 13.8 kV and 6.9 kV for operational flexibility of the plant nonsafety-related systems. Each UAT feeds one of the 13.8 kV and 6.9 kV power load groups and a RAT backs up each UAT.

The 13.8 kV medium voltage power level supplies power to nonsafety-related power generation loads required primarily for unit operation.

The 6.9 kV medium voltage power level supplies power to PIP A and PIP B (nonsafety-related loads), which, on account of their specific functions, are generally required to remain operational at all times or when the unit is shut down. The 6.9 kV medium voltage power level also supplies power to the safety-related loads through Isolation Power Centers.

Both PIP A and PIP B buses have a standby power supply from separate onsite standby diesel generators, in addition to their normal preferred power supply through the UATs, and their alternate preferred power supply from an independent offsite source through the RATs.

The first medium voltage power level distributes power at 60 Hz and voltage levels of 13.8 kV, 480V, 240/120V and 208/120V.

- GDC 17, "Electric Power Systems" - Safety-related DC power sources are provided to support passive core cooling and passive containment integrity safety-related functions. No offsite or diesel-generator-derived AC power is required for 72 hours after an abnormal event. However, the ESBWR ~~standard design~~ PPS complies with GDC 17 with respect to two independent and separate offsite power sources ~~and standby onsite power sources~~, each with the capacity and capability to power equipment during design basis operating modes (plant start-up, normal operation, safe shutdown, accident, and post-accident operation). Subsection 3.1.2.8, "Criterion 17 – Electric Power Systems," provides ESBWR electric power source availability requirements and conformance with Regulatory Guide 1.93.
- GDC 18, "Inspection and Testing of Electric Power Systems" - Safety-related DC power sources are provided to support passive core cooling and passive containment integrity safety-related functions. No offsite or diesel-generator-derived AC power is required for 72 hours after an abnormal event. However, the nonsafety-related offsite and onsite AC systems that supply AC power to the Isolation Power Centers are testable and meet GDC 18 requirements.
- GDC 50, "Containment Design Basis"

NRC Regulatory Guides:

- Regulatory Guide 1.6, "Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems" – The ESBWR Standard Plant does not need or have safety-related standby AC power sources; however, portions pertaining to the safety-related DC system are addressed within Subsection 8.3.2. The ESBWR offsite and onsite nonsafety-related power sources do comply with independence and redundancy between their sources and distribution systems.
- Regulatory Guide 1.9, "Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants"– The ESBWR diesel-generator units are not safety-related, nor is AC power needed for the ESBWR to achieve safe shutdown, therefore this regulatory guide is not applicable to the ESBWR design.
- Regulatory Guide 1.32, "Criteria for Power Systems for Nuclear Power Plants." Safety-related DC power sources are provided to support passive core cooling and containment integrity safety functions. No offsite or diesel-generator-derived AC power is required for 72 hours after an abnormal event. IEEE 1188, not IEEE 450, is applicable to VRLA batteries.
- Regulatory Guide 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems."
- Regulatory Guide 1.53, "Application of the Single-Failure Criterion to Safety Systems."
- Regulatory Guide 1.63, "Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants."
- Regulatory Guide 1.75, "Criteria for Independence of Electrical Safety Systems." Safety-related equipment relies only upon DC-derived power and meets the design requirements for physical independence.

trip coil. Equipment and cabling associated with each redundant system is physically separated from its redundant counterpart.

The DC power needed to operate redundant protection and control equipment of the offsite power system is supplied from two separate, dedicated switchyard batteries, each with a battery charger fed from a separate AC bus. Each battery is capable of supplying the DC power required for normal operation of the switchyard equipment.

Two redundant Plant Investment Protection (PIP) AC power supply systems supply AC power to the switchyard auxiliary loads as shown in Figure 8.1-1 Sheets 2 and 3. Each system is supplied from separate, independent AC buses. The capacity of each system is adequate to meet the AC power requirements for normal operation of the switchyard equipment.

The switchyard design is site specific. (See 8.2.4-2-A, 8.2.4-5-A, 8.2.4-6-A, 8.2.4-7-A, and 8.2.4-8-A.)

8.2.2 Analysis

8.2.2.1 Reliability and Stability Analysis

The transmission system reliability and stability analysis is site-specific. (See 8.2.4-9-A.)

8.2.2.2 Regulatory Analysis

In accordance with the NRC Standard Review Plan (NUREG-0800), Table 8-1 and Section 8.2, the preferred offsite power distribution system is designed consistent with the following criteria, so far as it applies to nonsafety-related equipment. Any exceptions or clarifications are so noted.

Applicable Criteria:

- GDC 5, "Sharing of Structures, Systems, and Components," and Regulatory Guide 1.81, "Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants" – The ESBWR Reference Plant is designed as a single-unit plant. Therefore, GDC 5 and Regulatory Guide 1.81 are not applicable.
- GDC 17, "Electric Power Systems" – The ESBWR Reference Plant design does not require an offsite or diesel-generated AC source of power for 72 hours after an abnormal event. Safety-related DC power sources are provided to support passive core cooling and containment safety-related functions. However, the ESBWR PPS complies with GDC 17 with respect to two independent and separate offsite power sources, each with the capacity and capability to power equipment during design basis operating modes (plant start-up, normal operation, safe shutdown, accident, and post-accident operation)~~standard design complies with GDC 17 with respect to two independent and separate offsite power sources and standby onsite power sources~~. Subsection 3.1.2.8, "Criterion 17 – Electric Power Systems," provides ESBWR electric power source availability requirements and conformance with Regulatory Guide 1.93.
- GDC 18, "Inspection and Testing of Electric Power Systems" – Safety-related DC power sources are provided to support passive core cooling and containment safety-related functions. No offsite or diesel-generator-derived AC power is required for 72 hours after an abnormal event. However, the nonsafety-related offsite and onsite AC systems that supply AC power to the Isolation Power Centers are testable.

8.3 ONSITE POWER SYSTEMS

8.3.1 AC Power Systems

8.3.1.1 Description

The main power transformer is within the onsite power system and consist of three single-phase transformers and an installed spare.

The UATs consist of two, three-phase transformers. The UATs provide normal preferred offsite power or main generator island mode power to each of the plant's two power generation and plant investment protection load groups.

The RATs consist of two three-phase transformers fed from the alternate preferred offsite power source. The RATs provide alternate preferred power to the plant's two power generation and plant investment protection load groups.

The RATs are of the same size as the UATs, and each functions as a backup power source in the event of a UAT failure.

The UAT and RAT are physically separated by distance or physical barriers so as to minimize to the extent practical the likelihood of their simultaneous failure under design basis conditions.

The main power transformers, UATs and RATs, are designed and constructed to withstand the mechanical and thermal stresses produced by external short circuits, and meet the corresponding requirements of IEEE Standard C57.12.00 (Reference 8.3-12).

An onsite main generator circuit breaker is provided with capability of interrupting the maximum available fault current. The main generator circuit breaker is sized and designed in accordance with IEEE Standard C37.010 (Reference 8.3-28). The main generator circuit breaker allows the generator to be taken off line and the main grid to be utilized as an immediate access power source for the onsite AC power system. Start-up power is normally provided through the UATs from the offsite power system.

The onsite isolated phase bus duct provides the electrical interconnection between the main generator output terminals and the low voltage terminals of the main transformers.

Onsite non-segregated phase bus duct provide for the electrical interconnection between the RATs and the 13.8 kV and 6.9 kV switchgear buses and are physically separated from the bus ducts provided for the interconnection of the UATs and the switchgear buses to minimize to the extent practical the likelihood of simultaneous failure under design basis conditions.

Disconnect links are provided for the main transformers so that a failed transformer may be taken out of service and the installed spare connected.

Input isolation breakers (Reference 8.3-26), MODs, and disconnect links are provided for the UATs so that a failed transformer may be taken out of service. On loss of power from the UATs, 13.8 kV and 6.9 kV switchgear buses are automatically transferred to the RATs, which are connected to the alternate preferred power source.

Disconnect links in addition to MODs are provided for the RATs so that a failed transformer may be taken out of service. Each of the connected RATs has the capability to replace one UAT.

The Preferred Power Supply (PPS) consists of the normal preferred and alternate preferred power sources and includes those portions of the offsite power system and the onsite power system required for power flow from the offsite transmission system to the safety-related Isolation Power Centers (IPC) incoming line breakers.

The PPS normal preferred power supply circuit breaker control power, instrumentation, and control circuits are electrically independent and are physically separated from the alternate preferred power supply circuit breaker control power, instrumentation, and control circuits by distance or physical barriers to minimize to the extent practical the likelihood of simultaneous failure under design basis conditions~~There is both a normal and an alternate preferred power path to the safety-related electrical system if the plant is operating with a RAT in place of an out of service UAT~~.

The onsite AC power system consists of a 60 Hz standby onsite AC power supply system and various pieces of electrical distribution equipment. Figure 8.1-1 shows the plant main one line diagram. The onsite power distribution system has multiple nominal bus voltage ratings. Throughout the discussion and on all the design drawings the equipment utilization voltages are designated as 13.8 kV, 6.9 kV, 480/277V, 208/120V and 240/120V.

The onsite AC power system is configured into two separate power load groups. Each power load group is fed by a separate UAT, each with a redundant RAT for backup, and consists of two types of buses:

- **Power Generation (PG) nonsafety-related buses** - are those buses that are not directly backed by standby onsite AC power sources and have connections to the normal preferred or alternate preferred offsite source through the UATs or RATs, respectively. The PG nonsafety-related buses are the 13.8 kV unit auxiliary switchgear and associated lower voltage load buses.
- **Plant Investment Protection (PIP) nonsafety-related buses** - are those buses that are backed by the standby onsite AC power supply system and have connections to the normal preferred and alternate preferred offsite sources through the UATs and RATs, respectively. Backfeed to the standby onsite AC power source is prevented by reverse power relaying. The PIP nonsafety-related buses are the 6.9 kV PIP buses and associated lower voltage load buses exclusive of the safety-related Isolation Power Center buses.

The PG nonsafety-related buses feed nonsafety-related loads required exclusively for unit operation and are normally powered from the normal preferred power source through the UATs. These buses are also capable of being powered from the alternate preferred power source (RATs), through an auto bus transfer, in the event that the normal preferred power source is unavailable. On restoration of UAT power, transfer back to the normal preferred power supply may be performed by a manually selected bus transfer or the bus may be placed in the automatic transfer mode and remain powered from the alternate preferred power source (RATs).

The PIP nonsafety-related buses feed nonsafety-related loads generally required to remain operational at all times, including when the unit is shut down. In addition, the PIP nonsafety-related buses supply AC power to the safety-related buses. The PIP nonsafety-related buses are backed up by a separate standby onsite AC power supply system connected to each PIP bus. These buses are also capable of being powered from the alternate preferred power source (RATs), through an auto bus transfer, in the event that the normal preferred power source is

power to motor loads, MCCs, and the ancillary diesel generator buses (see Figure 8.1-1 Sheets 2 and 3 and Figure 8.3-3). The power centers are of the single-fed or double-ended type depending on the redundancy requirements of the loads powered by a given power center. The power supplies to the double-ended power center transformers of the PIP nonsafety-related buses are supplied from different buses. Each double-ended power center is normally powered by its normal power source through its normal source main breaker, with the alternate source main breaker open. The power center normal and alternate source main breakers are electrically interlocked to prevent simultaneous powering of the power center by normal and alternate sources.

Isolation Power Centers

The Isolation Power Centers are powered from the PPS via the PIP nonsafety-related buses, which are backed up by the standby diesel-generators. There are four Isolation Power Centers, one each for Divisions 1, 2, 3 and 4. Each Isolation Power Center is double-ended and can be powered from either of the PIP load group buses.

The normal and alternate power supply circuits from the Plant Investment Protection PIP buses to the IPC buses are physically separated by distance or physical barriers so as to minimize to the extent practical the likelihood of their simultaneous failure under design basis conditions. The normal power supply circuit breaker control power, instrumentation, and control circuits are electrically independent and are physically separated from the alternate power supply circuit breaker control power, instrumentation, and control circuits by distance or physical barriers to minimize to the extent practical the likelihood of simultaneous failure under design basis conditions.

The normal and alternate source main breakers of each Isolation Power Center are electrically interlocked to prevent powering the Isolation Power Center from the normal and alternate sources simultaneously. The Isolation Power Centers are shown in Figure 8.3-1.

The Isolation Power Centers supply power to safety-related loads of their respective division. These loads consist of the safety-related battery chargers~~,~~ and rectifiers~~, and regulating transformers~~ as discussed in Subsections 8.3.2 and 8.3.1.1.3. In addition, there is no safety-related lighting that operates directly from the 480 VAC in the ESBWR design. The lighting system is discussed in Chapter 9.

Isolation power centers are protected against degraded voltage and frequency conditions by way of voltage and frequency relays installed in each Isolation Power Center to ~~prevent tripping of all Isolation Power Center loads, in accordance with BTP PSB1~~provide alarms and facilitate IPC bus isolation and transfer functions using two-out-of-three logic to prevent spurious actuation. The four safety-related Isolation Power Centers are located in the Seismic Category I Reactor Building in their respective divisional areas.

Motor Control Centers

MCCs supply power to motors, control power transformers, process heaters, motor-operated valves and other small electrically operated auxiliaries, including 480 - 208/120V and 480 - 240/120V transformers. MCCs are assigned to the same load group as the power center that supplies their power.

The ancillary diesel generators and associated buses are rated at 480 VAC. These buses are normally powered by offsite power or the onsite standby diesel generators through the PIP buses (see Figure 8.1-1 Sheets 2 and 3). The ancillary diesels will start on the loss of PIP AC power to their buses or on the sensing of low ancillary diesel room temperature. If the onsite standby diesel generators have started and loaded, they will provide the power to the ancillary diesel buses and loads. If an onsite standby diesel fails to start and provide power, the feed from the PIP bus to the ancillary diesel bus will be isolated and the ancillary diesel will power the associated ancillary diesel bus.

8.3.1.2 Analysis

8.3.1.2.1 General Design Criteria and Regulatory Guidance Compliance

The following paragraphs analyze compliance with Nuclear Regulatory Commission (NRC) General Design Criteria (GDC), NRC Regulatory Guides and other criteria consistent with the Standard Review Plan (SRP).

Table 8.1-1 identifies the onsite power system and applicability of the associated codes and standards applied in accordance with Table 8-1 of the SRP. All regulatory guides, BTPs and NUREGs are discussed in Subsection 8.1.5.2.4, where GDC compliance is evaluated.

GDC 2, Design Basis for Protection Against Natural Phenomena

GDC 4, Environmental and Dynamic Effects Design Bases

The requirements of the GDC 2 and 4 are met, in that all components of the safety-related power system are housed in seismic Category I structures designed to protect them from natural phenomena. These components have been qualified to the appropriate seismic, hydrodynamic, and environmental conditions as described in Chapter 3.

GDC 17, Electric Power Systems

Safety-related DC power sources are provided to support passive core cooling and containment safety-related functions. No offsite or diesel-generator-derived AC power is required for 72 hours after an abnormal event. However, the ESBWR PPS complies with GDC 17 with respect to two independent and separate offsite power sources, each with the capacity and capability to power equipment during design basis operating modes (plant start-up, normal operation, safe shutdown, accident, and post-accident operation)~~standard design complies with GDC 17 with respect to two independent and separate offsite power sources and standby onsite power sources~~. Subsection 3.1.2.8, "Criterion 17 – Electric Power Systems," provides ESBWR electric power source availability requirements and conformance with Regulatory Guide 1.93.

GDC 18, Inspection and Testing of Electric Power Systems

Safety-related DC power sources are provided to support passive core cooling and containment safety-related functions. No offsite or diesel-generator-derived AC power is required for 72 hours after an abnormal event. However, the nonsafety-related offsite and onsite AC systems that supply AC power to the Isolation Power Centers are testable and meet GDC 18 requirements.

The safety-related DC power system (including safety-related UPS and 480 VAC Isolation Power Centers) is designed to permit the following: