Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

CNL-19-121

December 26, 2019

10 CFR 50.4
10 CFR 50.54(f)

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Browns Ferry Nuclear Plant, Units 1, 2, and 3
Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

Sequoyah Nuclear Plant, Units 1 and 2
Renewed Facility Operating License Nos. DPR-77 and DPR-79
NRC Docket Nos. 50-327 and 50-328

Watts Bar Nuclear Plant, Units 1 and 2
Facility Operating License Nos. NPF-90 and NPF-96
NRC Docket Nos. 50-390 and 50-391

Subject: **Revised Response to NRC Bulletin 2012-01, "Design Vulnerability in Electrical Power System"**

References:

1. NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System," dated July 27, 2012 (ML12074A115)
2. TVA Letter to NRC, "90-Day Response to NRC Bulletin 2012-01, 'Design Vulnerability in Electric Power System'," dated October 25, 2012 (ML12312A167)
3. NRC Letter to TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3; Sequoyah Nuclear Plant, Units 1 and 2; Watts Bar Nuclear Plant, Units 1 and 2 - Issuance of Amendment Nos. 309, 332, 292, 345, 339, 128, and 31 Regarding Unbalanced Voltage Protection (EPID L-2017-LLA-0391)," dated August 27, 2019 (ML18277A110)
4. NRC Letter to TVA, "Watts Bar Nuclear Plant, Unit 2 - Issuance of Amendment No. 23 Regarding the Actions to Resolve Issues Identified in NRC Bulletin 2012-01, 'Design Vulnerability in Electric Power System' (EPID L-2018-LLA-0239)," dated December 21, 2018 (ML18334A333)

In Reference 1, the Nuclear Regulatory Commission (NRC) issued Bulletin 2012-01, "Design Vulnerability in Electric Power System," which requested information regarding how the design of the protection scheme for Engineered Safety Feature (ESF) buses detects and automatically responds to single-phase open circuit conditions or high impedance ground fault conditions, including a description of the operating configuration of the ESF buses.

In Reference 2, Tennessee Valley Authority (TVA) provided the information requested in Reference 1 for the Browns Ferry (BFN), Sequoyah (SQN), and Watts Bar Nuclear (WBN) Plants.

In Reference 3, the NRC approved a license amendment request (LAR) for TVA to add a new level of protection, "Unbalanced Voltage" to the BFN, SQN, and WBN Technical Specifications for the loss of power instrumentation. TVA's undervoltage protection scheme, located on the medium voltage Class 1E buses, includes loss of voltage protection, degraded voltage protection, and unbalanced voltage protection. The undervoltage protection scheme was designed to detect and provide automatic protection for the connected Class 1E system from offsite power that is not capable of performing its safety function due to undervoltage conditions. This undervoltage protection scheme minimizes the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit or the loss of power from the transmission network.

At the time of initial Bulletin response (Reference 2), unbalanced voltage protection was not approved by NRC for the TVA plants. With this level of undervoltage protection approved and enabled at BFN, SQN, and WBN, the station-specific system protection responses and consequences that were included in the original responses to Bulletin items 1, 1a, 1b, and 1c were no longer valid and have been revised. The responses to Bulletin items 2b, 2d, and 2e have been updated, where necessary, for clarity.

The Reference 2 responses to Bulletin items 2, 1d, and 2a included system descriptions specific to the electric power stations and require no modification or updates for BFN and WBN. As stated in the original response, a SQN LAR to restore the original unit station service transformer (USST) operating configuration was under review by the NRC at the time of the response. That LAR was approved on October 31, 2012 (ML12286A078), and responses to items 2, 1d, and 2a for SQN have been updated. The response to item 2c includes confirmation of consistency with the NRC-approved licensing basis and requires no modification or update for BFN and WBN. The updated response to item 2c for SQN reflects approval of the USST LAR.

Lastly, in Reference 4, the NRC approved an amendment for WBN Unit 2, which revised Operating License Condition 2.C(5) to state, "By December 31, 2019, the licensee shall report to the NRC that the actions to resolve the issues identified in Bulletin 2012-01, 'Design Vulnerability in Electrical Power System,' have been implemented." Therefore this submittal reports that the actions to resolve the issues identified in Bulletin 2012-01 have been implemented for WBN Unit 2.

TVA has determined that there is no design vulnerability associated with open phase events at TVA stations. All changes described above to the original Reference 2 response are noted by revision bars in the right margin for Enclosures 1, 2, and 3.

There are no new regulatory commitments associated with this submittal. Please address any questions regarding this request to Kimberly Hulvey at (423) 751-3275.

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 26th day of December 2019.

Respectfully,

James T. Polickoski
Director, Nuclear Regulatory Affairs

Enclosures:

1. Browns Ferry Nuclear Plant, Units 1, 2, and 3 Revised Response to NRC Bulletin 2012-01, “Design Vulnerability in Electric Power System”

2. Sequoyah Nuclear Plant, Units 1 and 2 Revised Response to NRC Bulletin 2012-01, “Design Vulnerability in Electric Power System”

3. Watts Bar Nuclear Plant, Units 1 and 2 Revised Response to NRC Bulletin 2012-01, “Design Vulnerability in Electric Power System”

cc (Enclosures):

NRC Regional Administrator - Region II
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant
NRC Senior Resident Inspector - Sequoyah Nuclear Plant
NRC Senior Resident Inspector - Watts Bar Nuclear Plant
NRC Project Manager – Browns Ferry Nuclear Plant
NRC Project Manager – Sequoyah Nuclear Plant
NRC Project Manager – Watts Bar Nuclear Plant
State Health Officer, Alabama Department of Public Health
Director, Division of Radiological Health - Tennessee State Department of Environment and Conservation

ENCLOSURE 1

Browns Ferry Nuclear Plant, Units 1, 2, and 3

Revised Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System"

ENCLOSURE 1

Browns Ferry Nuclear Plant, Units 1, 2, and 3
90-Day Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System"

Overview:

- Statement of No Open Phase Design Vulnerability for Class 1E Equipment
- System Description - Items 2., 1.d, 2.a, 2.c
- System Protection - Items 1., 1.a, 2.b, 2.d
- Consequences - Items 1.b, 1.c, 2.e
- References
- Attachment 1 - Simplified One-Line Diagram
- Attachment 2 - Tables
  - Table 1 - ESF Buses Continuously Powered From Offsite Power Source(s)
  - Table 2 - ESF Buses Not Continuously Powered From Offsite Power Source(s)
  - Table 3 - ESF Buses Normally Energized Major Loads
  - Table 4 - Offsite Power Transformers
  - Table 5 - Protective Devices

Statement of No Open Phase Design Vulnerability for Class 1E Equipment

The U. S. Nuclear Regulatory Commission (NRC) issued Bulletin 2012-01, "Design Vulnerability in Electrical Power System," which identified a vulnerability to an open phase condition (OPC) in electrical power systems at nuclear power plants. The bulletin required that licensees comprehensively verify their compliance with General Design Criterion (GDC) 17, "Electric Power Systems," and to respond to the bulletin. GDC 17 corresponds in general to Atomic Energy Commission Criterion 39 to which the Browns Ferry Nuclear Plant (BFN) units are licensed. The bulletin also requested information regarding how the design of the protection scheme for engineered safety feature (ESF) buses detects and automatically responds to single-phase open circuit conditions or high impedance ground fault conditions, including a description of the operating configuration of the ESF buses.

As stated in the bulletin, "At Byron, a failure to design the electric power system's protection scheme to sense the loss of a single phase between the transmission network and the onsite power distribution system resulted in unbalanced voltage at both ESF buses (degraded offsite power system), trip of several safety-related pieces of equipment such as Essential Service Water pumps, Centrifugal Charging Pumps, and Component Cooling Water Pumps and the unavailability of the onsite electric power system. This situation resulted in neither the onsite nor the offsite electric power system being able to perform its intended safety functions (i.e., to provide electric power to the ESF buses with sufficient capacity and capability to permit functioning of structures, systems, and components important to safety)."

TVA has designed and implemented an unbalanced voltage protection scheme to protect structures, systems, and components (SSCs) important to safety, as discussed below. As stated in the NRC's safety evaluation (SE) (Reference 1) for TVA's unbalanced voltage relay (UVR) license amendment request (LAR), "An open circuit in one phase of a three-phase power system results in an unbalanced voltage condition on plant buses. The unbalanced voltage condition results in unbalanced current flow that produces negative and zero sequence current." Therefore, because TVA employs a UVR protection scheme, TVA's SSCs important to safety are protected from an OPC event. Therefore, BFN has no vulnerability to an OPC.

TVA's unbalanced voltage protection scheme is designed to detect and provide automatic protection for the connected Class 1E system from offsite power that is not capable of performing its safety function due to unbalanced voltage conditions. This unbalanced protection scheme is part of the undervoltage protection scheme that minimizes the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit or the loss of power from the transmission network. TVA's undervoltage protection scheme, located on the medium voltage Class 1E buses, includes loss of voltage protection, degraded voltage protection, and unbalanced voltage protection.

Because aspects of the implementation of the unbalanced voltage protection scheme design described above required a change to the Technical Specifications, TVA submitted an associated LAR. In the NRC's SE (Reference 1) for that LAR, the NRC staff determined that TVA's UVR "…protection schemes will provide reasonable assurance that the safety-related equipment will be adequately protected from the consequences of negative sequence currents resulting from unbalanced voltage conditions. The UVR protection will be part of the primary success path that functions or actuates to mitigate a design-basis accident or transient that either assumes the failure of or presents a challenge to the integrity of a fission product barrier

and, therefore, will meet Criterion 3 of 10 CFR 50.36(c)(2)(ii) for inclusion into the TSs. The NRC staff concludes that the implementation of the UVR protection schemes will provide reasonable assurance that GDC 17 (AEC Criterion 39 for the Browns Ferry units) required onsite electric power system will be available to permit functioning of SSCs important to safety following a detectable degradation related to unbalanced voltages in the offsite power system." Therefore, as stated above, implementation of the undervoltage protection scheme will provide reasonable assurance that GDC 17 (AEC Criterion 39 for the Browns Ferry units) required onsite electric power system will be available to permit functioning of SSCs important to safety following a detectable degradation of voltages in the offsite power system, including those caused by an OPC.

System Description

Items 2, 1.d, 2.a, and 2.c request system information and will be addressed in this section:

> ***2. Briefly describe the operating configuration of the ESF buses (Class 1E for current operating plants or non-Class 1E for passive plants) at power (normal operating condition).***

See Attachment 1 for a simplified one-line diagram.

The Engineered Safety Feature (ESF) buses are normally powered from the main generator through the unit station service transformers (USSTs). During normal operating conditions the USSTs are connected to the respective unit generator isolated-phase bus and receive power from Generators 1, 2, and 3. The ESF buses are supplied through the B USSTs and plant auxiliaries buses are supplied from the A USSTs. The USSTs 1B, 2B, and 3B supply normal power to the ESF buses via 4.16 kilovolt (kV) Unit Boards 1A, 1B, 2A, 2B, 3A, and 3B. For Units 1 and 2, USST 1B and USST 2B each supply a 4.16 kV Unit Board with each 4.16 kV Unit Board feeding a safety-related 4.16 kV Shutdown Bus 1 or 2, with each 4.16 kV Shutdown Bus then feeding two of the Unit 1 and 2 safety-related Division I (A and B) or Division II (C and D) 4.16 kV Shutdown Boards. For Unit 3, USST 3B supplies two 4.16 kV Unit Boards with each 4.16 kV Unit Board feeding two of the Unit 3 safety-related 4.16 kV Shutdown Boards (Division I 3EA & 3EB and Division II 3EC & 3ED).

> ***1.d. Describe the offsite power transformer (e.g., start-up, reserve, station auxiliary) winding and grounding configurations.***

The 4.16 kV secondary winding of each unit and common station service transformer (CSST) is wye-connected, with the neutral grounded through a resistor which will limit ground fault current to 1600 amperes maximum. The neutral resistor serves to prevent overvoltage on the winding which could occur in the event of a ground fault if the 4.16 kV system were not intentionally grounded.

See Attachment 2, Table 4 for offsite power transformer winding and grounding configurations.

> ***2.a. Are the ESF buses powered by offsite power sources? If so, explain what major loads are connected to the buses including their ratings.***

No, for the normal (at power) operating configuration, the ESF buses are powered from the main generator through the unit station service transformers.

See Attachment 2, Tables 1 and 2 for ESF bus power sources, and Table 3 for ESF bus major loads energized during normal power operations.

2.c. Confirm that the operating configuration of the ESF buses is consistent with the current licensing basis. Describe any changes in offsite power source alignment to the ESF buses from the original plant licensing.

The operating configuration, as described under item 2, has been confirmed to be consistent with the current licensing basis as discussed in the BFN Updated Final Safety Analysis Report (UFSAR), License Amendments 75 and 72, respectively, issued on September 3, 1981, and Unit 3 License Amendment 52, issued on March 29, 1982, and their associated safety evaluations. The design changes associated with these amendments included adding one additional USST per unit, adding on-load tap changer on the primary windings of USSTs 1B, 2B, and 3B, and the addition of generator low-side breakers to all three units. The installation of the generator circuit breaker changed the normal and alternate supply to the Class 1E distribution system. Operation of the generator circuit breaker allows backfeeding from the 500 kV switchyard as the immediate access source of offsite power to the onsite distribution system. The breaker is designed to open automatically on a unit trip or maximum fault current.

See Attachment 2, Tables 1 and 2, for any changes in the offsite power source alignment to the ESF buses from the original plant licensing.

System Protection

Items 1, 1.a, 2.b, and 2.d request information regarding electrical system protection and will be addressed in this section:

1. Given the requirements above, describe how the protection scheme for ESF buses (Class 1E for current operating plants or non-Class 1E for passive plants) is designed to detect and automatically respond to a single-phase open circuit condition or high impedance ground fault condition on a credited off-site power circuit or another power sources.

Consistent with the current licensing basis documents (including those specified in item 2.c), existing protective circuitry will separate the ESF buses from a connected failed offsite source as a result of a loss of voltage, a sustained balanced degraded voltage, or a sustained unbalanced voltage. While the relay systems were not specifically designed to detect and automatically respond only to an open phase on a three phase system, the undervoltage protection scheme will automatically detect and provide automatic protection from the unbalanced voltage and/or degraded voltage created by the open phase or high impedance ground fault that prevents the connected safety equipment from operating due to insufficient voltage (Reference 1).

Normal Plant Operation Considerations:

During normal plant operation, the ESF buses sequence of events were described and evaluated as acceptable as part of the NRC's SE for TVA's UVRs (Reference 1, Section 3.2.2) for an open phase.

1.a. The sensitivity of protective devices to detect abnormal operating conditions and the basis for the protective device setpoint(s).

Consistent with the current licensing basis documents specified in item 2.c, existing electrical protective devices are sufficiently sensitive to detect design basis conditions like a loss of voltage or a sustained balanced degraded voltage, or a sustained unbalanced voltage. See Attachment 2, Table 5, for undervoltage protective devices and the basis for the device setpoint(s). Degraded voltage relay logic is 2 out of 3 and degraded voltage relays monitor A-B, B-C and C-A. The UVR logic is a permissive 1 out of 2 and each of the relays monitor A-B-C phases.

Existing electrical protective devices are also sufficiently sensitive to detect a ground fault. Attachment 2, Table 5 lists ground protection and the basis for the device setpoint(s).

2.b. If the ESF buses are not powered by offsite power sources, explain how the surveillance tests are performed to verify that a single-phase open circuit condition or high impedance ground fault condition on an off-site power circuit is detected.

The current BFN, Units 1, 2, and 3, Technical Specifications do not contain surveillance requirements for offsite power circuits. In addition, the ESF buses at BFN are powered by unit generators. Phase voltage is monitored for generator output.

2.d. Do the plant operating procedures, including off-normal operating procedures, specifically call for verification of the voltages on all three phases of the ESF buses?

No, the current plant operating procedures, including operating procedures for off-normal alignments, do not specifically call for verification of the voltages on all three phases of the ESF buses.

Consequences

Items 1.b, 1.c, and 2.e request information regarding the electrical consequences of an event and will be addressed in this section:

1.b. The differences (if any) of the consequences of a loaded (i.e., ESF bus normally aligned to offsite power transformer) or unloaded (e.g., ESF buses normally aligned to unit auxiliary transformer) power source.

There are no differences of consequences to any safety-related (Class 1E) equipment for an open phase occurring on a normally loaded power source (i.e., Class 1E bus normally aligned to

offsite power transformer) or an unloaded power source (i.e., standby offsite power source). No adverse consequences or loss of function occur in either case based on the Unbalanced Voltage setpoint methodology. (Reference 1, Section 3.4.4).

1.c. If the design does not detect and automatically respond to a single-phase open circuit condition or high impedance ground fault condition on a credited offsite power circuit or another power sources, describe the consequences of such an event and the plant response.

The UVR scheme provides detection and automatic protection for the Class 1E equipment for any adverse single-phase open circuit condition or high impedance ground fault condition on the offsite power circuit.

2.e. If a common or single offsite circuit is used to supply redundant ESF buses, explain why a failure, such as a single-phase open circuit or high impedance ground fault condition, would not adversely affect redundant ESF buses.

Not applicable since BFN does not use an offsite circuit to supply redundant ESF buses during normal operation.

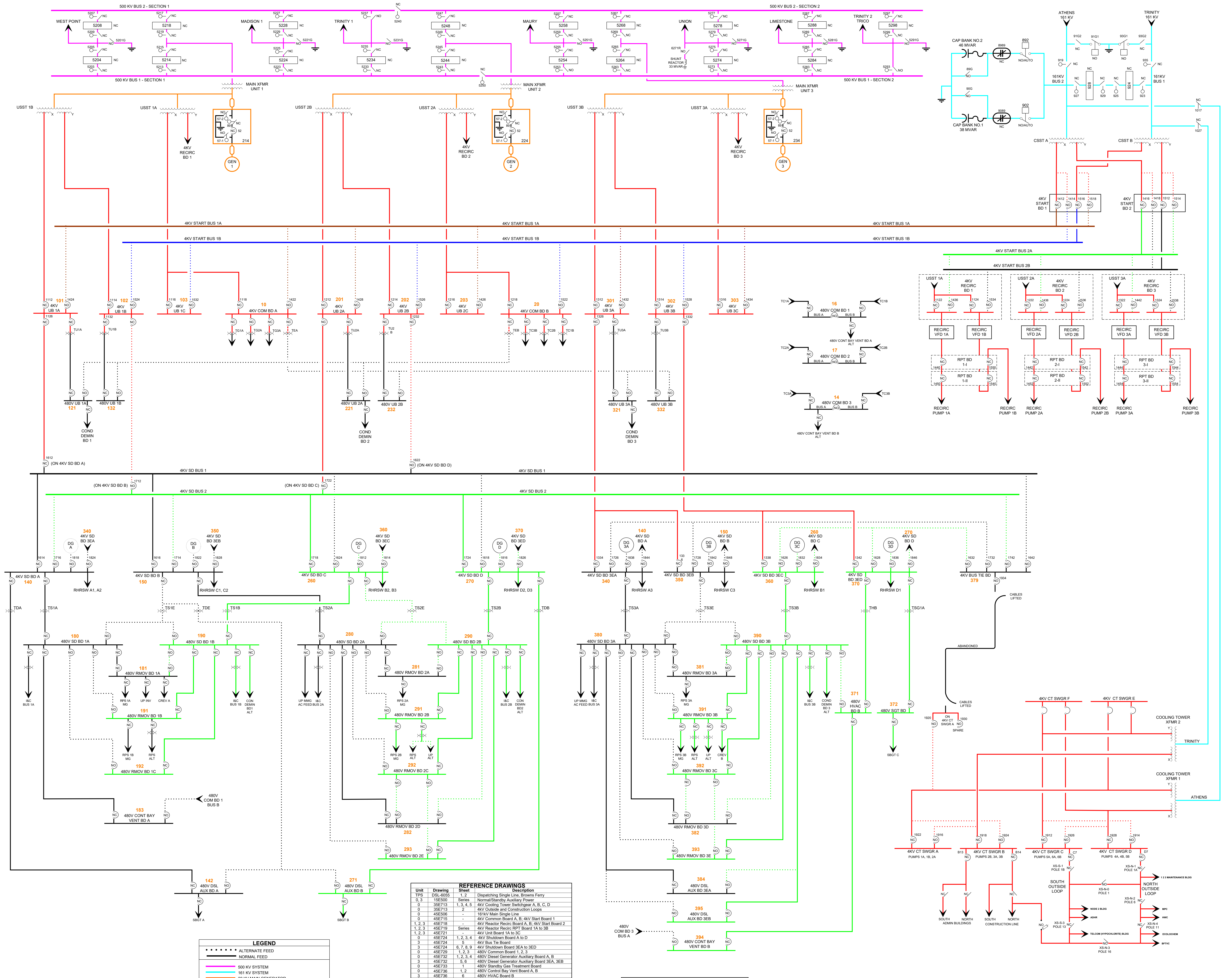
REFERENCES

1. NRC Letter to TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3; Sequoyah Nuclear Plant, Units 1 and 2; Watts Bar Nuclear Plant, Units 1 and 2 - Issuance of Amendment Nos. 309, 332, 292, 345, 339, 128, and 31 Regarding Unbalanced Voltage Protection (EPID L-2017-LLA-0391)," dated August 27, 2019 (ML18277A110)

Attachment 1

Simplified One-Line Diagram

(See next page)



REFERENCE DRAWINGS

Unit	Drawing	Sheet	Description
TPS	DSL-6055	1, 2	Dispatching Single Line, Browns Ferry
0, 3	15E500	Series	Normal/Standby Auxiliary Power
0	35E713	1, 3, 4, 5	4kV Cooling Tower Switchgear A, B, C, D
0	35E713	2	4kV Outside and Construction Loops
0	45E506	-	161kV Main Single Line
0	45E715	-	4kV Common Board A, B; 4kV Start Board 1
1, 2, 3	45E718	-	4kV Reactor Recirc Board A, B; 4kV Start Board 2
1, 2, 3	45E719	Series	4kV Reactor Recirc RPT Board 1A to 3B
1, 2, 3	45E721	-	4kV Unit Board 1A to 3C
0	45E724	1, 2, 3, 4	4kV Shutdown Board A to D
3	45E724	5	4kV Bus Tie Board
3	45E724	6, 7, 8, 9	4kV Shutdown Board 3EA to 3ED
0	45E729	1, 2, 3	480V Common Board 1, 2, 3
0	45E732	1, 2, 3, 4	480V Diesel Generator Auxiliary Board A, B
3	45E732	5, 6	480V Diesel Generator Auxiliary Board 3EA, 3EB
0	45E733	1	480V Standby Gas Treatment Board
0	45E736	1, 2	480V Control Bay Vent Board A, B
3	45E736	6	480V HVAC Board B
1, 2, 3	45E747	1, 2	480V Unit Board 1A to 3B
1, 2, 3	45E749	Series	480V Shutdown Board 1A to 3B
1, 2, 3	45E751	Series	480V RMOV Board 1A to 3E
0	45E1504	-	Main Generator 1 and 500kV Main Single Line
0	45E1505	-	Main Generator 2 and 500kV Main Single Line
0	45E1506	-	Main Generator 3 and 500kV Main Single Line
0	75E701	-	480V Transformer Yard Distribution Cabinet 1, 2, 3

TRANSFORMER LOAD TAP CHANGER POWER

	Normal	Auto Transfer To
USST 1B	480V Unit Bd 1B	480V Common Bd 2, Bus B
USST 2B	480V Unit Bd 2B	480V Common Bd 2, Bus A
USST 3B	480V Unit Bd 3B	480V Common Bd 2, Bus A
CSST A	480V Common Bd 2, Bus B	480V Unit Bd 1B
CSST B	480V Common Bd 2, Bus B	480V Unit Bd 1B

LEGEND

- ALTERNATE FEED (dotted line)
- NORMAL FEED (solid line)
- 500 KV SYSTEM
- 161 KV SYSTEM
- 22 KV MAIN GENERATOR
- 4KV NON-DIVISIONAL
- 4KV START BUS 1A
- 4KV START BUS 1B OR 4KV & 480V DIV I
- 4KV START BUS 2A OR 4KV & 480V DIV II
- 4KV START BUS 2B OR 480V NON-DIVISIONAL
- XXX ETAP NODE NUMBERS

INFORMATION ONLY

NOTE: See reference drawings for all loads on a board.

AC ELECTRICAL DISTRIBUTION SYSTEM
BROWNS FERRY NUCLEAR PLANT

PIP-02-03 REVISION DRAFT

Table 1 - ESF Buses Continuously Powered From Offsite Power Source(s)

Description of ESF Bus Power Source	ESF Bus Name (normal operating condition).	Original licensing basis configuration (Y/N)
N/A	N/A	N/A

Table 2 - ESF Buses Not Continuously Powered From Offsite Power Source(s)

Description of ESF Bus Power Source	ESF Bus Name (normal operating condition).	Original licensing basis configuration (Y/N)
Unit Station Service Transformer 1B or 2B	4.16 kV Shutdown Board A	N
Unit Station Service Transformer 1B or 2B	4.16 kV Shutdown Board B	N
Unit Station Service Transformer 1B or 2B	4.16 kV Shutdown Board C	N
Unit Station Service Transformer 1B or 2B	4.16 kV Shutdown Board D	N
Unit Station Service Transformer 3B	4.16 kV Shutdown Board 3EA	N
Unit Station Service Transformer 3B	4.16 kV Shutdown Board 3EB	N
Unit Station Service Transformer 3B	4.16 kV Shutdown Board 3EC	N
Unit Station Service Transformer 3B	4.16 kV Shutdown Board 3ED	N

Table 3 - ESF Buses Normally Energized Major Loads

Class 1E Bus	Load (Normally Running)	Voltage Level (kV)	Rating (HP)
4.16 kV Shutdown Board A	RHRSW (EECW) A1 *	4.16	400
4.16 kV Shutdown Board B	RHRSW (EECW) C1 *	4.16	400
4.16 kV Shutdown Board C	RHRSW (EECW) B3 *	4.16	400
4.16 kV Shutdown Board D	RHRSW (EECW) D3 *	4.16	400
4.16 kV Shutdown Board 3EA	RHRSW (EECW) A3 *	4.16	400
4.16 kV Shutdown Board 3EB	RHRSW (EECW) C3 *	4.16	400
4.16 kV Shutdown Board 3EC	RHRSW (EECW) B1 *	4.16	400
4.16 kV Shutdown Board 3ED	RHRSW (EECW) D1 *	4.16	400

* Normally, only 2 of the 8 RHRSW (EECW) Pump Motors will be energized at anytime during Normal Operation.

Table 4 - Offsite Power Transformers

Transformer	Winding Configuration	MVA Size (AO/FA/FA)	Voltage Rating (Primary/Secondary)	Grounding Configuration
Main Transformer 1	Wye-Delta (Y-Δ)	1500MVA (3-1Ø), OF AF	500 - 22 kV	High Side Grounded Wye
Main Transformer 2	Wye-Delta (Y-Δ)	1500MVA (3-1Ø), OF AF	500 - 22 kV	High Side Grounded Wye
Main Transformer 3	Wye-Delta (Y-Δ)	1500MVA (3-1Ø), OF AF	500 - 22 kV	High Side Grounded Wye
Unit Station Service Transformer 1B	Delta-Wye (Δ-YY)	24/32 MVA, 12/16 MVA (X Winding) 12/16 MVA (Y Winding), OA/FA	20.7- 4.16 - 4.16kV	Low Side Grounded Wye Resistance Grounded Neutral
Unit Station Service Transformer 2B	Delta-Wye (Δ-YY)	24/32 MVA, 12/16 MVA (X Winding) 12/16 MVA (Y Winding), OA/FA	20.7- 4.16 - 4.16kV	Low Side Grounded Wye Resistance Grounded Neutral
Unit Station Service Transformer 3B	Delta-Wye (Δ-YY)	24/32 MVA, 12/16 MVA (X Winding) 12/16 MVA (Y Winding), OA/FA	20.7- 4.16 - 4.16kV	Low Side Grounded Wye Resistance Grounded Neutral
Common Station Service Transformer A	Wye-Delta-Wye (Y-Δ-YY)	21.9/29.2/36.5/ MVA, 12/16/20 MVA (X Winding) 9.9/13.2/16.5 MVA (Y Winding), OA/FA/FOA	161- 4.16 - 4.16kV	High and Low Side Grounded Wye Resistance Grounded Neutral
Common Station Service Transformer B	Wye-Delta-Wye (Y-Δ-YY)	21.9/29.2/36.5/ MVA, 12/16/20 MVA (X Winding) 9.9/13.2/16.5 MVA (Y Winding), OA/FA/FOA	161- 4.16 - 4.16kV	High and Low Side Grounded Wye Resistance Grounded Neutral

Table 5 - Protective Devices

Protection Zone	Protective Device	Logic	Setpoint (Nominal)	Basis for Setpoint
Each 4.16 kV Shutdown Board (A, B, C, D, 3EA, 3EB,3EC, or 3ED)	Loss of Voltage Relay	2 of 2	2870V (68.99% of 4160V)	A “loss of voltage condition” is a reduction in voltage to a level which results in the immediate loss of equipment capability to perform its intended function. For a loss of shutdown board voltage of greater than 1.5 seconds, relays will drop out and start the diesel generator. Transfer from offsite power to diesel generator power will occur if voltage does not recover to the reset setpoint (2870V) within 1.5 seconds.
Each 4.16 kV Shutdown Board (A, B, C, D, 3EA, 3EB, 3EC, or 3ED)	Degraded Voltage	2 of 3	3920V (94.23% of 4160V)	Operation of the auxiliary power system under steady-state (running) conditions, with the safety-related bus voltage as low as possible while still keeping all connected safety-related loads within their rated operating voltage range (within ANSI C84.1 utilization voltages, range “B”)
Each 4.16 kV Shutdown Board (A, B, C, D, 3EA, 3EB, 3EC, or 3ED)	Unbalanced Voltage	Permissive 1 out of 2	1.34V @ 2.60 Sec 3.23V @ 7.86 Sec 19.5V @ 3.18 Sec	Operation of the auxiliary power system, with the safety-related bus voltage unbalanced while still keeping all connected safety-related loads within their rated operating voltage range (Reference 1)
USST 1B, 2B, or 3B	Transformer Neutral Ground Relay	N/A	180A	To provide protection for the neutral resistor for the 10 second rating.

ENCLOSURE 2

Sequoyah Nuclear Plant, Units 1 and 2

Revised Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System"

ENCLOSURE 2

Sequoyah Nuclear Plant, Units 1 and 2
90-Day Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System"

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Statement of No Open Phase Design Vulnerability for Class 1E Equipment

The U. S. Nuclear Regulatory Commission (NRC) issued Bulletin 2012-01, "Design Vulnerability in Electrical Power System," which identified a vulnerability to an open phase condition (OPC) in electrical power systems at nuclear power plants. The bulletin required that licensees comprehensively verify their compliance with General Design Criterion (GDC) 17, "Electric Power Systems," and to respond to the bulletin. The Sequoyah Nuclear Plant (SQN) units are licensed to the Proposed General Design Criteria of 1967 and SQN's compliance with the intent of GDC 17 is discussed in the SQN Updated Final Safety Analysis Report (UFSAR). The bulletin also requested information regarding how the design of the protection scheme for engineered safety feature (ESF) buses detects and automatically responds to single-phase open circuit conditions or high impedance ground fault conditions, including a description of the operating configuration of the ESF buses.

As stated in the bulletin, "At Byron, a failure to design the electric power system's protection scheme to sense the loss of a single phase between the transmission network and the onsite power distribution system resulted in unbalanced voltage at both ESF buses (degraded offsite power system), trip of several safety-related pieces of equipment such as Essential Service Water pumps, Centrifugal Charging Pumps, and Component Cooling Water Pumps and the unavailability of the onsite electric power system. This situation resulted in neither the onsite nor the offsite electric power system being able to perform its intended safety functions (i.e., to provide electric power to the ESF buses with sufficient capacity and capability to permit functioning of structures, systems, and components important to safety)."

TVA has designed and implemented an unbalanced voltage protection scheme to protect structures, systems, and components (SSCs) important to safety, as discussed below. As stated in the NRC's safety evaluation (SE) (Reference 1) for TVA's unbalanced voltage relay (UVR) license amendment request (LAR), "An open circuit in one phase of a three-phase power system results in an unbalanced voltage condition on plant buses. The unbalanced voltage condition results in unbalanced current flow that produces negative and zero sequence current." Therefore, because TVA employs a UVR protection scheme, TVA's SSCs important to safety are protected from an OPC event. Therefore, SQN has no vulnerability to an OPC.

TVA's unbalanced voltage protection scheme is designed to detect and provide automatic protection for the connected Class 1E system from offsite power that is not capable of performing its safety function due to unbalanced voltage conditions. This unbalanced protection scheme is part of the undervoltage protection scheme that minimizes the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit or the loss of power from the transmission network. TVA's undervoltage protection scheme, located on the medium voltage Class 1E buses, includes loss of voltage protection, degraded voltage protection, and unbalanced voltage protection.

Because aspects of the implementation of the unbalanced voltage protection scheme design described above required a change to the Technical Specifications, TVA submitted an associated LAR. In the NRC's SE (Reference 1) for that LAR, the NRC staff determined that TVA's UVR "…protection schemes will provide reasonable assurance that the safety-related equipment will be adequately protected from the consequences of negative sequence currents resulting from unbalanced voltage conditions. The UVR protection will be part of the primary success path that functions or actuates to mitigate a design-basis accident or transient that either assumes the failure of or presents a challenge to the integrity of a fission product barrier

and, therefore, will meet Criterion 3 of 10 CFR 50.36(c)(2)(ii) for inclusion into the TSs. The NRC staff concludes that the implementation of the UVR protection schemes will provide reasonable assurance that GDC 17 (AEC Criterion 39 for the Browns Ferry units) required onsite electric power system will be available to permit functioning of SSCs important to safety following a detectable degradation related to unbalanced voltages in the offsite power system." Therefore, as stated above, implementation of the undervoltage protection scheme will provide reasonable assurance that GDC 17 required onsite electric power system will be available to permit functioning of SSCs important to safety following a detectable degradation of voltages in the offsite power system, including those caused by an OPC.

System Description

Items 2, 1.d, 2.a, and 2.c request system information and will be addressed in this section:

> ***2. Briefly describe the operating configuration of the ESF [engineered safety feature] buses (Class 1E for current operating plants or non-Class 1E for passive plants) at power (normal operating condition).***

See Attachment 1 for a simplified one-line diagram.

Preferred electric power (normal power supply) to the emergency buses at SQN is normally supplied by unit power through the unit station service transformers (USSTs). For Unit 1, the normal power supply to start up and shut down the generator is typically supplied by the 500-kV system through the main bank transformers and USSTs. For Unit 2, the normal power supply to start up and shut down the generator is typically supplied by the 161-kV system through the main bank transformers and unit station service transformers.

SQN UFSAR Section 8.2.1.1 describes the two GDC 17 required sources for the Class 1E system. The intent of GDC 17 has been implemented in the design of the preferred power system by providing two main bank transformers; six 24-kV isolated phase buses; four 24-6.9-kV unit station service transformers; four 6.9-kV unit station service transformer buses; three 161-6.9-kV CSSTs (A and C, energized spare B); a 6.9-kV start board; four 6.9-kV start buses; eight 6.9-kV unit boards; four 6.9-kV shutdown boards; and all overhead conductors, buses, cable, and distribution equipment that interconnect the off-site power circuits with the 6.9-kV shutdown boards. The Preferred Power System is supplied power by way of either the plant 161-kV or 500-kV switchyard. The combination of Unit 1 and 2 main bank transformers, USSTs, 24-kV isolated phase buses, and 6.9-kV unit station service transformer buses comprise one qualified independent off-site power circuit.

> ***1.d. Describe the offsite power transformer (e.g., start-up, reserve, station auxiliary) winding and grounding configurations.***

The 6.9 kV secondary winding of each USST is wye-connected, with the neutral grounded through a resistor which will limit ground fault current to 1600 amperes maximum. The 6.9 kV secondary winding of each CSST is wye-connected, with the neutral grounded through a resistor, which will limit ground fault current to 1600 amperes maximum on CSST A and 800 amperes on CSST C. The neutral resistor serves to prevent overvoltage on the winding which could occur in the event of a ground fault if the 6.9 kV system were not intentionally grounded. Note: Installed spare (CSST B) is equivalent to CSST A.

See Attachment 2, Table 4 for offsite power transformer winding and grounding configurations.

2.a. Are the ESF buses powered by offsite power sources? If so, explain what major loads are connected to the buses including their ratings.

No, at normal (at power) operating condition configuration, the ESF buses are powered from the main generator through the unit station service transformers. For SQN, the ESF buses are the 6.9 kV shutdown boards and the associated downstream safety-related distribution.

See Attachment 2, Tables 1 and 2 for ESF bus power sources, and Table 3 for ESF bus major loads energized during normal power operations.

2.c. Confirm that the operating configuration of the ESF buses is consistent with the current licensing basis. Describe any changes in offsite power source alignment to the ESF buses from the original plant licensing.

The operating configuration, as described under item 2, has been confirmed to be consistent with the current licensing basis as discussed in the SQN UFSAR and Unit 1 and Unit 2 License Amendments 332 and 325, respectively, issued on October 31, 2012, and their associated safety evaluations.

In the original SQN design and alignment, the Unit Station Service Transformers (USST) supplied unit power to the 6.9 kV unit boards during plant operation, with the CSSTs available to provide offsite power via the Start Buses. In the event of a loss of a USST or a unit trip, offsite power to the Class 1E 6.9 kV Shutdown Boards was transferred at the 6.9 kV unit boards to the CSSTs. However, due to an issue identified in 1986 regarding USST impedance challenging the 6.9 kV Unit Board circuit breaker short circuit ratings, the CSSTs were replaced with transformers with auto tap changers to accommodate voltage variations in the 161 kV system. This change in the offsite lineup resulted in the CSSTs providing power to the 6.9 kV unit boards via the Start Buses and removed the necessity of power transfer during unit startups and shutdowns or the reliance on automatic power transfer in the event of a fault or plant trip in order to maintain power to the 6.9 kV unit boards.

A license amendment request, dated May 23, 2012 (Reference 2), was submitted to restore the original USST operating configuration, with modifications. This request was accepted under the safety evaluation dated October 31, 2012 (Reference 3) and is currently in place under Unit 1 and Unit 2 License Amendments 332 and 335.

See Attachment 2, Tables 1 and 2, for any changes in the offsite power source alignment to the ESF buses from the original plant licensing.

<u>**System Protection**</u>

Items 1, 1.a, 2.b, and 2.d request information regarding electrical system protection and will be addressed in this section:

1. Given the requirements above, describe how the protection scheme for ESF buses (Class 1E for current operating plants or non-Class 1E for passive plants) is designed to detect and

automatically respond to a single-phase open circuit condition or high impedance ground fault condition on a credited off-site power circuit or another power sources.

Consistent with the current licensing basis documents specified in item 2.c, existing protective circuitry will separate the ESF buses from a connected failed offsite source as a result of a loss of voltage or a sustained, balanced degraded grid voltage, or a sustained unbalanced voltage. While the relay systems were not specifically designed to detect and automatically respond only to an open phase on a three phase system, the undervoltage protection scheme will automatically detect and provide automatic protection from the unbalanced voltage and/or degraded voltage created by the open phase or high impedance ground fault that prevents the connected safety equipment from operating due to insufficient voltage. (See the NRC's SE for TVA's UVRs (Reference 1).)

Normal Plant Operation Considerations:

During normal plant operation the ESF buses sequence of events were described and evaluated as acceptable as part of the NRC's SE for TVA's UVRs (Reference 1, Section 3.2.2) for an open phase.

1.a. The sensitivity of protective devices to detect abnormal operating conditions and the basis for the protective device setpoint(s).

Consistent with the current licensing basis documents specified in item 2.c, existing electrical protective devices are sufficiently sensitive to detect design basis conditions like a loss of voltage or a sustained balanced degraded voltage, or a sustained unbalanced voltage. See Attachment 2, Table 5 for undervoltage protective devices and the basis for the device setpoint(s). Degraded voltage relay logic is 2 out of 3 and degraded voltage relays monitor phases A-B, B-C and C-A. The UVR logic is a permissive 1 out of 2 and each of the relays monitor A-B-C phases.

Existing electrical protective devices are also sufficiently sensitive to detect a ground fault. Attachment 2, Table 5 lists protection devices and the basis for the device setpoint(s).

2.b. If the ESF buses are not powered by offsite power sources, explain how the surveillance tests are performed to verify that a single-phase open circuit condition or high impedance ground fault condition on an off-site power circuit is detected.

The current SQN, Units 1 and 2, Technical Specifications do not contain surveillance requirements for offsite power circuits. In addition, the ESF buses at SQN are powered by unit generators. Phase voltage is monitored for generator output.

2.d. Do the plant operating procedures, including off-normal operating procedures, specifically call for verification of the voltages on all three phases of the ESF buses?

Yes, the current plant operating procedures, including operating procedures for off-normal alignments, do specifically call for verification of the voltages on all three phases of the ESF buses.

<u>Consequences</u>

Items 1.b, 1.c, and 2.e request information regarding the electrical consequences of an event and will be addressed in this section:

> ***1.b. The differences (if any) of the consequences of a loaded (i.e., ESF bus normally aligned to offsite power transformer) or unloaded (e.g., ESF buses normally aligned to unit auxiliary transformer) power source.***

There are no differences of consequences to any safety-related (Class 1E) equipment for an open phase occurring on a normally loaded power source (i.e., Class 1E bus normally aligned to offsite power transformer) or an unloaded power source (i.e., standby offsite power source). No adverse consequences or loss of function occur in either case based on the Unbalanced Voltage setpoint methodology. (Reference 1, Section 3.4.4).

> ***1.c. If the design does not detect and automatically respond to a single-phase open circuit condition or high impedance ground fault condition on a credited offsite power circuit or another power sources, describe the consequences of such an event and the plant response.***

The UVR scheme provides detection and automatic protection for the Class 1E equipment for any adverse single-phase open circuit condition or high impedance ground fault condition on the offsite power circuit.

> ***2.e. If a common or single offsite circuit is used to supply redundant ESF buses, explain why a failure, such as a single-phase open circuit or high impedance ground fault condition, would not adversely affect redundant ESF buses.***

Not applicable since SQN does not use an offsite circuit to supply redundant ESF buses during normal operation.

<u>REFERENCES</u>

1. NRC Letter to TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3; Sequoyah Nuclear Plant, Units 1 and 2; Watts Bar Nuclear Plant, Units 1 and 2 - Issuance of Amendment Nos. 309, 332, 292, 345, 339, 128, and 31 Regarding Unbalanced Voltage Protection (EPID L-2017-LLA-0391)," dated August 27, 2019 (ML18277A110)

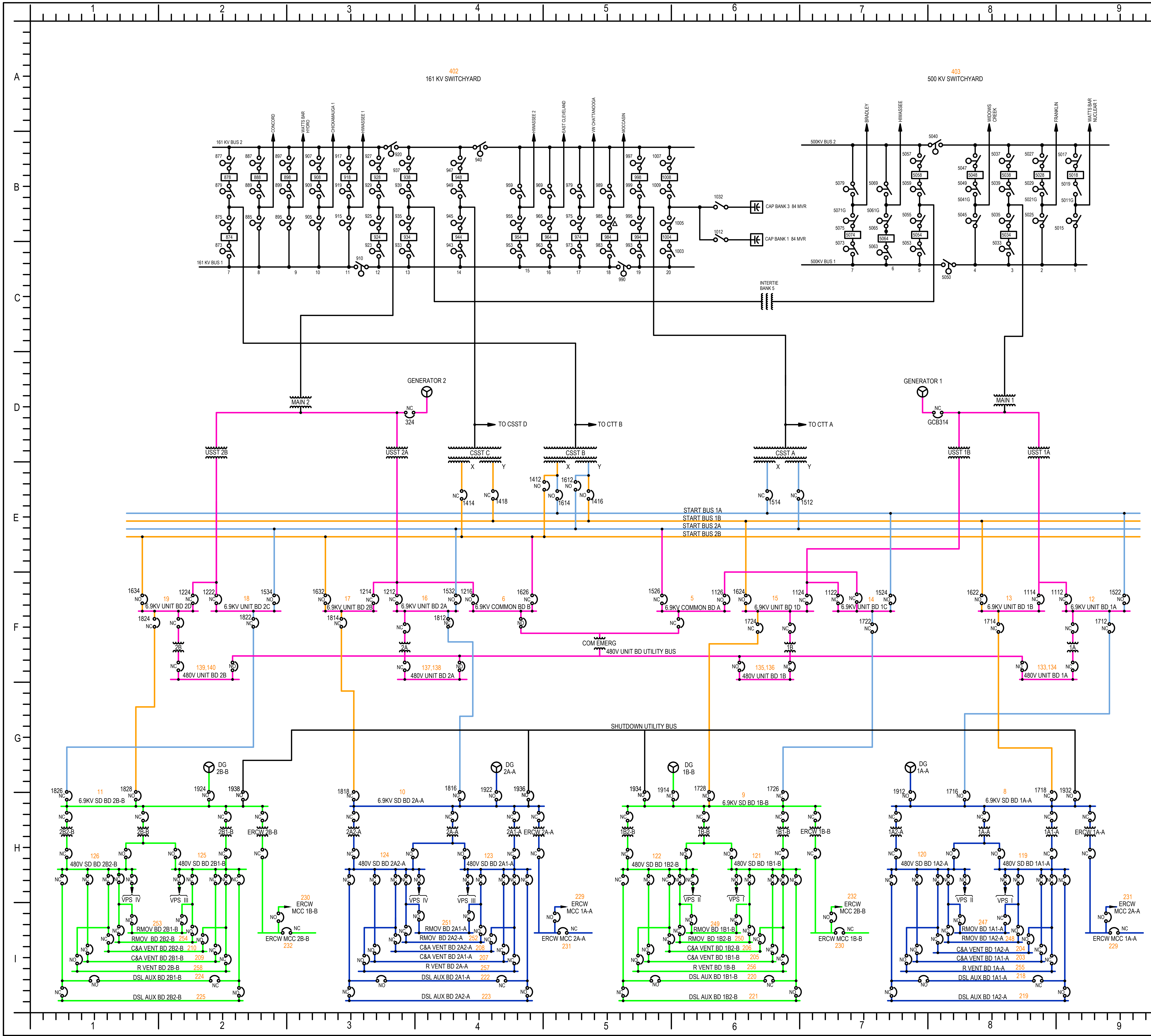
2. TVA Letter to NRC, "Application to Modify Technical Specifications in Support of Unit Station Service Transformer Modification (TS-SQN-12-01)," dated May 23, 2012 (ML12146A385)

3. NRC Letter to TVA, "Sequoyah Nuclear Plant, Units 1 and 2 - Issuance of Amendments to Revise the Technical Specifications 3/4.8.1 in Support of Unit Station Service Transformer Modification (TS-SQN-12-01) (TAC Nos. ME8772 and ME8773)," dated October 31, 2012 (ML12286A078)

Attachment 1

Simplified One-Line Diagram

(See next page)



LEGEND

- HIGH VOLTAGE
- OFFSITE POWER CKT 1
- OFFSITE POWER CKT 2
- NON-SAFETY B.O.P.
- SAFETY RELATED - TRAIN A
- SAFETY RELATED - TRAIN B
- XXX ETAP NODE NUMBERS

Reference Drawings

1-15E500-1	45N502
1-15E500-1-29	45N504
1-15E500-2	45N505
1-15E500-2-35	
1-75W500	
1-75W500-16	

Sequoyah Nuclear Plant Electrical Distribution System 480V-500KV

Engineer: Mark D. Bowman — CAD MAINTAINED DRAWING

8-7-2015 — SQN Electrical Distribution System — 4

Attachment 2 - Tables

Table 1 - ESF Buses Continuously Powered From Offsite Power Source(s)

Description of ESF Bus Power Source	ESF Bus Name (normal operating condition).	Original licensing basis configuration (Y/N)
N/A	N/A	N/A

Table 2 - ESF Buses Not Continuously Powered From Offsite Power Source(s)

Description of ESF Bus Power Source	ESF Bus Name (normal operating condition)	Original licensing basis configuration (Y/N)
Unit Station Service Transformer 1A (USST 1A) via 6.9 kV Unit Board 1A	Shutdown Board 1A-A	N
Unit Station Service Transformer 1B (USST 1B) via 6.9 kV Unit Board 1D	Shutdown Board 1B-B	N
Unit Station Service Transformer 2A (USST 2A) via 6.9 kV Unit Board 2A	Shutdown Board 2A-A	N
Unit Station Service Transformer 2B (USST 2B) via 6.9 kV Unit Board 2D	Shutdown Board 2B-B	N

Table 3 - ESF Buses Normally Energized Major Loads

Class 1E Bus	Load (Normally Running)	Voltage Level (kV)	Rating (HP)
Shutdown Board 1A-A	ERCW	6.9	700
Shutdown Board 1B-B	ERCW	6.9	700
Shutdown Board 1B-B	CCP	6.9	600
Shutdown Board 2A-A	ERCW	6.9	700
Shutdown Board 2A-A	CCP	6.9	600
Shutdown Board 2B-B	ERCW	6.9	700

Table 4 - Offsite Power Transformers

Transformer	Winding Configuration	MVA Size (AO/FA/FA)	Voltage Rating (Primary/Secondary)	Grounding Configuration
USST's 1A, 1B, 2A, and 2B (3Ø)	Delta-Wye	24 / 32 / 40	22.0kV / 6.9kV	Low Side Grounded Wye and Resistance Neutral Grounded
CSST A(3Ø)	Wye-Wye (3 Leg) Buried Delta	24 / 32 / 40	161kV / 6.9kV / 6.9kV	High and Low Side Grounded Wye and Resistance Neutral Grounded
CSST C(3Ø)	Wye-Wye (3 Leg) Buried Delta	24 / 32 / 40	161kV / 6.9kV / 6.9kV	High and Low Side Grounded Wye and Resistance Neutral Grounded

Table 5 - Protective Devices

Protection Zone	Protective Device	Logic	Setpoint (Nominal)	Basis for Setpoint
Each 6.9 kV Shutdown Board (1A, 1B, 2A, or 2B)	Loss of Voltage Relay	2 of 3	5520V (80% of 6900V)	Operation of the auxiliary power system under steady-state (running) conditions, with the safety-related bus voltage as low as possible while keeping all connected safety-related motor loads above their stall voltage. (greater than 70.7 percent of rated motor voltage for NEMA Design "B" motors)
Each 6.9 kV Shutdown Board (1A, 1B, 2A, or 2B)	Degraded Voltage	2 of 3	6456V (93.5% of 6900V)	Operation of the auxiliary power system under steady-state (running) conditions, with the safety-related bus voltage as low as possible while still keeping all connected safety-related loads within their rated operating voltage range (within ANSI C84.1 utilization voltages, range “B”)
Each 6.9 kV Shutdown Board (1A, 1B, 2A, or 2B)	Unbalanced Voltage	Permissive 1 out of 2	1.30V @ 2.95 Sec 2.96V @ 9.95 Sec 18.13V @ 3.95 Sec	Operation of the auxiliary power system, with the safety-related bus voltage unbalanced while still keeping all connected safety-related loads within their rated operating voltage range (Reference 1)
CSST A	Transformer Neutral Ground Relay	N/A	360A	To provide protection for the neutral resistor for the 10 second rating.
CSST B	Transformer Neutral Ground Relay	N/A	360A	To provide protection for the neutral resistor for the 10 second rating.
CSST C	Transformer Neutral Ground Relay	N/A	72A	To provide protection for the neutral resistor for the 10 second rating.

ENCLOSURE 3

Watts Bar Nuclear Plant, Units 1 and 2

Revised Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System"

ENCLOSURE 3

Watts Bar Nuclear Plant, Units 1 and 2
90-Day Response to NRC Bulletin 2012-01, “Design Vulnerability in Electric Power System”

Overview:

- Statement of No Open Phase Design Vulnerability for Class 1E Equipment
- System Description - Items 2., 1.d, 2.a, 2.c
- System Protection - Items 1., 1.a, 2.b, 2.d
- Consequences - Items 1.b, 1.c, 2.e
- References
- Attachment 1 - Simplified One-Line Diagram
- Attachment 2 - Tables
  - Table 1 - ESF Buses Continuously Powered From Offsite Power Source(s)
  - Table 2 - ESF Buses Not Continuously Powered From Offsite Power Source(s)
  - Table 3 - ESF Buses Normally Energized Major Loads
  - Table 4 - Offsite Power Transformers
  - Table 5 - Protective Devices

Statement of No Open Phase Design Vulnerability for Class 1E Equipment

The U. S. Nuclear Regulatory Commission (NRC) issued Bulletin 2012-01, "Design Vulnerability in Electrical Power System," which identified a vulnerability to an open phase condition (OPC) in electrical power systems at nuclear power plants. The bulletin required that licensees comprehensively verify their compliance with General Design Criterion (GDC) 17, "Electric Power Systems," and to respond to the bulletin. The Watts Bar Nuclear Plant (WBN) units are licensed to the Proposed General Design Criteria of 1967 and WBN's compliance with the intent of GDC 17 is discussed in the WBN Updated Final Safety Analysis Report (UFSAR). The bulletin also requested information regarding how the design of the protection scheme for engineered safety feature (ESF) buses detects and automatically responds to single-phase open circuit conditions or high impedance ground fault conditions, including a description of the operating configuration of the ESF buses.

As stated in the bulletin, "At Byron, a failure to design the electric power system's protection scheme to sense the loss of a single phase between the transmission network and the onsite power distribution system resulted in unbalanced voltage at both ESF buses (degraded offsite power system), trip of several safety-related pieces of equipment such as Essential Service Water pumps, Centrifugal Charging Pumps, and Component Cooling Water Pumps and the unavailability of the onsite electric power system. This situation resulted in neither the onsite nor the offsite electric power system being able to perform its intended safety functions (i.e., to provide electric power to the ESF buses with sufficient capacity and capability to permit functioning of structures, systems, and components important to safety)."

TVA has designed and implemented an unbalanced voltage protection scheme to protect structures, systems, and components (SSCs) important to safety, as discussed below. As stated in the NRC's safety evaluation (SE) (Reference 1) for TVA's unbalanced voltage relay (UVR) license amendment request (LAR), "An open circuit in one phase of a three-phase power system results in an unbalanced voltage condition on plant buses. The unbalanced voltage condition results in unbalanced current flow that produces negative and zero sequence current." Therefore, because TVA employs a UVR protection scheme, TVA's SSCs important to safety are protected from an OPC event. Therefore, WBN has no vulnerability to an OPC.

TVA's unbalanced voltage protection scheme is designed to detect and provide automatic protection for the connected Class 1E system from offsite power that is not capable of performing its safety function due to unbalanced voltage conditions. This unbalanced protection scheme is part of the undervoltage protection scheme that minimizes the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit or the loss of power from the transmission network. TVA's undervoltage protection scheme, located on the medium voltage Class 1E buses, includes loss of voltage protection, degraded voltage protection, and unbalanced voltage protection.

Because aspects of the implementation of the unbalanced voltage protection scheme design described above required a change to the Technical Specifications, TVA submitted an associated LAR. In the NRC's SE (Reference 1) for that LAR, the NRC staff determined that TVA's UVR "…protection schemes will provide reasonable assurance that the safety-related equipment will be adequately protected from the consequences of negative sequence currents resulting from unbalanced voltage conditions. The UVR protection will be part of the primary success path that functions or actuates to mitigate a design-basis accident or transient that either assumes the failure of or presents a challenge to the integrity of a fission product barrier

and, therefore, will meet Criterion 3 of 10 CFR 50.36(c)(2)(ii) for inclusion into the TSs. The NRC staff concludes that the implementation of the UVR protection schemes will provide reasonable assurance that GDC 17 (AEC Criterion 39 for the Browns Ferry units) required onsite electric power system will be available to permit functioning of SSCs important to safety following a detectable degradation related to unbalanced voltages in the offsite power system." Therefore, as stated above, implementation of the undervoltage protection scheme will provide reasonable assurance that GDC 17 required onsite electric power system will be available to permit functioning of SSCs important to safety following a detectable degradation of voltages in the offsite power system, including those caused by an OPC.

System Description

Items 2, 1.d, 2.a, and 2.c request system information and will be addressed in this section:

> ***2. Briefly describe the operating configuration of the ESF buses (Class 1E for current operating plants or non-Class 1E for passive plants) at power (normal operating condition).***

See Attachment 1 for a simplified one-line diagram.

The engineered safety features (ESF) buses are normally powered directly from offsite power via common station service transformer connections to the 161 kilovolt (kV) switchyard.

Preferred offsite power is supplied from TVA's 161 kV transmission grid at Watts Bar Hydro Plant switchyard over two separate transmission lines, each connecting to two 161-6.9 kV common station service transformers (CSSTs) at WBN. The Class 1E power system is normally supplied from offsite power through CSSTs C and D. CSSTs C and D are connected to 6.9 kV common switchgear C and D via a bus similar to 6.9 kV start buses A and B. The 6.9 kV common switchgear C and D are then connected to the 6.9 kV shutdown boards.

> ***1.d. Describe the offsite power transformer (e.g., start-up, reserve, station auxiliary) winding and grounding configurations.***

The 6.9 kV secondary winding of each unit and common station service transformer is wye-connected, with the neutral grounded through a resistor which will limit ground fault current to 1600 amperes maximum. The neutral resistor serves to prevent overvoltage on the winding which could occur in the event of a ground fault if the 6900V system were not intentionally grounded.

See Attachment 2, Table 4 for offsite power transformer winding and grounding configurations.

> ***2.a. Are the ESF buses powered by offsite power sources? If so, explain what major loads are connected to the buses including their ratings.***

At normal (at power) operating condition configuration the ESF buses are powered by offsite power sources.

See Attachment 2, Tables 1 and 2 for ESF bus power sources, and Table 3 for ESF bus major loads energized during normal power operations.

2.c. Confirm that the operating configuration of the ESF buses is consistent with the current licensing basis. Describe any changes in offsite power source alignment to the ESF buses from the original plant licensing.

The operating configuration, as described under item 2, has been confirmed to be consistent with the configuration described in WBN's UFSAR, Chapter 8.2. There have not been any changes to the offsite power source alignment to the ESF buses from the WBN original plant licensing.

System Protection

Items 1, 1.a, 2.b, and 2.d request information regarding electrical system protection and will be addressed in this section:

1. Given the requirements above, describe how the protection scheme for ESF buses (Class 1E for current operating plants or non-Class 1E for passive plants) is designed to detect and automatically respond to a single-phase open circuit condition or high impedance ground fault condition on a credited off-site power circuit or another power sources.

Consistent with the current licensing basis document specified in item 2.c, existing protective circuitry will separate the ESF buses from a connected failed offsite source as a result of a loss of voltage, a sustained balanced degraded grid voltage, or a sustained unbalanced voltage. While the relay systems were not specifically designed to detect and automatically respond only to an open phase on a three phase system, the undervoltage protection scheme will automatically detect and provide automatic protection from the unbalanced voltage and/or degraded voltage created by the open phase or high impedance ground fault that prevents the connected safety equipment from operating due to insufficient voltage (Reference 1).

Normal Plant Operation Considerations:

During normal plant operation, the ESF buses sequence of events were described and evaluated as acceptable as part of NRC's SE for UVRs (Reference 1) for an open phase.

1.a. The sensitivity of protective devices to detect abnormal operating conditions and the basis for the protective device setpoint(s).

Consistent with the current licensing basis document specified in item 2.c, existing electrical protective devices are sufficiently sensitive to detect design basis conditions like a loss of voltage or sustained balanced degraded voltage, or a sustained unbalanced voltage. See Attachment 2, Table 5 for undervoltage protective devices and the basis for the device setpoint(s). Degraded voltage relay logic is 2 out of 3 and degraded voltage relays monitor phases A-B, B-C and C-A. The UVR logic is a permissive 1 out of 2 and each of the relays monitor A-B-C phases.

Existing electrical protective devices are also sufficiently sensitive to detect a ground fault. Attachment 2, Table 5 lists ground protection and the basis for the device setpoint(s).

2.b. If the ESF buses are not powered by offsite power sources, explain how the surveillance tests are performed to verify that a single-phase open circuit condition or high impedance ground fault condition on an off-site power circuit is detected.

Not Applicable - the ESF buses at WBN are powered by offsite power sources.

2.d. Do the plant operating procedures, including off-normal operating procedures, specifically call for verification of the voltages on all three phases of the ESF buses?

No, the current plant operating procedures, including operating procedures for off-normal alignments, do not specifically call for verification of the voltages on all three phases of the ESF buses.

<u>Consequences</u>

Items 1.b, 1.c, and 2.e request information regarding the electrical consequences of an event and will be addressed in this section:

1.b. The differences (if any) of the consequences of a loaded (i.e., ESF bus normally aligned to offsite power transformer) or unloaded (e.g., ESF buses normally aligned to unit auxiliary transformer) power source.

There are no differences of consequences to any safety-related (Class 1E) equipment for an open phase occurring on a normally loaded power source (i.e., Class 1E bus normally aligned to offsite power transformer) or an unloaded power source (i.e., standby offsite power source). No adverse consequences or loss of function occur in either case based on the Unbalanced Voltage setpoint methodology. (Reference 1, Section 3.4.4).

1.c. If the design does not detect and automatically respond to a single-phase open circuit condition or high impedance ground fault condition on a credited offsite power circuit or another power sources, describe the consequences of such an event and the plant response.

The UVR scheme provides detection and automatic protection for the Class 1E equipment for any adverse single-phase open circuit condition or high impedance ground fault condition on the offsite power circuit.

2.e. If a common or single offsite circuit is used to supply redundant ESF buses, explain why a failure, such as a single-phase open circuit or high impedance ground fault condition, would not adversely affect redundant ESF buses.

Not applicable since WBN does not use a common or single offsite circuit to supply redundant ESF buses.

REFERENCES

1. NRC Letter to TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3; Sequoyah Nuclear Plant, Units 1 and 2; Watts Bar Nuclear Plant, Units 1 and 2 - Issuance of Amendment Nos. 309, 332, 292, 345, 339, 128, and 31 Regarding Unbalanced Voltage Protection (EPID L-2017-LLA-0391)," dated August 27, 2019 (ML18277A110)

2. NRC Letter to TVA, "Watts Bar Nuclear Plant, Units 1 and 2 - Issuance of Amendment Nos. 131 and 34 Regarding Correction to Unbalanced Voltage Relay Instrumentation Values (EPID L-2019-LIA-0228)," dated December 10, 2019 (ML19336C519)

Attachment 1

WBN Simplified One-Line Diagram

(See next page)

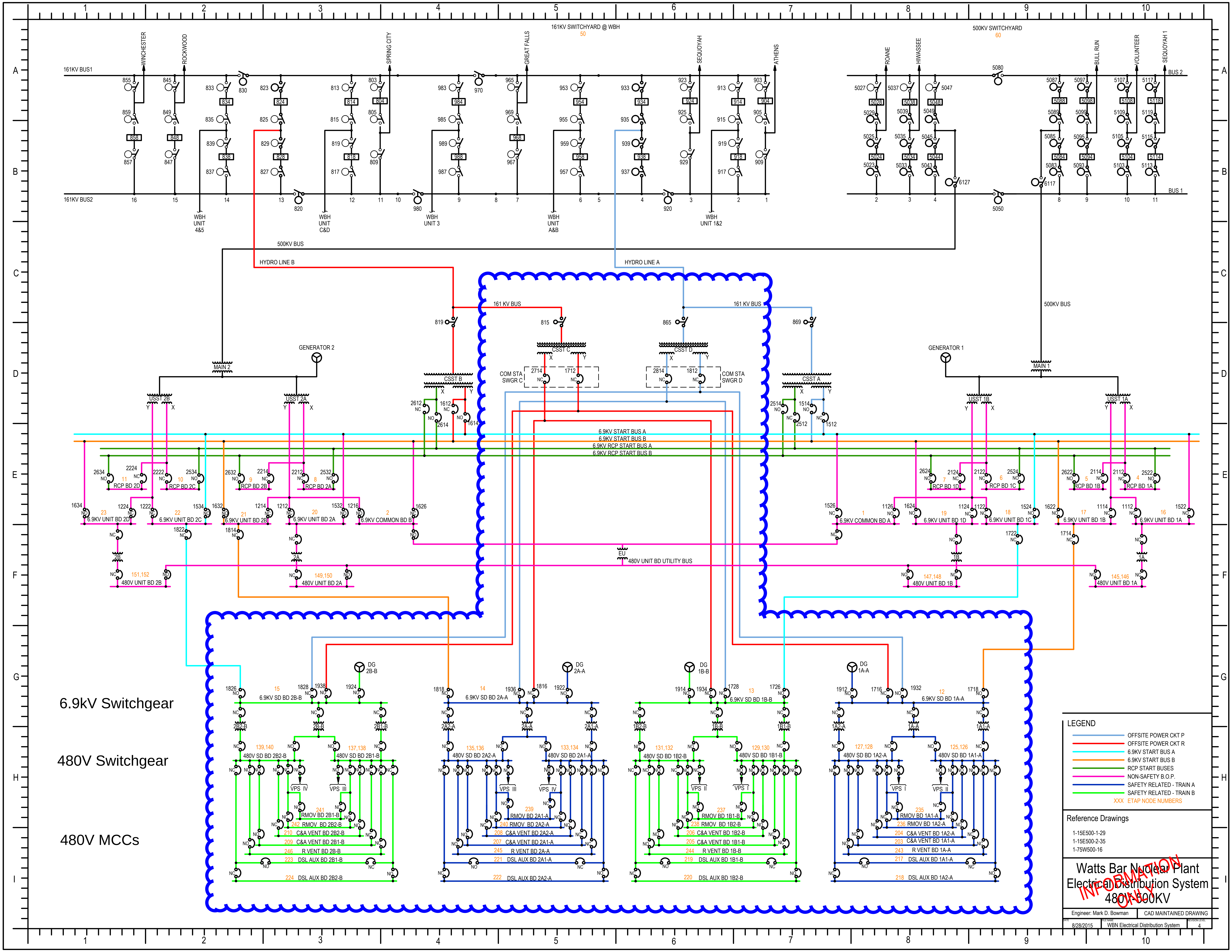

161KV SWITCHYARD @ WBH
500KV SWITCHYARD
161KV BUS1
161KV BUS2
BUS 2
BUS 1
WINCHESTER
ROCKWOOD
SPRING CITY
GREAT FALLS
SEQUOYAH
ATHENS
ROANE
HIWASSEE
BULL RUN
VOLUNTEER
SEQUOYAH 1
WBH UNIT 4&5
WBH UNIT C&D
WBH UNIT 3
WBH UNIT A&B
WBH UNIT 1&2
500KV BUS
HYDRO LINE B
HYDRO LINE A
161 KV BUS
GENERATOR 2
GENERATOR 1
MAIN 2
MAIN 1
CSST C
CSST D
CSST B
CSST A
COM STA SWGR C
COM STA SWGR D
USST 2B
USST 2A
USST 1B
USST 1A
6.9KV START BUS A
6.9KV START BUS B
6.9KV RCP START BUS A
6.9KV RCP START BUS B
RCP BD 2D
RCP BD 2C
RCP BD 2B
RCP BD 2A
RCP BD 1D
RCP BD 1C
RCP BD 1B
RCP BD 1A
6.9KV UNIT BD 2D
6.9KV UNIT BD 2C
6.9KV UNIT BD 2B
6.9KV UNIT BD 2A
6.9KV COMMON BD B
6.9KV COMMON BD A
6.9KV UNIT BD 1D
6.9KV UNIT BD 1C
6.9KV UNIT BD 1B
6.9KV UNIT BD 1A
480V UNIT BD UTILITY BUS
480V UNIT BD 2B
480V UNIT BD 2A
480V UNIT BD 1B
480V UNIT BD 1A
6.9kV Switchgear
480V Switchgear
480V MCCs
6.9KV SD BD 2B-B
6.9KV SD BD 2A-A
6.9KV SD BD 1B-B
6.9KV SD BD 1A-A
DG 2B-B
DG 2A-A
DG 1B-B
DG 1A-A
480V SD BD 2B2-B
480V SD BD 2B1-B
480V SD BD 2A2-A
480V SD BD 2A1-A
480V SD BD 1B2-B
480V SD BD 1B1-B
480V SD BD 1A2-A
480V SD BD 1A1-A
RMOV BD 2B1-B
RMOV BD 2B2-B
C&A VENT BD 2B2-B
C&A VENT BD 2B1-B
R VENT BD 2B-B
DSL AUX BD 2B1-B
DSL AUX BD 2B2-B
RMOV BD 2A1-A
RMOV BD 2A2-A
C&A VENT BD 2A2-A
C&A VENT BD 2A1-A
R VENT BD 2A-A
DSL AUX BD 2A1-A
DSL AUX BD 2A2-A
RMOV BD 1B1-B
RMOV BD 1B2-B
C&A VENT BD 1B2-B
C&A VENT BD 1B1-B
R VENT BD 1B-B
DSL AUX BD 1B1-B
DSL AUX BD 1B2-B
RMOV BD 1A1-A
RMOV BD 1A2-A
C&A VENT BD 1A2-A
C&A VENT BD 1A1-A
R VENT BD 1A-A
DSL AUX BD 1A1-A
DSL AUX BD 1A2-A
LEGEND
OFFSITE POWER CKT P
OFFSITE POWER CKT R
6.9KV START BUS A
6.9KV START BUS B
RCP START BUSES
NON-SAFETY B.O.P.
SAFETY RELATED - TRAIN A
SAFETY RELATED - TRAIN B
XXX ETAP NODE NUMBERS
Reference Drawings
1-15E500-1-29
1-15E500-2-35
1-75W500-16
Watts Bar Nuclear Plant
Electrical Distribution System
480V-500KV
INFORMATION ONLY
Engineer: Mark D. Bowman
CAD MAINTAINED DRAWING
DATE 8/28/2015
FILE NAME WBN Electrical Distribution System
REVISION LEVEL 4

Table 1 - ESF Buses Continuously Powered From Offsite Power Source(s)

Description of ESF Bus Power Source	ESF Bus Name (normal operating condition).	Original licensing basis configuration (Y/N)
Common Station Service Transformer C (CSST C)	6.9 kV Shutdown Board 1A-A	Y
Common Station Service Transformer D (CSST D)	6.9 kV Shutdown Board 1B-B	Y
Common Station Service Transformer C (CSST C)	6.9 kV Shutdown Board 2A-A	Y
Common Station Service Transformer D (CSST D)	6.9 kV Shutdown Board 2B-B	Y

Table 2 - ESF Buses Not Continuously Powered From Offsite Power Source(s)

Description of ESF Bus Power Source	ESF Bus Name (normal operating condition).	Original licensing basis configuration (Y/N)
N/A	N/A	N/A

Table 3 - ESF Buses Normally Energized Major Loads

Class 1E Bus	Load (Normally Running)	Voltage Level (kV)	Rating (HP)
6.9 kV Shutdown Board 1A-A	ERCW	6.9	800
6.9 kV Shutdown Board 1A-A	CCP	6.9	600
6.9 kV Shutdown Board 1B-B	ERCW	6.9	800
6.9 kV Shutdown Board 1B-B	CCP	6.9	600
6.9 kV Shutdown Board 2A-A	ERCW	6.9	800
6.9 kV Shutdown Board 2B-B	ERCW	6.9	800

Table 4 - Offsite Power Transformers

Transformer	Winding Configuration	MVA Size (AO/FA/FA)	Voltage Rating (Primary/Secondary)	Grounding Configuration
CSST C (3Ø)	Wye-Wye (3 Leg) Buried Delta	24 / 32 / 40	161 kV/6.9 kV/6.9 kV	High and Low Side Grounded Wye and Resistance Neutral Grounded
CSST D (3Ø)	Wye-Wye (3 Leg) Buried Delta	24 / 32 / 40	161 kV/6.9 kV/6.9 kV	High and Low Side Grounded Wye and Resistance Neutral Grounded

Table 5 - Protective Devices

Protection Zone	Protective Device	Logic	Setpoint (Nominal)	Basis for Setpoint
Each 6.9 kV Shutdown Board (1A, 1B, 2A, or 2B)	Loss of Voltage Relay	2 of 3	6000V (87% of 6900V)	Operation of the auxiliary power system under steady-state (running) conditions, with the safety-related bus voltage as low as possible while keeping all connected safety-related motor loads above their stall voltage. (greater than 70.7 percent of rated motor voltage for NEMA Design "B" motors)
Each 6.9 kV Shutdown Board (1A, 1B, 2A, or 2B)	Degraded Voltage	2 of 3	6600V (96% of 6900V)	Operation of the auxiliary power system under steady-state (running) conditions, with the safety-related bus voltage as low as possible while still keeping all connected safety-related loads within their rated operating voltage range (within ANSI C84.1 utilization voltages, range "B")
Each 6.9 kV Shutdown Board (1A, 1B, 2A, or 2B)	Unbalanced[1] Voltage	Permissive 1 out of 2	1.30V @ 2.95 Sec 2.96V @ 9.95 Sec 18.13V @ 3.45 Sec	Operation of the auxiliary power system, with the safety-related bus voltage unbalanced while still keeping all connected safety-related loads within their rated operating voltage range (Reference 1)
CSST C or CSST D	Transformer Neutral Ground Relay	N/A	240A	To provide protection for the neutral resistor for the 10 second rating.

[1] The setpoints for unbalanced voltage were corrected in Reference 2.