CHAPTER 8

ELECTRIC POWER

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CHAPTER 8

ELECTRIC POWER

8.1 INTRODUCTION

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

8.1.1 UTILITY GRID DESCRIPTION

Replace the existing information in DCD Subsection 8.1.1 with the following information.

BLN SUP 8.1-1 The Tennessee Valley Authority (TVA) is a corporate agency of the United States Government serving most of the State of Tennessee and parts of six other states in the Southeast on the boundaries of the Tennessee River. TVA is interconnected with electric power companies to the north, west, south, and east of its service area. The TVA grid consists of interconnected hydro plants, fossil-fueled plants, combustion turbine plants, and nuclear plants supplying electric energy over a transmission system consisting of various voltages up through 500 kV.

The Bellefonte Nuclear Plant Units 3 and 4 (BLN) is located 44 miles southwest of Chattanooga, Tennessee, on the west bank of the Tennessee River, seven miles northeast of Scottsboro, Alabama. The plant is connected into TVA's 500 kV transmission grid through a 500 kV switchyard at the plant site. The 500 kV switchyard is a double bus, double breaker arrangement. There are four 500 kV transmission lines connected in the 500 kV switchyard.

8.1.4.3 Design Criteria, Regulatory Guides, and IEEE Standards

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BLN SUP 8.1-2 Add the following information between the second and third paragraphs of this subsection.

Offsite and onsite ac power systems' conformance to Regulatory Guides and IEEE Standards identified by DCD Table 8.1-1 as site-specific and to other applicable Regulatory Guides is as indicated in Table 8.1-201.

BLN SUP 8.1-2

TABLE 8.1-201

SITE-SPECIFIC GUIDELINES FOR ELECTRIC POWER SYSTEMS

Criteria				Applicability (FSAR[a] Section/Subsection) 8.2	8.3.1	8.3.2	Remarks
1.	Regulatory Guides						
	a.	RG 1.129	Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Nuclear Power Plants			G	Battery Service tests are performed in accordance with the Regulatory Guide.
	b.	RG 1.155	Station Blackout				Not applicable[b]
	c.	RG 1.204	Guidelines for Lightning Protection of Nuclear Power Plants	G	G		Implemented via IEEE 665.
	d.	RG 1.206	Combined License Applications for Nuclear Power Plants (LWR Edition)	G	G	G	
2.	Branch Technical Positions						
	a.	BTP 8-3 (BTP ICSB-11 in DCD)	Stability of Offsite Power Systems	G			Stability Analysis of the Offsite Power System is performed in accordance with the BTP.

a) "G" denotes guidelines as defined in NUREG-0800, Rev. 3, Table 8-1 (SRP). No letter denotes "Not Applicable."
b) Station Blackout and the associated guidelines were addressed as a design issue in the DCD.

8.2 OFFSITE POWER SYSTEM

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

8.2.1 SYSTEM DESCRIPTION

Delete the first, second, and sixth paragraphs, and the first and last sentences of the fourth paragraph, of DCD Section 8.2.1. Add the following information before the fifth paragraph of DCD Subsection 8.2.1.

BLN COL 8.2-1 The BLN is connected into a network supplying large load centers. The BLN is tied into the Tennessee Valley Authority's (TVA) 500 kV transmission system via a 500 kV switchyard and 500 kV transmission lines. The interconnection of the BLN, the switchyard, and the 500 kV transmission system is shown in Figures 8.2-201 and 8.2-202.

There are four transmission lines connected to the 500 kV switchyard. Each 500 kV transmission line is connected to a TVA substation located 20 to 75 mi. from the plant.

500 kV line	Termination Point	Length (miles)	Thermal Rating (MVA)
Widows Creek 1	Widows Creek Steam Plant	21	2120
Madison	Madison 500 kV Substation	41	1730
East Point	East Point 500 kV Substation	72	2120
Widows Creek 2	Widows Creek Steam Plant	30	1730

The previously de-energized 500 kV transmission lines are re-energized and the previously de-energized 500 kV switchyard is modified to serve the BLN. The existing Units 1 and 2 are disconnected from the switchyard.

The Widows Creek 1 and the Madison 500 kV lines are on a common right-of-way for approximately the first 12.5 mi. from the plant. The lines exit the site in a northwesterly direction before splitting off eastward to Widows Creek and westward to Madison.

The Widows Creek 2 and the East Point 500 kV lines are on common right-of-way for approximately the first 3.3 mi. from the plant. The two lines share a common tower structure on either side of their Tennessee River crossing. The lines exit the site in a southeasterly direction before splitting off northeast to Widows Creek and southwest to East Point.

BLN CDI A transformer area containing the main step-up transformer (GSU), unit auxiliary transformers (UAT), and reserve auxiliary transformers (RAT) is located next to each turbine building.

8.2.1.1 Transmission Switchyard

Replace the information in DCD Subsection 8.2.1.1 with the following information.

BLN COL 8.2-1 The BLN is served by a 500 kV switchyard, modified to meet the requirements for Units 3 and 4. The 500 kV switchyard has two main buses. Each of the four 500 kV lines and each of the two GSUs connect to both buses. This switchyard is referred to as a “double bus double breaker” arrangement. Two 500 kV to 230 kV step-down transformers, used to supply power to the RATs, are located in the 500 kV switchyard with one transformer connected to each main bus. These transformers provide power to both RATs for Units 3 and 4, respectively.

The circuit breakers in the 500 kV switchyard are 60 Hz, 3 pole breakers with sufficient fault current interrupting capacity, and ratings as shown on Figure 8.2-201. The 500 kV switchyard disconnect switches are 60 Hz, 3 pole switches, and are rated on the same continuous current basis as the associated circuit breakers, as shown on Figure 8.2-201.

Failure Analysis

BLN SUP 8.2-1 The design of the offsite power system provides for a robust system that supports reliable power production. While offsite power is not required to meet any safety function, and physical independence is obviated by this lack of safety function and by the certified design's partial exemption to GDC 17 granted by the NRC, multiple, reliable transmission circuits are provided to support operation of the facility. Neither the accident analysis nor the Probabilistic Risk Assessment has identified the non-safety related offsite power system as risk significant for normal plant operation.

The BLN switchyard is connected to four transmission lines. No single transmission line is designated as the preferred circuit, but each has sufficient capacity and capability from the transmission network to power the safety-related systems and other auxiliary systems under normal, abnormal, and accident conditions.

A failure modes and effects analysis (FMEA) of the Bellefonte switchyard confirms that a single initiating event, such as a transmission line fault, plus a single breaker not operating does not cause failure of more than one single offsite transmission line, or a loss of offsite power to either Unit 3 or 4 via the GSU. This evaluation recognizes that a single failure of some switchyard components could directly cause the loss of the switchyard feed to the GSU, such as a fault on this feed. Evaluated events include a breaker not operating during a fault condition; a fault on a switchyard bus; a spurious relay trip; and a loss of control power supply. In summary:

- In the event of a fault on a 500 kV transmission line, the associated bus breakers trip and both buses stay energized and both units continue operation.

- In the event of a fault on a 500 kV transmission line with a stuck bus breaker, the affected bus differential relays cause circuit breakers on the affected bus to trip and thereby isolate the faulted bus. Both units continue operation through the non-affected bus.

- In the event of a 500 kV bus fault, bus differential relays sense the fault and the breakers associated with the affected bus trip, thereby isolating the faulted bus. In this event, both units continue normal operation through the non-affected bus.

- In the event of a 500 kV bus fault with a stuck breaker, the adjacent breaker senses the fault and trip, which isolates the faulted bus. If the stuck breaker is associated with either the Unit 3 or Unit 4 GSU output, opening of the adjacent breaker interrupts power to the associated GSU and unit auxiliary transformers resulting in a reactor trip. The unaffected unit continues operation through the non-affected bus.

- In the event of transmission line relay mis-operation, both associated switchyard breakers trip, isolating one of the transmission lines from the yard. In this event, both switchyard buses stay energized and both units continue normal operation.

- In the case of a loss of DC control power, the loss of control power to a breaker or to a transmission line primary relay is compensated for by redundant trip coils powered from a different source which allow the protective function to occur. Both units continue normal operation.

The results of the analysis show that a single fault in any section of a 500 kV bus is cleared by the adjacent breakers and does not interrupt operation of the remaining part of the 500 kV switchyard bus or the connection of the unaffected transmission lines. A bus fault with a stuck breaker associated with either the Unit 3 or Unit 4 GSU output causes the loss of power to, and a reactor trip in the associated unit. A bus fault concurrent with any other stuck breaker does not cause a loss of power to either unit.

Transmission System Provider/Operator (TSP/TSO)

The TSP/TSO establishes a voltage schedule for the 500 kV switchyard. The BLN, while generating, is expected to supply or absorb reactive power to help regulate voltage in the 500 kV switchyard in accordance with TSP/TSO voltage schedule criteria. The TSP/TSO also maintains switchyard voltage such that steady state voltage on the 26 kV isophase bus is within 0.95 – 1.05 p.u. of its nominal value.

TVA Power Systems Operations (PSO) maintains nuclear plant operating guides that provide grid configuration requirements and operating limits to maintain the grid's ability to provide qualified offsite power to the BLN. The voltage requirements and plant loading are provided by the BLN to the transmission operator, which then studies various system configurations. The guides consider transmission system outages including transmission lines, transformers, nearby generation, and other transmission devices that could affect the capability of the grid. The transmission operators maintain awareness of the qualification status of offsite power and promptly communicate any changes to the BLN. If a condition arises where the grid cannot supply qualified offsite power, plant operators are notified and appropriate actions are taken.

BLN SUP 8.2-2 The formal agreement between TVA Nuclear (TVAN) and TVA PSO, which is the TSP/TSO, sets the requirements for transmission system studies and analyses. These analyses demonstrate the capability of the offsite provider of supporting plant start up and normal shutdown.

BLN SUP 8.2-3 TVA PSO is the approving grid organization for reliability studies performed on the area bulk electric system. TVA conducts planning studies of the transmission grid on an ongoing basis. Model data used to perform simulation studies of projected future conditions is maintained and updated as load forecasts and future generation / transmission changes evolve. Studies are performed annually to assess future system performance in accordance with North American Electric Reliability Corporation (NERC) Reliability Standards. These studies form a basis for identifying future transmission expansion needs.

New large generating units requesting to connect to the area bulk electric system are required to complete the Large Generator Interconnection Procedure. The studies performed by PSO as part of this procedure examine the generating unit (combined turbine-generator-exciter) and the main step-up transformer(s).

BLN SUP 8.2-4 The agreement between TVAN and PSO demonstrates protocols in place for the BLN to remain cognizant of grid vulnerabilities to make informed decisions regarding maintenance activities critical to the electrical system.

In the operations horizon, the PSO grid operator continuously monitors real-time power flows and assesses contingency impacts through use of a state-estimator tool. Operational planning studies are also performed using offline power flow study tools to assess near term operating conditions under varying load, generation, and transmission topology patterns.

8.2.1.2 Transformer Area

Add the following paragraph at the end of the first paragraph of DCD Subsection 8.2.1.2.

BLN COL 8.2-1 The transformer area for each unit contains the main step-up transformer (the GSU), (3 single phase transformers plus one spare), three unit auxiliary transformers (the UATs), and two reserve auxiliary transformers (the RATs). The two RATs are connected to the 500 kV to 230 kV transformer located in the 500 kV switchyard. The high side (500 kV) winding of the GSUs is connected in wye configuration to the 500 kV switchyard.

Add the following paragraph and subsections at the end of the DCD Subsection 8.2.1.2.

Each transformer is connected to the switchyard by an offsite circuit beginning at the switchyard side of the breaker(s) within the switchyard and ending at the high voltage terminals of the GSU and RATs.

8.2.1.2.1 Switchyard Transformer Ratings

Each RAT supply transformer is a 500 kV to 230 kV three phase transformer, with wye-delta-delta windings. The primary winding is rated at 140 MVA and each of the secondary windings is rated at 70 MVA.

8.2.1.2.2 Switchyard Protection Relay Scheme

BLN COL 8.2-2 The switchyard is designed as a double-bus double-breaker arrangement for reliability and flexibility. This arrangement allows for isolation of components and buses, while preserving the BLN’s connection to the grid.

Under normal operating conditions the 500 kV circuit breakers and the bus sectionalizing motor operated disconnect switches are closed; all bus sections are energized.

Each of the 500 kV lines is protected by two independent pilot systems to achieve high-speed clearing for a fault anywhere on the line. The breaker failure relays operate through a timing relay and should a breaker fail to trip within the time setting of its timing relay, the associated breaker failure trip relay will trip and lock out breakers on the bus side plus the other breaker in that bay.

The protective devices controlling the switchyard breakers are set with consideration given to preserving the plant grid connection following a turbine trip.

8.2.1.3 Switchyard Control Building

BLN COL 8.2-1 A control building is erected to serve the needs of the switchyard. The control building houses switchyard batteries (redundant battery systems are housed in separate battery rooms and appropriately ventilated) and accommodates a sufficient number of relay/control panels.

The 500 kV switchyard breakers associated with the GSU and RATs are under the administrative control of the plant. Transmission line circuit breakers in the BLN 500 kV switchyard are under the administrative control of PSO.

8.2.1.4 Switchyard and Transmission Lines Testing and Inspection

An agreement between TVAN and PSO for development, maintenance, calibration, testing and modification of transmission lines, switchyards, transformer yards and associated transmission equipment, provides the procedure, policy and organization to carry out maintenance, calibration, testing and inspection of transmission lines and switchyards.

This agreement defines the interfaces and working relationship between TVAN and PSO. As a service to TVAN, PSO performs maintenance, calibration, and testing of TVAN transformer assets at TVA’s nuclear sites. TVAN and PSO are responsible for control of plant/grid interface activities. For reliability, TVAN and PSO coordinate maintenance and testing of offsite power systems. PSO establishes communication and coordination protocols for restoration of external power supply to the nuclear plant on a priority basis.

For performance of maintenance, testing, calibration and inspection, PSO follows its own field test manuals, vendor manuals and drawings, and industry maintenance practices to comply with applicable NERC Reliability Standards.

PSO verifies that these test results demonstrate compliance with design requirements and takes corrective actions as necessary. PSO plans and schedules maintenance activities, notifying the plant and transmission system operations group in advance. PSO also procures and stores necessary spare parts prior to the commencement of inspection, testing, and maintenance activities.

Transmission lines in the TVA transmission system are inspected through an aerial inspection twice per year. The inspection has a specific focus on right of way encroachments, vegetation management, conductor and line hardware condition assessment, and supporting structures. Herbicide is used to control vegetation within the boundaries of the transmission line rights-of-way. Where herbicides cannot be applied, vegetation is cut and removed. This cutting and removal effort is extended beyond the formal right-of-way limit to address the presence of any danger trees which may adversely affect the operation of the transmission line.

The interconnecting switchyard, as well as other substation facilities, has multiple levels of inspection and maintenance, including the following:

- Walk throughs and visual inspections of the entire substation facility.
- Relay functional tests.
- Oil sampling of large power transformers. Oil samples are evaluated through the use of gas chromatography and dielectric breakdown analysis.
- Power circuit breakers are subjected to three levels of inspection and maintenance. The frequency of each is a function of the number of operations and time. Maintenance leverages the use of external visual inspection of all functional systems, an external test, and an internal inspection. Frequency of the various maintenance/inspection efforts is based on a combination of operating history of the type of breaker, industry practice and manufacturer’s recommended maintenance requirements.
- A power test (Doble Test) is typically performed on oil filled equipment.
- Thermography is used to identify potential thermal heating issues on buses, conductors, connectors and switches.

8.2.2 GRID STABILITY

Add the following information at the end of DCD Subsection 8.2.2.

BLN COL 8.2-2 A transmission system study of the offsite power system is performed regularly. In order to maintain reactor coolant pump (RCP) operation for three seconds following a turbine trip as specified in DCD Subsection 8.2.2, the grid voltage at the high-side of the GSU, and RATs cannot dip more than 0.15 pu from the pre-trip steady-state voltage.

The study analyzes cases for load flow, transient stability, and fault analysis. In order to complete the forward-looking study, the following assumptions are made:

- Grid voltage of 515 kV.
- GSU tap setting is 1.0.
- A summer peak base case is used for stability studies.
- A summer peak base case is used for load flow studies.

The computer analysis was performed using the Siemens Power Technology International software PSS/E. The analysis examines four conditions:

- Normal Running
- Normal Shutdown
- Startup
- Turbine Trip

Each condition is modeled both with and without the other unit running.

The results of the study conclude that the transmission system remains stable preserving the grid connection, and supporting RCP operation for at least three seconds following a turbine trip under the modeled conditions. The 0.15 pu maximum voltage dip requirement is also met when there is another transmission element out of service, including the largest generator or most critical transmission line.

Table 8.2-201 confirms that the interface requirements for steady state load, inrush kVA for motors, nominal voltage, allowable voltage regulation, nominal frequency, allowable frequency fluctuation, maximum frequency decay rate, and limiting under frequency value for RCP have been met.

BLN SUP 8.2-5 From 1989 to 2007, average grid availability for the four 500 kV transmission lines looped into the BLN site is approximately 99.7 percent, with 158 forced outages. The average frequency of forced line outages since 1989 is approximately eight per year for the involved lines, with the majority due to lightning strikes causing momentary outages. Leading causes of forced outages of significant duration are customer equipment trouble, relay misoperation, pollution from bird droppings, ice formation, emergency forced outages (for emergent equipment problems and cutting trees), and lightning.

8.2.5 COMBINED LICENSE INFORMATION FOR OFFSITE ELECTRICAL POWER

BLN COL 8.2-1 This COL item is addressed in Subsections 8.2.1, 8.2.1.1, 8.2.1.2, 8.2.1.3, and 8.2.1.4.

BLN COL 8.2-2 This COL item is addressed in Subsections 8.2.1.2.2 and 8.2.2.

TABLE 8.2-201 GRID STABILITY INTERFACE EVALUATION

BLN COL 8.2-2

DCD Table 1.8-1 Item 8.2 Parameter	WEC AC Requirements	BLN Value Assumed
Steady-state load	“normal running values provided as input to grid stability”	“normal running values provided as input to grid stability”
Inrush kVA for motors	56,712 KVA*	88,969 KVA
Nominal voltage	Not provided	1.03 pu (515 KV)
Allowable voltage regulation	0.95-1.05 pu steady state 0.15 pu transient dip**	0.95-1.05 pu steady state 0.15 pu transient dip**
Nominal frequency	60 Hz	assumed 60 Hz
Allowable frequency fluctuation	±½ Hz indefinite	±½ Hz indefinite
Maximum frequency decay rate	5 Hz/sec	5 Hz/sec

*Based on the inrush of a single 10,000 HP feedwater pump assuming efficiency = 0.95, pf= 0.9, and inrush = 6.5x FLA.

**Applicable to Turbine Trip Only. The maximum allowable voltage dip from the pre-event steady state voltage value during the 3 second turbine trip event transient as measured at the point of connection to the high side of the generator step-up transformer and the reserve auxiliary transformer.

DCD Table 1.8-1 Item 8.2 Parameter	WEC Acceptance Criteria	BLN Value Calculated
Limiting under frequency value for RCP	≥57.7 Hz	>59 Hz

8.3 ONSITE POWER SYSTEMS

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

8.3.1.1.1 Onsite AC Power System

Add the following to the end of the fourth paragraph of DCD Subsection 8.3.1.1.1.

BLN SUP 8.3-2 The site specific switchyard and transformer voltage is shown on Figure 8.2-201.

8.3.1.1.2.3 Onsite Standby Power System Performance

Add the following text between the second and third paragraphs of DCD Subsection 8.3.1.1.2.3.

BLN SUP 8.3-1 The BLN site conditions provided in Sections 2.1 and 2.3 are bounded by the standard site conditions used to rate both the diesel engine and the associated generator in DCD Subsection 8.3.1.1.2.3.

Add the following subsection after DCD Subsection 8.3.1.1.2.3.

8.3.1.1.2.4 Operation, Inspection, and Maintenance

STD COL 8.3-2 Operation, inspection, and maintenance (including preventive, corrective, and predictive maintenance) procedures consider both the diesel generator manufacturer's recommendations and industry diesel working group recommendations.

8.3.1.1.6 Containment Building Electrical Penetrations

Add the following text at the end of DCD Subsection 8.3.1.1.6.

STD COL 8.3-2 Procedures implement periodic testing of protective devices that provide penetration overcurrent protection. A sample of each different type of overcurrent device is selected for periodic testing during refueling outages. Testing includes:

- Verification of thermal and instantaneous trip characteristics of molded case circuit breakers.
- Verification of long time, short time, and instantaneous trips of medium voltage vacuum circuit breakers.
- Verification of long time, short time, and instantaneous trips of low voltage air circuit breakers.
- Verification of Class 1E and non-Class 1E dc protective device characteristics (except fuses) per manufacturer recommendations, including testing for overcurrent interruption and/or fault current limiting.

Penetration protective devices are maintained and controlled under the plant configuration control program. A fuse control program, including a master fuse list, is established based on industry operating experience.

8.3.1.1.7 Grounding System

Replace the sixth paragraph of DCD Subsection 8.3.1.1.7 with the following information.

BLN COL 8.3-1 A grounding grid system design within the plant boundary includes step and touch potentials near equipment that are within the acceptable limit for personnel safety. Actual resistivity measurements from soil samples taken at the plant site were analyzed to create a soil model. The ground grid conductor size was then determined using the methodology outlined in IEEE 80, “IEEE Guide for Safety in AC Substation Grounding” (Reference 201) and a grid configuration for the site was created. The grid configuration was modeled in conjunction with the soil model. The resulting step and touch potentials are within the acceptable limits.

8.3.1.1.8 Lightning Protection

Replace the third paragraph of DCD Subsection 8.3.1.1.8 with the following information.

BLN COL 8.3-1 In accordance with IEEE 665, "IEEE Standard for Generating Station Grounding" (DCD Section 8.3 Reference 18), a lightning protection risk assessment for the buildings comprising the BLN was performed based on the methodology in NFPA 780 (DCD Section 8.3 Reference 19). The tolerable lightning frequency for each of the buildings was determined to be less than the expected lightning frequency; therefore, lightning protection is required for the BLN buildings based on the design in accordance with NFPA 780. The zone of protection is based on the elevations and geometry of the structures. It includes the space covered by a rolling sphere having a radius sufficient enough to cover the building to be protected. The zone of protection method is based on the use of ground masts, air terminals and shield wires. Either copper or aluminum is used for lightning protection. Lightning protection grounding is interconnected with the station or switchyard grounding system.

8.3.1.4 Inspection and Testing

Add the following text at the end of DCD Subsection 8.3.1.4.

STD SUP 8.3-4 Procedures are established for periodic verification of proper operation of the Onsite AC Power System capability for automatic and manual transfer from the preferred power supply to the maintenance power supply and return from the maintenance power supply to the preferred power supply.

8.3.2.1.1.1 Class 1E DC Distribution

Add the following text at the end of DCD Subsection 8.3.2.1.1.1.

STD SUP 8.3-3 No site-specific non-Class 1E dc loads are connected to the Class 1E dc system.

8.3.2.1.4 Maintenance and Testing

Add the following text at the end of DCD Subsection 8.3.2.1.4.

STD COL 8.3-2 Procedures are established for inspection and maintenance of Class 1E and non-Class 1E batteries. Class 1E battery maintenance and service testing is performed in conformance with Regulatory Guide 1.129. Batteries are inspected periodically to verify proper electrolyte levels, specific gravity, cell temperature and battery float voltage. Cells are inspected in conformance with IEEE 450 and vendor recommendations.

The clearing of ground faults on the Class 1E dc system is also addressed by procedure. The battery testing procedures are written in conformance with IEEE 450 and the Technical Specifications.

8.3.3 COMBINED LICENSE INFORMATION FOR ONSITE ELECTRICAL POWER

BLN COL 8.3-1 This COL Item is addressed in Subsections 8.3.1.1.7 and 8.3.1.1.8.

STD COL 8.3-2 This COL Item is addressed in Subsections 8.3.1.1.2.4, 8.3.1.1.6 and 8.3.2.1.4.

8.3.4 REFERENCES

201. Institute of Electrical and Electronics Engineers (IEEE), "IEEE Guide for Safety in AC Substation Grounding," IEEE Std 80-2000, August 4, 2000.