8. ELECTRIC POWER

The electric power system is the source of power for station auxiliaries during normal operation and for the reactor protection system and engineered safety features during abnormal and accident conditions. This chapter provides information on the functional adequacy of the offsite power systems and safety-related onsite electric power systems as applicable to the Economic Simplified Boiling-Water Reactor (ESBWR) design and ensures that these systems have adequate redundancy, independence, and testability in conformance with the current criteria established by the U.S. Nuclear Regulatory Commission (NRC).

8.1 Introduction (FSAR Section 8.1)

8.1.1 Introduction

This section provides a brief description of the transmission grid and its interconnection to the nuclear unit and other grid interconnections. It describes those onsite alternating and direct current (ac and dc) loads that are added to the certified ESBWR design and the function provided by these loads.

The section includes a regulatory requirements applicability matrix that lists design bases, criteria, regulatory guides (RGs), standards, and other documents to be implemented in the design of the electrical systems that are beyond the scope of the design certification. The review of this section is coordinated closely with the reviews described in Sections 8.2, 8.3.1, 8.3.2, and 8.4.

8.1.2 Summary of Application

Section 8.1 of the North Anna 3 combined license (COL) final safety analysis report (FSAR), Revision 1, incorporates by reference Section 8.1 of the ESBWR design control document (DCD), Revision 5. In addition, in FSAR Section 8.1, the applicant provided the following:

Supplemental Information

- North Anna Power Station (NAPS) SUP 8.1-1 Utility Power Grid

This supplemental information describes the connection of North Anna 3 to the 500/230-kilovolt (-kV) switchyard.

8.1.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is addressed within the final Safety Evaluation Report (FSER) related to the DCD.

In addition, the regulatory basis for acceptance of the COL supplemental information is established in General Design Criterion (GDC) 17, “Electric Power Systems,” of Appendix A, “General Design Criteria for Nuclear Power Plants,” to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, “Domestic Licensing of Production and Utilization Facilities.”

8.1.4 Technical Evaluation

The NRC staff reviewed Section 8.1 of the North Anna 3 COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the information in the COL represent the complete scope of information relating to this review topic.[1] The staff's review confirmed that the information contained in the application and incorporated by reference addresses the required information related to the introduction section to Chapter 8, "Electric Power." The NRC staff is reviewing Section 8.1 of the ESBWR DCD on Docket No. 52-010. The NRC staff's technical evaluation of the information incorporated by reference related to introduction section will be documented in the staff safety evaluation report (SER) on the design certification application for the ESBWR design.

The staff reviewed the following information contained in the COL FSAR:

Supplemental Information

- NAPS SUP 8.1-1 Utility Power Grid

The staff reviewed the supplemental information provided by the applicant to modify Section 8.1.2.1, "Utility Power Grid Description." The applicant provided the following supplement to Section 8.1.2.1:

> The output of North Anna 3 is delivered to a main 500/230 kV switchyard through the unit main step-up transformers, and an intermediate switchyard. The main switchyard serves four 500 kV lines and one 230 kV line. The plant is connected to the main switchyard by a 500 kV normal preferred transmission line, and a 230 kV alternate preferred transmission line that supplies power to the two reserve auxiliary transformers.

The staff finds that the applicant has adequately described the North Anna 3 connection to the utility grid and the connection conforms to the requirements of GDC 17.

8.1.5 Post Combined License Activities

There are no post COL activities related to this chapter.

8.1.6 Conclusion

The NRC staff reviewed the application and checked the referenced DCD. The review confirmed that the applicant addressed the required information relating to the introduction, and no outstanding information is expected to be addressed in the FSAR related to this section.

The staff is reviewing the information in DCD Section 8.1 on Docket No. 52-010. The results of the staff's technical evaluation of information related to the introduction to electric power incorporated by reference in the North Anna 3 COL FSAR will be documented in the SER on the DC application for the ESBWR. The SER on the ESBWR is not yet complete, and this is being

[1] See Section 1.2.2, "Finality of Referenced NRC Approvals," for a discussion on the staff's review related to verification of the scope of information to be included within a COL application that references a design certification.

tracked as part of Open Item 1-1. The staff will update Section 8.1 of this SER to reflect the final disposition of the DC application.

In addition, the staff has compared the additional COL supplemental information within the application for this section to the relevant NRC regulations, guidance in Section 8.1 of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (the SRP), and other NRC RGs and concludes that the applicant is in compliance with the NRC regulations. In conclusion, the applicant has provided sufficient information to satisfy the requirements of GDC 17 for this section.

8.2 Offsite Power System

8.2.1 Introduction

This section provides descriptive information, analyses, and referenced documents, including electrical single-line diagrams, electrical schematics, logic diagrams, tables, and physical arrangement drawings for the offsite power system. Industry standards and RGs refer to the offsite power system as the "preferred power system." It should include two or more physically independent circuits capable of operating independently of the onsite standby power sources and encompasses the grid, transmission lines (overhead or underground), transmission line towers, transformers, switchyard components and control systems, switchyard battery systems, the main generator, generator circuit breakers, disconnect switches, and other switchyard equipment, such as capacitor banks and volt amperes reactive compensators, provided to supply electric power to safety-related and other equipment.

The ESBWR passive reactor design used at North Anna 3 minimizes the potential risk contribution of a station blackout (SBO) (loss of all ac power) by not requiring ac power sources for design-basis events for 72 hours. The plant's safety-related passive systems automatically establish and maintain safe-shutdown conditions for the plant following design-basis events, including the extended loss of ac power sources. The passive systems can maintain these safe-shutdown conditions after design-basis events for 72 hours without operator action, following loss of both onsite and offsite ac power sources.

8.2.2 Summary of Application

Section 8.2 of the North Anna 3 COL FSAR, Revision 1, incorporates by reference Section 8.2 of the ESBWR DCD, Revision 5.

In addition, in FSAR Section 8.2, the applicant provided site-specific supplemental information to resolve COL Items 8.2.4-1-A through 8.2.4-10-A as follows.

COL Items

- NAPS COL 8.2.4-1-A Transmission System Description

The applicant provided detailed information on the designs of the plant site 500-kV switchyard, the four 500-kV and one 230-kV transmission lines connecting the plant switchyard to Dominion's transmission system, and the interface of the switchyard with the transmission grid. The applicant provided Figures 8.2-201 through 8.2-203, which show a one-line diagram of the electrical system from the switchyard to the onsite electrical system, physical arrangement of the offsite power source, and a map of offsite transmission lines, respectively.

- NAPS COL 8.2.4-3-A Normal Preferred Power
- NAPS COL 8.2.4-4-A Alternate Preferred Power

The applicant provided additional information in FSAR Section 8.2.1.2, "Offsite Power System," describing details of normal preferred power and alternate preferred power

- NAPS COL 8.2.4-2-A Switchyard Description
- NAPS COL 8.2.4-6-A Switchyard DC Power
- NAPS COL 8.2.4-7-A Switchyard AC Power
- NAPS COL 8.2.4-8-A Switchyard Transformer Protection

The applicant provided additional information in FSAR Section 8.2.1.2.1, "Switchyard," describing details of the switchyard, switchyard dc and ac power, and switchyard transformer protection.

- NAPS COL 8.2.4-5-A Protective Relaying

The applicant provided additional information in new FSAR Section 8.2.1.2.2, "Protective Relaying," describing the existing relay schemes protecting 500-kV transmission lines and switchyard buses and generating unit tie-line and auxiliary transformers.

- NAPS COL 8.2.4-9-A Stability and Reliability of the Offsite Transmission Power System
- NAPS COL 8.2.4-10-A Interface Requirements

The applicant provided additional information in FSAR Section 8.2.2.1, "Reliability and Stability Analysis," describing details of a transmission system study performed regularly to verify grid stability, switchyard voltage, and frequency. The purpose of the study is to confirm the transmission system capability and demonstrate formal agreement between the control room and the transmission operator

Supplemental Information

- NAPS SUP 8.2-2 Testing and Inspection

The applicant provided a new FSAR Section 8.2.1.2.3, "Testing and Inspection," which gives details of testing and inspection of the switchyard components.

- NAPS SUP 8.2-3 Failure Mode and Effects Analysis

The applicant provided a new FSAR Section 8.2.2.3, "Failure Modes and Effects Analysis," which describes details of the failure modes and effect analysis of transmission system, switchyard, and intermediate switchyard components.

8.2.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is addressed within the FSER related to the DCD.

In addition, Section 8.2 of NUREG-0800 gives the relevant guidance applicable to the Commission's regulation for the offsite power system and associated acceptance criteria.

Specifically, the regulatory bases for acceptance of the supplemental COL information items are established in the following:

- for NAPS COL 8.2.4-1-A, the requirements of GDC 17
- for NAPS COL 8.2.4-3-A and 8.2.4-4-A, the requirements of GDC 17
- For NAPS COL 8.2.4-2-A, 8.2.4-6-A, and 8.2.4-7-A, the requirements of GDC 17 and GDC 5, "Sharing of Structures, Systems, and Components"
- for NAPS COL 8.2.4-5-A and 8.2.4-8-A, the requirements of GDC 17
- for NAPS COL 8.2.4-9-A and 8.2.4-10-A, the requirements of GDC 17 and the guidelines of RG 1.32, "Criteria for Power Systems for Nuclear Power Plants"; RG 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)"; Branch Technical Position (BTP) 8-3, "Stability of Offsite Power Systems"; BTP 8-6, "Adequacy of Station Electric Distribution System Voltages"; RG 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants"; and RG 1.182, "Assessing and Monitoring Risk Before Maintenance Activities at Nuclear Power Plants"
- for NAPS SUP 8.2-2, the requirements of GDC 18, "Inspection and Testing of Electric Power and Protective Systems," and the guidelines of RG 1.118, "Periodic Testing of Electric Power and Protection Systems"
- for NAPS SUP 8.2-3, the guidelines of RG 1.206

8.2.4 Technical Evaluation

The NRC staff reviewed Section 8.2 of the North Anna 3 COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the information in the COL represent the complete scope of information relating to this review topic.. The NRC staff's review confirmed that the information contained in the application and incorporated by reference addresses the required information related to the offsite power system. The staff is reviewing Section 8.2 of the ESBWR DCD on Docket No. 52-010. The staff's technical evaluation of the information incorporated by reference relating to offsite power systems will be documented in the staff SER on the design certification application for the ESBWR design.

The staff reviewed the following information contained in the FSAR:

COL Items

- NAPS COL 8.2.4-1-A Transmission System Description

The applicant provided additional information in NAPS COL 8.2.4-1-A to address COL Item 8.2.4-1-A. The applicant stated that the following replaces DCD Section 8.2.1.1:

> NAPS, that is, Units 1, 2, and 3, is connected to the Dominion transmission system by four 500 kV lines and one 230 kV line. The lines are designed and located to minimize the likelihood of simultaneous failure. The Unit 3 main generator feeds electric power through a 27 kV isolated phase bus to a bank of three single phase transformers, stepping the generator voltage up to the transmission voltage of 500 kV. Figure 8.2-201 provides a one-line diagram of the electric system from the switchyard to the onsite system. The transmission lines and towers connecting the switchyard to the transmission system are as follows:
>
> - Two 500 kV overhead lines to the Ladysmith substation (approximately 15 miles)
> - A 500 kV overhead line to the Midlothian substation (approximately 41 miles)
> - A 500 kV overhead line to the Morrisville substation (approximately 33 miles)
> - A 230 kV overhead line to the Gordonsville substation (approximately 31 miles)
>
> Two Ladysmith lines utilize a common right-of-way. Each of the other lines utilizes separate right-of-way. The 230 kV Gordonsville line crosses under the 500-kV Ladysmith and Morrisville lines near the switchyard.
>
> The applicant stated that transmission tower separation, line installation, and clearances are consistent with the National Electric Safety Code (NESC) and Dominion transmission line standards. Adequate clearance exists between wire galloping ellipses to minimize conductor or structural damage.

The NRC staff reviewed the resolution to COL Items 8.2.4-1-A in NAPS COL 8.2.4-1-A related to the transmission system design included under Section 8.2 of the North Anna 3 COL.

Staff review of FSAR Chapter 8, Figure 8.2-201, indicates a discrepancy with the corresponding DCD Figure 8.1-1, Revision 4. Figure 8.1-1 shows the main generator circuit breaker as part of the onsite power system, while Figure 8.2-201 shows the same breaker as being in the intermediate switchyard. Also, in Figure 8.1-1, the main transformer and unit auxiliary transformers (UATs) are connected at the high-voltage side of the main transformer; however, in Figure 8.2-201, UATs high-side voltage is 230 kV, and the main transformer's high-side voltage is 500 kV. It is not clear how the connection can be made with different voltages. In **Request for Additional Information (RAI) 8.2-1**, the staff asked the applicant to clarify the apparent discrepancies. In its response of July 28, 2008, the applicant stated that the main

generator circuit breaker is physically located in the NAPS intermediate switchyard. The applicant stated that it will revise FSAR Figure 8.2-201 to remove the main generator circuit breaker symbol from the figure and will add a note to clarify the interface between DCD Figure 8.1-1 and FSAR Figure 8.2-201. The applicant stated that at North Anna, the high-voltage side of the UATs and RATs will be at 230 kV and generator step-up transformers will be at 500 kV on the high side. Because of this, a 500/230-kV transformer bank will be located in the intermediate switchyard to step down 500 kV to 230 kV for use by the UATs, as depicted in FSAR Figure 8.2-201. The applicant will add a note to FSAR Figure 8.2-201 to clarify that equipment on the offsite power portion of FSAR Figure 8.2-201 replaces equipment on the offsite power portion of DCD Figure 8.1-1. On the basis of its review, the staff finds that the applicant has adequately addressed the staff's question. The staff confirmed that these changes are incorporated in FSAR Revision 1, and the issue is resolved.

The staff finds that COL Item 8.2.4-1-A conforms with the requirements of GDC 17.

- NAPS COL 8.2.4-3-A Normal Preferred Power
- NAPS COL 8.2.4-4-A Alternate Preferred Power

The applicant provided additional information in NAPS COL 8.2.4-3-A and 8.2.4-4-A to address COL Items 8.2.4-3-A and 8.2.4-4-A. The applicant stated that it has replaced the first paragraph of DCD Section 8.2.1.2 with the following:

> The offsite power system is a non-safety-related system. Power is supplied to the plant from multiple independent and physically separate offsite power sources. The normal preferred power source is any one of the four 500 kV lines, and the alternate preferred power source is any other one of the four 500 kV lines. The normal preferred power source is supplied to the UATs through the intermediate transformer, MODs and isolation circuit breakers. The normal preferred power interface with offsite power system occurs at the incoming disconnect switch of the intermediate switchyard. Underground cables connect the normal and alternate preferred power source to the UATs and RATs, respectively and routed in duct banks and are physically and electrically separate from each other.

In **RAI 8.2-2**, the staff asked the applicant to provide a discussion of the routing of control and instrumentation cables, and miscellaneous power cables associated with normal and alternate preferred circuits, between the switchyard and the power block. In its response on July 28, 2008, the applicant stated that adequate separation is ensured either by routing cables associated with the normal preferred circuit in a duct bank separate from cables associated with the alternate preferred circuit, or by routing these cables in separate conduits within the same duct bank. The applicant will revise FSAR Section 8.2.1.2 to add a description of the routing of control, instrumentation, and miscellaneous power cables. On the basis of its review, the staff finds that the applicant has adequately addressed the issue. The staff confirmed that these changes are incorporated in FSAR Revision 1, and the issue is resolved.

Since underground cables are susceptible to moisture, in **RAI 8.2-4**, the staff asked the applicant to identify the design features and/or in situ monitoring programs that it will use to avoid or arrest the degradation of the cable insulation from the effects of moisture. In its response on July 28, 2008, the applicant stated that the normal preferred power supply and alternate preferred power supply both use 230-kV cable. Periodic monitoring of cable insulation for underground medium- and high-voltage cable will be conducted to detect potential cable

degradation from moisture intrusion using one of the following methods or an equivalent: partial discharge testing, time domain reflectometry, dissipation factor testing, or very-low-frequency ac testing. On the basis of its review, the staff finds that the applicant did not address the testing frequency. Additionally, the staff finds that testing alone is not sufficient. The manholes should be inspected every 6 months for water accumulation, and adequate corrective actions (increased inspection frequency) should be taken if water accumulation is found. Furthermore, the staff needs technical justification for using one of the testing methods indicated above to detect potential high-voltage (230-kV) cable degradation. In **RAI 8.2-29**, the staff asked the applicant to address these issues. On December 1, 2008, the applicant stated that the underground cables in duct banks have a metallic sheath to prevent moisture ingress into the cable insulation. The metallic sheath is applied by machine to the cable core and mechanically sealed to form a continuous barrier against moisture. Moisture can be introduced into the insulation during the curing (cross-linking) process if a steam cure is used, further aggravating the water-treeing process and leading to early failure. Dominion specifies a dry cure process for its 230-kV cross-linked polyethylene cable during manufacture. No splices are designed into the underground portion of these cables. Splice kits and termination kits for metallic sheathed cables are designed to seal to the metallic sheath at the cable ends and restore the continuous barrier to moisture intrusion. Therefore, no periodic testing is expected to be necessary because Dominion will use the 230-kV cables with design features (the metallic sheath) that will avoid insulation degradation from moisture. The manholes associated with these duct banks will be inspected every 6 months for excessive accumulation of water. Under the applicant's corrective action program, actions (such as increased inspection frequency) are expected to be taken if excessive water accumulation is found. The staff confirmed that it has revised COL FSAR Section 8.2.1.2 to cite the metallic sheath cable design feature and the requirement for manhole inspections for water accumulation in Revision 1 of the FSAR. Given that the "Maintenance Rule" (10 CFR 50.65) will apply for these cables and the NRC Reactor Oversight Program has acted to address this issue for operating reactors, further response is not needed for this review. On this basis, the staff has reasonable assurance that the 230-kV underground cables will perform their function, and the issue is resolved.

FSAR Section 8.2.1.2 notes that the 500-kV transmission line rated current is 3,954 amps and the 500-kV bus is rated as 3,891 amps. In **RAI 8.2-5**, the staff asked the applicant to explain why the bus rating is less than the transmission line rating and clarify the actual loading of the line and bus. In its response on July 28, 2008, the applicant stated that transmission line loading (normal loading and emergency loading) is well below the bus rating. Additionally, both Dominion and the Pennsylvania, New Jersey, and Maryland Interconnection (PJM) perform periodic studies to verify that bus work and transmission lines can be operated within their rating. The staff accepted the applicant's response, and this issue is resolved.

Since all North Anna units share the same switchyard, the offsite power system provided for the site should have sufficient capacity and capability to safely shut down all units. As documented in NRC generic communications (e.g., NRC Generic Letter (GL) 07-01, "Inaccessible or Underground Power Cable Failures That Disable Accident Mitigation Systems or Cause Plant Transients," dated February 7, 20007; NRC Information Notice (IN) 98-07, "Offsite Power Reliability Challenges from Industry Deregulation," dated February 27, 1998; and NRC IN 95-37, "Inadequate Offsite Power Voltages During Design-Basis Events," dated September 7, 1995), operational experience has shown the need to demonstrate that the offsite power system operation supports equipment important to safety and avoids plant transients. In addition, NRC GL 06-02, "Grid Reliability and the Impact on Plant Risk and the Operability of Offsite Power," dated February 1, 2006, states that "For nuclear plants licensed in accordance with the GDC in Appendix A to 10 CFR Part 50, the design criteria for onsite and offsite electrical power systems

are provided in GDC 17…which requires, among other things, that an offsite electric power system be provided to permit the functioning of certain SSCs important to safety in the event of anticipated operational occurrences."

In **RAI 8.2-28**, the staff asked the applicant to discuss the capacity and capability of the offsite system (i.e., the 500-kV lines and associated switchyard equipment) to mitigate the consequences of anticipated abnormal operational occurrences associated with unit operation. On August 21, 2008, the applicant stated that Dominion will submit its response within 45 days following the General Electric Hitachi Nuclear America, LLC (GEH) response to DCD **RAI 14.3-394** to ensure that the response is consistent and complete. GEH submitted their responses to RAI 14.3-394 on August 27, 2008 and RAI 14.3-394 S01 December 9, 2008 respectively. On November 19, 2008, the applicant stated that the switchyard for the North Anna Power Station was evaluated under a system impact study (SIS) for interconnection of Unit 3 by PJM, the regional transmission operator (RTO). The SIS was performed to verify load flow capability, short-circuit capability, and system stability of the local transmission system in the vicinity of the North Anna switchyard. The study was performed in accordance with North American Electric Reliability Corporation (NERC) criteria. Individual cases are run to NERC contingency categories A, B, and C. The applicant stated that this level of detail meets the specific requirements of the RTO and ensures that the local transmission system, including the North Anna switchyard, will continue to be a reliable power source. The applicant also stated that the SIS recommended specific upgrades to the transmission system to ensure that PJM interconnection criteria are met with the interconnection of Unit 3. In the SIS, PJM concludes that the transmission system is capable of accepting the interconnection of Unit 3 and of operating with the contingencies evaluated.

Furthermore, the applicant notes that the DCD does not presently contain the limits for voltage and frequency variation that need to be met by site-specific offsite power systems. Analysis of the as-built onsite power system will be performed to determine the load requirements during all operating modes. These analyses will, in part, specify required power, voltage, frequency, and interrupting capability necessary for the offsite power system to support safety-related load operation during all operating modes. These analyses will be accomplished as part of a site-specific inspection, test, analysis, and acceptance criterion (ITAAC) (see Section 14.3 of this SER) and will ensure that each as-built offsite circuit has sufficient capacity and capability. On the basis of its review, the staff finds that the applicant has addressed the issue adequately, and the issue is resolved.

The staff finds that COL Items 8.2.4-3-A and 8.2.4-4-A conform with the requirements of GDC 17.

- NAPS COL 8.2.4-2-A Switchyard Description
- NAPS COL 8.2.4-6-A Switchyard DC Power
- NAPS COL 8.2.4-7-A Switchyard AC Power

The applicant provided additional information in NAPS COL 8.2.4-2-A, 8.2.4-6-A, and 8.2.4-7-A to address COL Items 8.2.4-2-A, 8.2.4-6-A, and 8.2.4-7-A. The applicant stated that it has replaced the last paragraph of DCD Section 8.2.1.2.1 with the following:

> NAPS switchyard, prior to the point of interconnection with Unit 3, is a 500/230 kV, air-insulated, breaker-and-a-half bus arrangement. Unit 3 is connected to this switchyard by an overhead conductor circuit. The physical

> location and electrical interconnection of the switchyard is shown on Figures 8.2-201 and 8.2-202. Control and relay protection systems are provided. Support systems, such as grounding, raceway, lighting, AC/DC station service, and switchyard lightning protection, are also provided.

FSAR Chapter 1, Table 1.9-201, "Conformance with Standard Review Plan," for SRP Section 8.2, indicates that GDC 5 is not applicable. DCD, Revision 4, Section 8.2.2.2 states that the ESBWR reference plant is designed as a single-unit plant, and therefore, GDC 5 is not applicable. However, the staff notes that the North Anna Unit 3 switchyard is shared with Units 1 and 2 and therefore GDC 5 would apply. In **RAI 8.2-16**, the staff asked the applicant to clarify the applicability of and conformance with GDC 5. In its response on July 28, 2008, the applicant stated that the North Anna switchyard is not important to safety for Unit 3, and thus, GDC 5 is not applicable. In accordance with GDC 17, the offsite power system supports safety functions in the ESBWR design as it provides power to equipment important to safety (e.g., scram pilot valves, main steam isolation valve solenoid). These systems require support systems to be operable according to Section 1.1, "Definitions," of the technical specifications (TS), which defines "operability" as follows:

> OPERABLE–OPERABILITY—A system, subsystem, train, division, component, or device shall be OPERABLE or have OPERABILITY when it is capable of performing its specified safety function(s) and when all necessary attendant instrumentation, controls, normal (emphasis added) or emergency electric power, cooling and seal water, lubrication, and other auxiliary equipment that are required for the system, subsystem, train, division, component, or device to perform its specified safety function(s) are also capable of performing their related support function(s).

Therefore, the design must provide for the operability of systems that support systems and equipment important to safety.

GDC 5 is a technology-neutral (i.e., not dependent on the specific design or technology) requirement. (See Table J-5 of NUREG-1860, "Feasibility Study for a Risk-Informed and Performance-Based Regulatory Structure for Future Plant Licensing," Volume 2, issued December 2007 (Agencywide Documents Access and Management System Accession No. ML080440215). GDC 5 requires that the sharing of support systems required for the operability of equipment important to safety must be demonstrated not to impair said operability.

Therefore, GDC 5 applies to multiunit sites that share offsite power as a support system for equipment important to safety. In response to **RAI 8.2-27**, the applicant stated that Unit 3 will be operating under the same switchyard voltage limits as Units 1 and 2. This implies that sufficient power will be available to support Unit 3 and the analysis will meet BTP 8-6. Additionally, in response to **RAI 8.2-13**, the applicant stated that Unit 3 will implement operating procedures to maintain the switchyard voltage schedule and address challenges to the maximum and minimum limits. Analysis of the as-built onsite power system will be performed to determine the load requirements during all operating modes. These analyses will, in part, specify required power, voltage, frequency, and interrupting capability necessary for the offsite power system to support safety-related load operation. These analyses will be accomplished as part of a site-specific ITAAC (see Section 14.3 of this SER) and will ensure that the shared offsite circuits have sufficient capacity and capability.

On the basis of its review, the staff notes that Unit 3 UATs and RATs are not shared with Units 1 and 2, which are connected to the same grid, and the capacity of the offsite power system is large compared to the minimal safety-related loads (battery chargers and uninterruptible power supply (UPS)). Based on the above, North Anna 3 meets GDC 5 in this matter, and the issue is resolved.

DCD Section 8.2.3 states that a station ground grid is provided that consists of a ground mat below grade at the switchyard that is connected to the foundation embedded loop grounding system provided for the entire power block and associated buildings. In **RAI 8.2-24**, the staff asked the applicant to describe the station ground grid. On July 28, 2008, the applicant stated that a description of the station ground grid appears in Appendix 8a to DCD Section 8. However, the staff notes that the North Anna Station ground grid consists of the switchyard ground grid, existing Unit 1 and 2 ground grid, and the new Unit 3 ground grid. In **RAI 8.2-37**, the staff requests that the applicant discuss the interface and impact of station grounding resulting from the addition of the Unit 3 ground grid to the existing station ground consisting of the switchyard and the Unit 1 and 2 grounding. In addition, the staff asked the applicant to provide a summary description of the existing grounding system at North Anna and the proposed grounding of Unit 3 to achieve a single point ground at the site. On December 1, 2008, the applicant provided additional information. The applicant stated that the ground grids for Unit 3, the intermediate switchyard, and the existing North Anna switchyard will be interconnected. Since each of these ground grids either will provide, or is currently designed to provide, adequate grounding for the associated structures and equipment, the interconnection of all of these ground grids will serve to improve the quality of each of the ground grids. On the basis of its review, the staff finds that the applicant has adequately addressed the issue, and the issue is resolved.

SRP Section 8.2 (III.1.I) identifies the need to address provisions for surge protection and lightning protection. The staff's review of Chapter 8 found that these issues were not addressed. In **RAI 8.2-25**, the staff asked the applicant to discuss the adequacy of the surge protection and lightning protection of the offsite power system. On July 28, 2008, the applicant stated that the North Anna switchyard uses surge suppressors on the high and low sides of transformers 1, 2, 3, 5, and 6. The insulation coordination and surge protective devices are applied in conformance with Institute of Electrical and Electronics Engineers (IEEE) 1313.2 (2004), "IEEE Guide for the Application of Insulation Coordination," and IEEE C62.22 (2003), "IEEE Guide for Application of Metal Oxide Surge Arresters for Alternating Current Systems." The surge protective devices are maintained according to National Electrical Manufacturers Association requirements and manufacturer's recommendations. A shield wire arrangement is designed for lightning abatement in the switchyard in accordance with IEEE Standard 62.22 (2003); IEEE Standard 988-2000, "Guide to Direct Lightning Shielding of Substations"; and "Insulation Coordination for Power Systems" by Andrew R. Hileman. The staff accepted the applicant's response, and this issue is resolved.

The staff finds that COL Items 8.2.4-2-A, 8.2.4-6-A, and 8.2.4-7-A conform with the requirements of GDC 17 and GDC 5.

- NAPS COL 8.2.4-5-A Protective Relaying
- NAPS COL 8.2.4-8-A Switchyard Transformer Protection

The applicant provided additional information in NAPS COL 8.2.4-5-A and 8.2.4-8-A to address COL Items 8.2.4-5-A and 8.2.4-8-A. The applicant added a new Section 8.2.1.2.2, "Protective Relaying," which included the following:

The applicant stated that the 500 kV transmission lines are protected with redundant high-speed relay schemes with re-closing and communication equipment to minimize line outages. The 500 kV switchyard buses have redundant bus differential protection using separate and independent current and control circuits. Generating unit tie-lines and auxiliary transformer underground cable circuits are protected with redundant high-speed relay schemes. Transformers are protected with differential and over-current relay schemes. Breakers are equipped with dual trip coils. Each redundant protection circuit that supplies a trip signal is powered from its redundant dc power load group and connected to a separate trip coil. Equipment and cabling associated with each redundant system is physically separated from its redundant counterpart. Breakers are provided with a breaker failure scheme.

IEEE Standard 141, "Electrical Power Distribution for Industrial Plants," and Standard 242, "Protection and Coordination of Industrial and Commercial Power System," address the provision of sudden pressure relay and ground fault protection for transformers. In **RAI 8.2-6**, the staff asked the applicant to discuss the provision for such transformer protection. In addition, if the transformer neutrals are high-resistance grounded, the applicant was asked to discuss the monitoring schemes it implements for detection of ground faults in the system. On July 28, 2008, the applicant stated that transformers 1, 2, 3, 5, and 6 in the North Anna switchyard are protected by sudden pressure relays. Transformers 1 and 2 have solid grounds on their 500-kV, wye connected windings. The 34.5–kV, delta connected windings have zigzag transformers connected on the bus, which creates a ground source. This ground source is monitored by relays for ground fault detection. Differential relays applied across these transformers also provide ground fault protection. Since transformers 3, 5, and 6 have no tertiary winding, differential relays provide ground fault protection. On the basis of its review, the staff finds that the applicant did not identify transformers 1, 2, 3, 5, and 6 in Figure 8.2-201. In **RAI 8.2-30**, the staff asked the applicant to revise or supplement Figure 8.2-201 accordingly. On December 1, 2008, the applicant stated that it will revise FSAR Figure 8.2-201 to identify transformers 1, 2, 3, 5, and 6. The staff finds the applicant's response acceptable, and the issue is resolved. The staff confirmed that these changes are incorporated in FSAR Revision 1.

DCD, Revision 4, Section 8.2.4, item 8.2.4-5-A, notes that the COL applicant is responsible for switchyard protective relaying and will ensure that such relaying is coordinated, reviewed, and accepted by the applicable grid reliability organization. In **RAI 8.2-7**, the staff asked the applicant to discuss how it will accomplish such coordination, review, and acceptance. On July 28, 2008, the applicant stated that Dominion is responsible for engineering, constructing, operating, and maintaining the electric transmission system and interfacing with the RTO, PJM. This responsibility includes the design, maintenance, and operation of the switchyard protective relaying that will be required by the interconnection of Unit 3 to the North Anna switchyard. PJM studied the interconnection of Unit 3 to the North Anna switchyard and recommended no additional design requirements above those typically used by Dominion in the design of the protective relaying scheme at the switchyard. The staff accepted the applicant's response, and this issue is resolved.

The staff finds that COL Items 8.2.4-5-A and 8.2.4-8-A conform with the requirements of GDC 17.

- NAPS COL 8.2.4-9-A Stability and Reliability of the Offsite Transmission Power System

- NAPS COL 8.2.4-10-A Interface Requirements

The applicant provided additional information in NAPS COL 8.2.4-9-A and 8.2.4-10-A to address COL Items 8.2.4-9-A and 8.2.4-10-A. The applicant stated that it has replaced DCD Section 8.2.2.1, "Reliability and Stability Analysis," with the following:

> The applicant stated that a SIS analyzed load flow, transient stability and fault analysis for the addition of Unit 3. The study was prepared using 2011 summer light-load and 2014 summer base-load projections. The analysis was performed using Power Technology International software PSS/E. The analysis examined conditions involving loss of the largest generating unit, loss of the most critical transmission line, and multiple facility contingencies. The maximum and minimum switchyard voltage limits have been established for the 500 kV switchyard, at 534 kV and 505 kV, respectively. Normal operating and abnormal procedures exist to maintain the switchyard voltage schedule and address challenges to the maximum and minimum limits. Dominion has established a switchyard interface agreement and protocols for maintenance, communications, switchyard control, and system analysis sufficient to safely operate and maintain the power station interconnection to the transmission system. The transmission system operator provides analysis capabilities for both long term planning and real time operations. A real time system estimator is used to assist in the evaluation of actual system conditions. The study concluded that with the additional generating capacity of Unit 3, the transmission system remains stable under the analyzed conditions, preserving the grid connection and supporting the normal and shutdown power requirements of Unit 3. Grid stability is evaluated on an ongoing basis based on load growth, the addition of new transmission lines, or new generation capacity.
>
> The applicant stated that grid availability in the region over the past 20 years was examined and it was confirmed that the system has been highly reliable with minimal outages due to equipment failures.

In **RAI 8.2-3**, the staff asked the applicant to provide the MVA rating of the intermediate transformer. On July 28, 2008, the applicant stated that the intermediate transformer consists of three single-phase auto transformers rated at 112 MVA each. The staff accepted the applicant's response, and this issue is resolved.

In **RAI 8.2-10**, the staff asked the applicant to clarify whether the analysis addressed multiple facility contingencies (e.g., the analysis included tripping of all three nuclear units). On July 28, 2008, the applicant stated that it performed the grid stability analysis in accordance with NERC criteria. Individual cases were run to NERC Categories A, B, and C for no contingency evaluations, N-1 evaluations, and N-2 evaluations, respectively. NERC Category D is considered an extreme event analysis and exceeds N-2. This includes a case for loss of all generating units at a single station. SRP Section 8.2 III.F indicates that grid stability analyses should consider normal conditions, N-1 events, and N-2 events. Palo Verde Nuclear Generating Station lost offsite power, and all three units tripped on June 14, 2004. As a result of this operating experience, the staff asked the applicant to clarify whether the stability analysis for the North Anna switchyard included tripping of all three nuclear units. In **RAI 8.2-31**, the staff asked the applicant to provide a discussion (including failure mode and effect analysis) of why it believes that an event similar to that at Palo Verde will not cause the loss of three units at North Anna Station, or if such an event occurs, why it will not impact grid stability.

On December 1, 2008, the applicant stated that it had reviewed the description of the Palo Verde event in NRC IN 2005-15, "Three-Unit Trip and Loss of Offsite Power at Palo Verde Nuclear Generating Station," dated June 1, 2005. As a result of its review of IN 2005-15, Dominion implemented certain modifications to the protective scheme within the 230-kV portion of the North Anna switchyard. The 500-kV portion of the North Anna switchyard and its connecting substations has circuit breakers with dual trip coils and dual control circuits. The 230-kV portion of the North Anna switchyard and its connecting substation has circuit breakers with single trip coils and single control circuits. The circuit protection scheme at the 230-kV transmission level uses overlapping zones of protection and relies on communications that span the transmission lines from substation to switchyard. If a fault occurs on the 230-kV line at the first remote substation from the North Anna switchyard and the remote substation breaker fails to open, a transfer trip signal will be sent to open the North Anna breaker. This same logic is true for a fault on the 230-kV line near the North Anna switchyard. Also, if a fault occurs on the 230-kV line at North Anna that is not immediately cleared because of breaker failure to operate, trip signals will be generated to open breakers in expanding zones of protection until the fault is cleared. If necessary, the 500-kV breakers will open to isolate the 230-kV portion of the switchyard. At this level, the breakers have dual trip coils and dual control circuits. Since North Anna Units 1 and 2 interconnect at the 500-kV level, and since Unit 3 is proposed to interconnect at the 500-kV level, the generating units are ultimately protected by equipment that uses dual trip coils and dual control circuits, thus limiting the possibility of an event similar to the Palo Verde event. The staff finds the applicant's response acceptable and the issue is resolved.

FSAR Section 8.2.2.1 states that the stability analysis did not consider the 34.5-kV portion of the North Anna switchyard. The staff review identified the station auxiliary loads for all three units to be substantial. In **RAI 8.2-11**, the staff asked the applicant to provide the basis, and identify the connected total station auxiliary loads (of all three units), for excluding analysis of the 34.5-kV portion of the switchyard. On July 28, 2008, the applicant stated that the stability analysis discussed in the FSAR is an angular stability analysis that verifies stability of the transmission system when exposed to loss of selected transmission and generation assets. This study is performed at the transmission voltage level and would therefore exclude loads operating at distribution voltage levels of 34.5 kV as they have limited ability to cause angular stability difficulties at the transmission level. This is the standard method for performing angular stability by Dominion and PJM. In **RAI 8.2-32**, the staff asked the applicant to quantify the 34.5-kV distribution loads (MW/MVA) in terms of the total load modeled for the 500-kV transmission system. In addition, the staff asked the applicant to explain the reason for its belief that the distribution loads have limited ability to affect the grid stability. On December 1, 2008, the applicant stated that in the North Anna switchyard, the 34.5-kV buses are fed from either the 500-kV switchyard or the 230-kV switchyard. Each of the 34.5-kV buses serves plant auxiliary loads associated with Units 1 and 2 only. There is no generation source connected to the 34.5-kV buses. The study did not explicitly model the 34.5-kV buses in the North Anna switchyard, but it did include the plant auxiliary loads on each of these buses at the 500-kV level. The applicant stated that it will revise FSAR Section 8.2.2.1 to indicate that the 34.5-kV loads are considered at the 500-kV level. The staff finds the applicant's response acceptable. The staff confirmed that these changes are incorporated in FSAR Revision 1, and the issue is resolved.

FSAR Section 8.2.2.1 states that an examination of grid availability in the region over the past 20 years confirmed that the system has been highly reliable with minimal outages resulting from equipment failure. In **RAI 8.2-12**, the staff asked the applicant to provide supporting information for this statement to include the frequency, duration, and causes of outages over the past

20 years for both the transmission system accepting the unit's output and the transmission system providing the preferred power for the unit's load. On July 28, 2008, the applicant stated that Dominion has reviewed equipment failure history for the period from 1988 to 2008. The major types of equipment that can affect the reliability of the North Anna switchyard are transmission lines, transformers, and specific circuit breakers within the switchyard. The applicant concluded that the switchyard has experienced relatively few equipment lockouts because of equipment failure, and the equipment lockouts have been limited to individual pieces of equipment. The North Anna switchyard and local transmission system have not experienced a complete loss of power in the past 20 years. The staff accepted the applicant's response, and this issue is resolved.

FSAR Section 8.2.2.1 states, "Upon approaching or exceeding a limit, these procedures verify available of required and contingency equipment and materials, direct notifications to outside agencies and address unit TSs (TS) actions until the normal voltage schedule can be maintained." In **RAI 8.2-13**, the staff asked the applicant to clarify the reference to TS in this statement. On July 28, 2008, the applicant stated that the operating procedures for controlling the normal voltage schedule for existing Units 1 and 2 reference the associated Unit 1 and 2 TS for the offsite power system. Unit 3 will implement similar operating procedures to maintain the switchyard voltage schedule and address challenges to the maximum and minimum limits. However, the Unit 3 procedures will not reference any TS for offsite power, because they are not required. Therefore, Dominion will revise the FSAR Section 8.2.2.1 discussion of the operating procedures to delete the reference to the TS. On the basis of its review, the staff finds that the applicant has adequately addressed the issue. The staff confirmed that these changes are incorporated in FSAR Revision 1, and the issue is resolved.

In **RAI 8.2-14**, the staff asked the applicant to provide the basis for using 2011 summer light-load and 2014 summer base-case projections rather than the summer heavy-load projections. The staff also asked the applicant to clarify whether the summer loads bound winter peak loads. On July 28, 2008, the applicant stated that load flow analysis and the import/export study portion of the SIS were based on data projected for the timeframe corresponding to Dominion's requested interconnection date of April 2014. The 2014 summer base case was used because it is considered to be the peak load for the transmission system affected and envelops the peak winter load. The stability study portion of the SIS requires the use of a lighter load to identify any problems with angular stability of the system. Dominion submitted the stability study request to the RTO in 2006. The RTO uses a 5-year horizon for its studies; therefore, the 2011 summer case was selected for the stability study. After 2011, the RTO will perform annual baseline analyses to update the Regional Transmission Expansion Plan and identify potential reliability problems. The staff accepted the applicant's response, and this issue is resolved.

In **RAI 8.2-15**, the staff asked the applicant to identify the maximum and minimum grid frequency. Additionally, the staff asked the applicant to discuss how the auxiliary power system studies consider the combined effect of frequency and voltage variation on the operation of safety-related loads (safety-related battery chargers and safety-related UPS) and other running motor loads. On July 28, 2008, the applicant stated that the potential maximum and minimum grid frequency can be 62 hertz to 57.5 hertz with the time restriction stated in the response. The auxiliary power system studies conducted by GEH consider the combined effect of frequency and voltage variations on the safety-related loads and other motor loads. The staff accepted the applicant's response, and this issue is resolved.

FSAR Chapter 1, Table 1.9-201, "Conformance with Standard Review Plan," for SRP Section 8.2 indicates that North Anna 3 satisfies the requirements of 10 CFR 50.65(a)(4). However, the staff review of Chapter 8 found no discussion of 10 CFR 50.65. In **RAI 8.2-19**, the staff asked the applicant to clarify compliance with the requirements of 10 CFR 50.65(a)(4). On July 28, 2008, the applicant stated that North Anna 3 complies with the requirements of 10 CFR 50.65(a)(4). In particular, the subject regulation is one aspect of the "Maintenance Rule" (10 CFR 50.65), an operational program. Item 17 in FSAR Table 13.4-201 addresses the implementation of the program, and FSAR Section 17.6 discusses its content. However, the staff finds that the applicant did not address the applicability of the Maintenance Rule to switchyard equipment. In **RAI 8.2-36**, the staff asked the applicant to address the applicability of the Maintenance Rule to switchyard components, discuss actions to limit the risk associated with transmission system degradation, and discuss actions required before performing "grid-risk-sensitive" maintenance activities for switchyard components. On December 1, 2008, the applicant stated that Maintenance Rule Program implementation incorporates by reference Nuclear Energy Institute (NEI) Technical Report 07-02, "Generic FSAR Template Guidance for Maintenance Rule Program Description for Plants Licensed Under 10 CFR Part 52." The scope of structures, systems, and components covered by the Maintenance Rule Program is determined using the scoping procedure defined in the program description in NEI 07-02A. The offsite power system and its components will be evaluated for inclusion in the Maintenance Rule Program in accordance with these scoping procedures during program implementation. NEI 07-02A, Section 17.X.1.5, addresses risk assessment and risk management pursuant to 10 CFR 50.65(a)(4) and considers the issues associated with grid and offsite power system reliability as identified in NRC GL 2006-02, items 5 and 6. Therefore, although detailed Maintenance Rule Program development is not anticipated in advance of the schedule defined in Table 13.4-201, performance of grid reliability evaluation 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) is considered a necessary part of the program in accordance with NEI 07-02A guidance. The staff finds the applicant's response acceptable and the issue is resolved.

DCD, Revision 4, Section 8.2.3, states that a transmission system reliability and stability review of the site-specific configuration to which the plant is connected will be performed to determine the reliability of the offsite power system and verify that it is consistent with the analysis of Chapter 19. In **RAI 8.2-23**, the staff asked the applicant to clarify the manner in which the reliability of the offsite power system is verified to be consistent with the analysis of Chapter 19. On July 28, 2008, the applicant stated that the ESBWR probabilistic risk assessment (PRA) used site-specific PRA information from the North Anna site to develop PRA parameters for loss of preferred power (LOPP) frequency. The LOPP frequency is divided into plant-centered, switchyard, grid-related, and weather-related initiating events. ESBWR LOPP frequencies are based on NUREG/CR-6890, "Reevaluation of Station Blackout Risk at Nuclear Power Plants, Analysis of Loss of Offsite Power Events: 1986–2004," issued November 2005. The North Anna LOPP frequencies were compared to the ESBWR frequencies to identify any outliers. The data show that grid-related losses of power are significantly more frequent than plant-centered, switchyard, or weather-related losses of power. According to the applicant , there is a variance in the values for the LOPP frequencies, but their range is acceptable because the change in core damage frequency by using the highest frequency is less than $1x10^{-10}$ per year. Furthermore, the conclusions in DCD Tier 2, Section 19.2.3.1, "Risk from Internal Events," remain valid for the minor variances in LOPP frequencies. The applicant concludes that the ESBWR PRA provides a reasonable representation of the parameters and conditions that are specific to the North Anna site. Additionally, the SIS has identified the required transmission facility upgrades to ensure that reliability is not reduced below the

required set standards. Finally, when the required upgrades are made, the reliability of the offsite power system will be consistent with the analysis of Chapter 19. The staff accepted the applicant's response, and this issue is resolved.

FSAR Section 8.2.2.1, "Reliability and Stability Analysis," NAPS COL 8.2.4-9-A, identified maximum and minimum switchyard voltage limits of 534 kV and 505 kV. In **RAI 8.2-27**, the staff asked the applicant to explain how these limits were established and confirm that these voltage limits are acceptable for auxiliary power system equipment operation, including safety-related battery chargers and safety-related UPS during different operating conditions. The staff requested that the confirmation include assumptions, acceptance criteria, and summary of results for the following: load flow analysis (bus and load terminal voltages of the station auxiliary system), short-circuit analysis, equipment sizing studies, protective relay setting and coordination, and motor starting with minimum and maximum grid voltage conditions. The staff also requested a separate set of calculations for each available connection to offsite power supply. In addition, the applicant should discuss how the results of the calculations will be verified.

On August 21, 2008, the applicant stated that Dominion will submit its response at a later date. On November 19, 2008, the applicant stated that the North Anna 500-kV switchyard voltage limits of 534 kV and 505 kV were established for the operation of Units 1 and 2. Furthermore, the DCD does not presently contain limits for voltage and frequency variation that need to be met by site-specific offsite power systems. Analyses of the as-built onsite power system will be performed to determine the load requirements during design-basis operating modes. These analyses will, in part, specify required power, voltage, frequency, and interrupting capability necessary for the offsite power system to support safety-related load operation during design-basis operating modes. These analyses will be accomplished as part of a site-specific ITAAC (see Section 14.3 of this SER) and will ensure that each as-built offsite circuit has sufficient capacity and capability.

On March 18, 2009, the applicant stated that the effect of a North Anna Unit 3 trip on the switchyard voltage and frequency limits is addressed as a part of the ITAAC process (see Section 14.3 of this SER). The staff accepted the applicant's response, and the issue is resolved.

The staff finds that NAPS COL Items 8.2.4-9-A and 8.2.4-10-A conform with the requirements of 10 CFR 50.65 and GDC 17 and the guidance of BTP 8-3, BTP 8-6, RG 1.32, RG 1.160, RG 1.182, and RG 1.206.

Supplemental Information

- NAPS SUP 8.2-2 Testing and Inspection

The applicant provided a new Section 8.2.1.2.3, "Testing and Inspection," as NAPS SUP 8.2-2 with the following addition:

> Transmission lines are inspected via an aerial inspection program approximately twice per year. The inspection focuses on such items as right-of-way encroachment, vegetation management, conductor and line hardware condition, and the condition of supporting structures. Routine switchyard inspection activities include, but are not necessarily limited to, the following:

- Daily transformer inspections
- Periodic inspections of circuit breakers and batteries
- Quarterly infrared scans
- Semi-annual infrared scans (relay panels)
- Semi-annual inspection of substation equipment
- Annual infrared scans
- Annual corona camera scan

Routine switchyard testing activities include, but are not necessarily limited to, the following:

- Biennial circuit breaker profile or timing tests
- Biennial 500 kV relay testing
- Triennial 230 kV relay testing
- 5-year battery discharge testing
- 8-year PT testing
- 8-year ground grid testing
- 10-year CCVT testing
- 10-year arrester testing
- 10-year wave trap testing

In **RAI 8.2-8**, the staff asked the applicant to address the industry (FERC, NERC, and IEEE) standards that will be followed for switchyard protection system, monitoring, maintenance, and testing. The staff also asked the applicant to confirm that generator circuit breakers will meet the requirements of IEEE Standard C37.013, "Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current." On July 28, 2008, the applicant stated that monitoring, maintenance, and testing of the switchyard protection system are performed under NERC Standard PRC-005-1, "Transmission and Generation Protection System Maintenance and Testing"; Standard PRC-008-0, "Underfrequency Load Shedding Equipment Maintenance Program"; and Standard PRC-017-0, "Special Protection System Maintenance and Testing." IEEE C37.013 was written specifically for high-current circuit breakers installed between generators and transformer terminals. The proposed Unit 3 at North Anna places the circuit breaker on the high side terminals of the generator step-up transformers. Thus, IEEE C37.013 does not directly apply. The applicant stated that it will revise FSAR Section 8.2.1.2.3 to include the above NERC standards for monitoring, maintenance, and testing of the switchyard protection system. The staff finds that the applicant's commitment to these industry standards provides reasonable assurance that switchyard components will be adequately tested and maintained. The staff confirmed that these changes are incorporated in FSAR Revision 1, and the issue is resolved.

In **RAI 8.2-9**, the staff asked the applicant to include transformer testing as part of the overall routine switchyard component testing. On July 28, 2008, the applicant stated that North Anna switchyard transformers have dissolved gas analysis performed every 6 months. Additionally, if the transformer has a load tap changer (LTC), the dissolved gas analysis is performed on the LTC every 4 years. Infrared scans are performed quarterly on transformers. FSAR Section 8.2.1.2.3 will be revised to include the requirement to conduct semiannual dissolved gas analysis on transformers and 4-year dissolved gas analysis on LTC. The staff finds that the applicant addressed the issue adequately. The staff confirmed that these changes are incorporated in FSAR Revision 1, and the issue is resolved.

The staff concludes that NAPS SUP 8.2-2 conforms with the requirements of GDC 18 and the guidance of RG 1.118.

- NAPS SUP 8.2-3 Failure Mode and Effects Analysis

The applicant provided a new Section 8.2.2.3, "Failure Modes and Effects Analysis," as NAPS SUP 8.2-3 with the following addition:

> Unit 3 is connected to the Dominion transmission system via four 500 kV and one 230 kV overhead transmission lines. Each transmission line occupies a separate right-of-way, except the two parallel Ladysmith lines, which share the same right-of-way. Failure of any one tower due to structural failure can at most disrupt and cause a loss of power distribution to itself and the adjacent line. Failure of a line conductor would cause the loss of one of the four 500 kV lines, with the other three lines remaining available as normal and alternate preferred power sources.
>
> A breaker-and-a-half scheme is incorporated in the design of the switchyard. This arrangement offers the following flexibility to control a failed condition within the switchyard.
>
> - Any faulted transmission line into the switchyard can be isolated without affecting any other transmission line.
> - Either bus can be isolated without interruption of any transmission line or other bus.
> - All relay schemes used for protection of the offsite power circuits and switchyard equipment include primary and backup protection features. All breakers are equipped with dual trip coils. Each protection circuit that supplies a trip signal is connected to a separate trip coil.

The failure of any component within the intermediate switchyard may disrupt the normal preferred power supply. However, the alternate preferred power supply will remain available to supply the load.

On the basis of its review, the staff determined that there are no single failures that can prevent the NAPS offsite power system from performing its function to provide power to Unit 3, and thus the guidance of RG 1.206 has been followed.

8.2.5 Post Combined License Activities

There are no post COL activities related to this chapter.

8.2.6 Conclusion

The NRC staff reviewed the application and checked the referenced DCD. The NRC staff's review confirmed that the applicant has addressed the required information relating to offsite power systems, and no outstanding information is expected to be addressed in the COL FSAR related to this subsection.

The staff is reviewing the information in DCD Section 8.2 on Docket No. 52-010. The results of the NRC staff's technical evaluation of the information related to offsite power systems incorporated by reference in the North Anna 3 COL FSAR will be documented in the staff SER on the DC application for the ESBWR. The SER on the ESBWR is not yet complete, and this is being tracked as part of Open Item 1-1. The staff will update Section 8.2 of this SER to reflect the final disposition of the DC application.

In addition, the staff has compared the additional COL and supplemental information within the application for this section to the relevant NRC regulations, guidance in Section 8.2 of NUREG-0800, and other NRC RGs. The applicant has adequately addressed COL information items NAPS COL 8.2.4-1-A through 8.2.4-10-A involving the design details of the plant site switchyard and its interface with the local transmission grid and NAPS SUP 8.2-2 and 8.2-3 involving testing and inspection of switchyard components and failure modes and effects analysis. The staff concludes that the requirements of GDC 5, 17, and 18 and 10 CFR 50.65 will be met for this section.

8.3 Onsite Power Systems

8.3.1 AC Power Systems

8.3.1.1 Introduction

This section provides descriptive information, analyses, and referenced documents, including electrical single-line diagrams, electrical schematics, logic diagrams, tables, and physical arrangement drawings for the onsite ac power system. The onsite ac power system includes those 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.

In the ESBWR passive reactor design used at North Anna 3, the onsite ac power system is a non-Class 1E system that provides reliable ac power to the various system electrical loads. It does not perform any safety-related functions. These loads enhance an orderly shutdown under emergency (not accident) conditions. Additional loads for investment protection can be manually loaded on the standby power supplied. Diesel generator sets are used as the standby power source for the onsite ac power systems. Those portions of the onsite ac power systems that are not related to safety are described only in sufficient detail to permit an understanding of their interactions with the safety-related portions.

The plant UPS system (120 V ac vital power) comprises independent Class 1E and non-Class 1E UPS systems. Each system consists of rectifiers, inverters, ungrounded batteries, and distribution panels. The Class 1E UPS system provides reliable power for the safety-related equipment required for the plant instrumentation, control, monitoring, and other vital functions needed for shutdown of the plant. In addition, the Class 1E UPS system provides power to the emergency lighting in the main control room and remote shutdown area.

8.3.1.2 Summary of Application

Section 8.3 of the North Anna 3 COL FSAR, Revision 1, incorporates by reference Section 8.3 of the ESBWR DCD, Revision 5. Section 8.3 of the ESBWR DCD includes Section 8.3.1, "AC Power Systems," which addresses SRP Section 8.3.1, "AC Power Systems (Onsite)."

In addition, in FSAR Section 8.3.1, the applicant provided the following information:

COL Item

- NAPS COL 8A.2.3-1-A Cathodic Protection System

The applicant provided additional information regarding a cathodic protection system to address NAPS COL 8A.2.3-1-A.

Supplemental Information

- NAPS SUP 8.3-1 Onsite Power Description

In FSAR Section 8.3.1.1, "Description," the applicant provided information describing an intermediate switchyard to transition offsite power from the NAPS switchyard.

8.3.1.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is addressed within the FSER related to the DCD.

In addition, the regulatory basis for acceptance of the COL supplemental information is established in GDC 17.

8.3.1.4 Technical Evaluation

The NRC staff reviewed Section 8.3.1 of the North Anna 3 COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the information in the COL represent the complete scope of information relating to this review topic.. The NRC staff's review confirmed that the information contained in the application and incorporated by reference addresses the required information related to ac power systems (onsite). The staff is reviewing Section 8.3.1 of the ESBWR DCD on Docket No. 52-010. The NRC staff's technical evaluation of the information incorporated by reference related to the AC power systems (onsite) will be documented in the staff SER on the design certification application for the ESBWR design.

The staff reviewed the following information contained in the COL FSAR:

Combined License Item

- NAPS COL 8A.2.3-1-A Cathodic Protection System

The applicant provided additional information in NAPS COL 8A.2.3-1-A. The applicant stated that a cathodic protection system is provided, as required, and that the system is designed in accordance with the standards of the National Association of Corrosion Engineers.

The staff finds that the applicant has adequately addressed the COL item.

Supplemental Information

- NAPS SUP 8.3-1 Onsite Power Description

The applicant provided the following supplemental information to modify Section 8.3.1.1, "Description":

> An intermediate switchyard is utilized to transition off-site power from the NAPS switchyard to the Unit 3 main power transformers, and unit auxiliary transformers (UATs). This intermediate switchyard contains the main generator circuit breaker, and a supply circuit breaker, which provides power to 500/230 kV intermediate transformers used to supply power to the UATs. These intermediate transformers consist of three single phase transformers and include an installed spare transformer. Also included in the intermediate switchyard is a transmission tower which supports a 500 kV disconnect switch that is identified as the point of interconnection between the onsite power sources and offsite power sources.

The staff finds that the applicant has adequately described the North Anna 3 connection to the utility grid and the connection conforms to the requirements of GDC 17.

8.3.1.5 Post Combined License Activities

There are no post COL activities related to this chapter.

8.3.1.6 Conclusion

The NRC staff reviewed the application and checked the referenced DCD. The NRC staff's review confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this subsection.

The staff is reviewing the information in DCD Section 8.3.1 on Docket No. 52-010. The staff will document the results of its technical evaluation of the information related to the ac power systems (onsite) incorporated by reference in the North Anna 3 COL FSAR in the staff SER on the DC application for the ESBWR. The SER on the ESBWR is not yet complete, and this is being tracked as part of Open Item 1-1. The staff will update Section 8.3.1 of this SER to reflect the final disposition of the DC application.

In addition, the staff has compared the additional COL item and supplemental information within the application to the relevant NRC regulations, guidance in Section 8.3.1 of NUREG-0800, and other NRC RGs and concludes that the applicant is in compliance with the NRC regulations.

The staff concludes that the applicant has adequately addressed the North Anna 3 COL item involving cathodic protection systems and supplemental information involving the transmission system and its electrical connection to the plant. In conclusion, the staff finds that the applicant has provided sufficient information to satisfy the requirements of GDC 17 for this section.

8.3.2 DC Power Systems

8.3.2.1 Introduction

This section provides descriptive information, analyses, and referenced documents, including electrical single-line diagrams, electrical schematics, logic diagrams, tables, and physical arrangement drawings for the onsite dc power systems. The onsite dc power systems include those power sources and their distribution systems that supply motive or control power to

safety-related equipment. The nonsafety-related portions are described only in sufficient detail to permit an understanding of their interactions with the safety-related portions. This section clearly identifies the safety loads and states the length of time they would be operable in the event of a loss of ac power.

The plant dc power system comprises independent Class 1E and non-Class 1E dc power systems. Each system consists of ungrounded stationary batteries, dc distribution equipment, and UPS.

The Class 1E dc and UPS system in the ESBWR passive reactor design plant is capable of providing reliable power for the safe shutdown of the plant without the support of battery chargers during a loss of all ac power sources coincident with a design-basis accident for 72 hours. The system is designed so that no single failure will result in a condition that will prevent the safe shutdown of the plant.

The non-Class 1E dc and UPS system in the ESBWR passive reactor design plant provides continuous, reliable electric power to the plant non-Class 1E control and instrumentation loads and equipment that are required for plant operation and investment protection and to the hydrogen igniters located inside containment. Operation of the non-Class 1E dc and UPS system is not required for nuclear safety.

8.3.2.2 Summary of Application

Section 8.3 of the North Anna 3 COL FSAR, Revision 1, incorporates by reference Section 8.3 of the ESBWR DCD, Revision 5. Section 8.3 of the ESBWR DCD includes Section 8.3.2, "DC Power Systems," which addresses SRP Section 8.3.2, "DC Power Systems (Onsite)."

In addition, in FSAR Section 8.3.2, the applicant provided the following:

Supplemental Information

- NAPS SUP 8.3-2 Safety-Related Station Batteries and Battery Chargers Station Blackout

In FSAR Section 8.3.2.1.1, "Safety-Related Station Batteries and Battery Chargers Station Blackout," the applicant provided information on the training and procedures to mitigate SBO, with references to Sections 13.2 and 13.5 of the FSAR and DCD Section 15.5.5

8.3.2.3 Regulatory Basis

The FSER related to the DCD regulatory basis addresses the information incorporated by reference.

In addition, the regulatory bases for acceptance of the COL supplemental information are established in 10 CFR 50.63, "Loss of All Alternating Current Power"; the guidelines of RG 1.155, "Station Blackout"; and Nuclear Management and Resource Council (NUMARC) 87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," issued November 1987.

8.3.2.4 Technical Evaluation

The NRC staff reviewed Section 8.3 of the North Anna 3 COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the information in the COL represent the complete scope of information relating to this review topic. The NRC staff's review confirmed that the information contained in the application and incorporated by reference addresses the required information related to the dc power system. The staff is reviewing Section 8.3.2 of the ESBWR DCD on Docket No. 52-010. The staff's technical evaluation of the information incorporated by reference related to the DC power systems (onsite) will be documented in the staff SER on the design certification application for the ESBWR.

The staff reviewed the following information contained in the FSAR:

Supplemental Information

- NAPS SUP 8.3-2 Safety-Related Station Batteries and Battery Chargers Station Blackout

The applicant provided supplemental information in Section 8.3.2.1.1 of the FSAR for addressing training and procedures to mitigate an SBO event by adding the following at the end of FSAR Section 8.3.2.1.1:

> Training and procedures to mitigate an SBO event are implemented in accordance with Sections 13.2 and 13.5. The ESBWR is a passive design and does not rely on offsite or onsite AC sources of power for at least 72 hours after an SBO event, as described in DCD Section 15.5.5, Station Blackout. In addition, there are no nearby large power sources, such as a gas turbine or black start fossil fuel plant, that can directly connect to the station to mitigate the SBO event. Restoration from an SBO event will be contingent upon power being made available from any one of the following sources: (1) Either of the station diesel generators; (2) Restoration of any one of the four 500 kV transmission lines described in Section 8.2; and (3) Restoration of the 230 kV transmission line described in Section 8.2.

According to NUMARC 87-00, which is endorsed by RG 1.155, the SBO response procedures include (1) SBO response guidelines, (2) ac power restoration, and (3) severe weather guidelines. In **RAI 8.3.2-1**, the staff asked the applicant to confirm that training and procedures cover all three SBO response procedures. On August 4, 2008, the applicant stated that it will revise the FSAR to indicate that procedures will include these three areas. The applicant further stated that licensed and nonlicensed plant personnel receive adequate training for responding to all plant events, both normal and abnormal, and such training encompasses an SBO event. The staff finds that the applicant met the requirements of 10 CFR 50.63 and RG 1.155 contingent on maintaining these procedures and personnel training. The subject RAI is adequately addressed. The staff confirmed that these changes are incorporated in Revision 1 of the FSAR, and the issue is resolved.

The staff finds that NAPS SUP 8.3-2 conforms with the requirements of 10 CFR 50.63 and the guidance of RG 1.155.

8.3.2.5 Post Combined License Activities

There are no post COL activities related to this chapter.

8.3.2.6 Conclusion

The NRC staff reviewed the application and checked the referenced DCD. The NRC staff's review confirmed that the applicant has addressed the required information, and no outstanding information is expected to be addressed in the COL FSAR related to this subsection.

The staff is reviewing the information in DCD Section 8.3.2 on Docket No. 52-010. The staff will document the results of its technical evaluation of the information related to the dc power systems (onsite) incorporated by reference in the North Anna 3 COL FSAR in the staff SER on the DC application for the ESBWR. The SER on the ESBWR is not yet complete, and this is being tracked as part of Open Item 1-1. The staff will update Section 8.3.2 of this SER to reflect the final disposition of the DC application.

In addition, the staff has compared the supplemental information within the application to the relevant NRC regulations, guidance in Section 8.3.2 of NUREG-0800, and other NRC RGs and concludes that the applicant is in compliance with the NRC regulations.

The applicant has adequately addressed North Anna 3 COL supplemental information pertaining to training and procedures to mitigate an SBO event. The staff finds that the applicant has provided sufficient information to satisfy the requirements of 10 CFR 50.63 for this section.

8.4 Station Blackout

The North Anna 3 COL FSAR does not include Section 8.4. ESBWR DCD Section 15.5.5 presents the SBO safety analysis. In the North Anna 3 COL FSAR, Revision 1, Section 15.5.5, "Station Blackout," the applicant incorporated by reference Section 15.5.5, "Station Blackout," of the ESBWR DCD, Revision 5, with no departures or supplements.