TVA

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

October 25, 2012

10 CFR 50.4
10 CFR 50.54(f)

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-001

Browns Ferry Nuclear Plant, Units 1, 2, and 3
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
Facility Operating License Nos. DPR-77 and DPR-79
NRC Docket Nos. 50-327 and 50-328

Watts Bar Nuclear Plant, Unit 1
Facility Operating License No. NPF-90
NRC Docket No. 50-390

Watts Bar Nuclear Plant, Unit 2
Construction Permit No. CPPR-92
NRC Docket No. 50-391

Subject: **90-Day Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System"**

The Nuclear Regulatory Commission (NRC) issued Bulletin 2012-01, "Design Vulnerability in Electric Power System," dated July 27, 2012, to notify addressees that the NRC staff is requesting information about the facilities' electric power system designs to determine if further regulatory action is warranted. Bulletin 2012-01 requires addressees to comprehensively verify compliance with the regulatory requirements of General Design Criterion (GDC) 17, "Electric Power Systems," or the applicable principal design criteria in the updated final safety analysis report and the design criteria for protection systems under 10 CFR 50.55a(h)(2) and 10 CFR 50.55a(h)(3). A written response is required to be provided to the NRC in accordance with 10 CFR 50.54(f).

Enclosures 1, 2, and 3 to this letter provide the Bulletin's 90-day requested response for Browns Ferry Nuclear Plant, Units 1, 2, and 3, Sequoyah Nuclear Plant, Units 1 and 2, and

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Watts Bar Nuclear Plant, Units 1 and 2, respectively, regarding electric power system designs in light of the recent operating experience involving the loss of one of the three phases of the offsite power circuit (single-phase open circuit condition) at Byron Station, Unit 2. Because Bulletin 2012-01 was issued on July 27, 2012, this 90-day response is due October 25, 2012.

This letter does not contain any new regulatory commitments. If you have any questions concerning this matter, please contact Beth Wetzel, Manager, Emerging Regulatory Issues, at (423) 751-2403.

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 25th day of October, 2012.

Respectfully,

J. W. Shea
Vice President, Nuclear Licensing

Enclosures:

1. Browns Ferry Nuclear Plant, Units 1, 2 and 3, 90-Day Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System"
2. Sequoyah Nuclear Plant, Units 1 and 2, 90-Day Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System"
3. Watts Bar Nuclear Plant, Units 1 and 2, 90-Day 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, Unit 1
NRC Senior Resident Inspector - Watts Bar Nuclear Plant, Unit 2

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:

- 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
- 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

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 Brown Ferry Nuclear Plant (BFN) Updated

Final Safety Analysis Report (UFSAR), Unit 1 and Unit 2 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 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. The relay systems were not specifically designed to detect an open single phase of a three phase system. Detection of a single-open phase condition is beyond the approved design basis of the plant and is not considered to be part of the licensing basis of the plant as reflected in the documents specified in item 2.c.

Normal Plant Operation Considerations:

During normal plant operation the ESF buses are powered from the USST. An open phase on the main bank transformer 500 kV side would have no effect on the ESF bus voltage. Since the main bank transformer is tied directly to the generator terminals, via a generator circuit breaker, it will continue to receive three phase voltage on its primary side for as long as the generator remains online. If the generator trips on negative sequence due to the open phase, the generator circuit breaker will open and power will continue to be received from the connected source.

An ungrounded open phase on the high side of the USST (500 kV) or CSST (161 kV) is highly unlikely due to the isophase bus connection arrangement and overhead transmission line. Note: Isophase bus sections are surrounded by ground by design and are connected in such a manner that damage to any section would result in automatic grounding. Additionally, overhead transmission lines have sufficient distance between connection points that grounding would be ensured during any line failure (i.e., transmission line lengths are longer than the height of suspension). In the case of a grounded open phase on the high side of the USST, the voltage on two phases would be reduced. Although the degraded voltage protection scheme at BFN was not designed to detect and automatically respond to a single-phase open circuit condition on a credited off-site power circuit, preliminary studies have shown that the undervoltage protection, specifically the degraded voltage relay, will respond to a grounded single-phase open circuit condition by isolating the affected power source in 6.9 seconds and automatically transfer power to the emergency diesel generator.

During normal plant operation an open phase on the high side of the CSST (161 kV) has no effect on safety or non-safety bus voltages since these loads are fed from the USSTs.

In addition to the plant configuration, the USST winding configuration includes a delta winding and the ESF equipment is ungrounded. The ESF bus and off-site circuit grounding protection has been reviewed with regard to ground faults. Since there is a deliberate ground current path, each medium voltage motor and transformer feeder circuit is protected by ground overcurrent relays which will trip that circuit's feeder breaker. The USST neutral resistor has an instantaneous over-current relay and a neutral ground which will trip the 500 kV breakers which supply that transformer from the 500 kV system.

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 balanced degraded voltage, but were not designed to detect a single phase open circuit condition. 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.

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. General Operating Instruction, 0-GOI-300-1/Att-17, "Unit 2 Operator at the Controls Duty Station Checklist," is performed hourly to record the 500 kV and 161 kV voltages.

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.***

Installed relays were not designed to detect single phase open circuit conditions. Existing loss of voltage and degraded voltage relays may respond depending on load and possible grounds. In general, there will be no plant response for an unloaded (e.g., ESF buses normally aligned to USST) power source in the event of a single-phase open circuit on a credited off-site power circuit because there is insufficient current to detect a single-phase open circuit for this configuration.

The plant response for a loaded power source cannot be calculated without specifying the amount of loading and the specific loads involved.

Loading differences for a ground will have no effect on plant operation. If the ground is sufficiently large (i.e. low impedance ground) to affect plant operation, protective relaying will isolate the ground automatically.

> ***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.***

BFN does not credit in the Current Licensing Basis (CLB) documents specified in item 2.c that the Class 1E protection scheme (for the ESF buses) was designed to detect and automatically respond to a single-phase open circuit condition or high impedance ground fault condition on the credited off-site power source as described in the UFSAR and Technical Specifications.

The offsite power circuits at the BFN consists of two independent circuits from the USSTs to the 4.16 kV Shutdown Board and CSSTs to 4.16 kV Shutdown Boards. See response to "System Description", item 2.

Since BFN does not credit the ESF bus protection scheme as being capable of detecting and automatically responding to a single phase open circuit condition or high impedance ground fault condition, an open phase fault was not included in the design criteria for the loss of voltage, the degraded voltage relay scheme or loss of voltage protection system design criteria. Since open phase detection was not credited in the BFN design or licensing basis of the plant as reflected in the documents specified in item 2.c, no design basis calculations or design documents exist that previously considered this condition.

Without formalized engineering calculations or engineering evaluations, the electrical consequences of such an open phase event or high impedance ground fault condition (including plant response), can only be evaluated to the extent of what has already been published by Electric Power Research Institute (EPRI) and Basler; which is a generic overview. The difficulty in applying these documents to the BFN specific response is that these are generic assessments and cannot be formally credited as a basis for an accurate response. The primary reason is that detailed plant specific models would need to be developed (e.g., transformer magnetic circuit models, electric distribution models, motor models; including positive, negative, and zero sequence impedances (voltage and currents), and the models would need to be compiled and analyzed for the BFN specific Class 1E electric distribution system).

While the specific consequences of a single phase open circuit on the credited offsite power circuit have not been determined, preliminary studies have revealed that BFN's transformer configuration, transformer connection to unit generation and 2 out of 3 undervoltage protection eliminate the possibility of the same consequences for the event that occurred at Byron.

Preliminary results indicate that in the ungrounded open circuit condition, the degraded voltage protection may actuate, causing the effected ESF buses to disconnect from the offsite power source in 6.9 seconds. However, this cannot be confirmed until the model and critical parameters have been developed and accurate values obtained. TVA recognizes the significance of the consequences of the Byron event and is participating in the ongoing effort to develop parameters, led by the nuclear industry and coordinated with the Nuclear Energy Institute.

Should the open phase condition occur at BFN, neither train of ESF buses would be affected while at normal operation due to the connection of the ESF buses to the generators through the USSTs. To enhance reliability, increased operator awareness of the potential consequences (i.e. what happened at Byron) and increased surveillance of off-site power sources are being evaluated.

The effects on ESF equipment, with regard to high impedance grounds while all three phases remain intact, have been evaluated using known electrical engineering theory.

- The effect of a high impedance ground on the primary side of the USST will have no impact on the ESF system. Zero sequence current will be unable to pass to the secondary side of the transformer due to a delta winding. Additionally, the phase to phase voltage differences in the system, due to a high impedance ground, are unaffected.
- The effect of a high impedance ground on the secondary side of the USST will have no impact on the ESF system. The medium voltage ESF buses are ungrounded and cannot be affected by any zero sequence current produced by a high impedance ground. Additionally, the phase to phase voltage differences in the system, resulting from a high impedance ground, are unaffected.

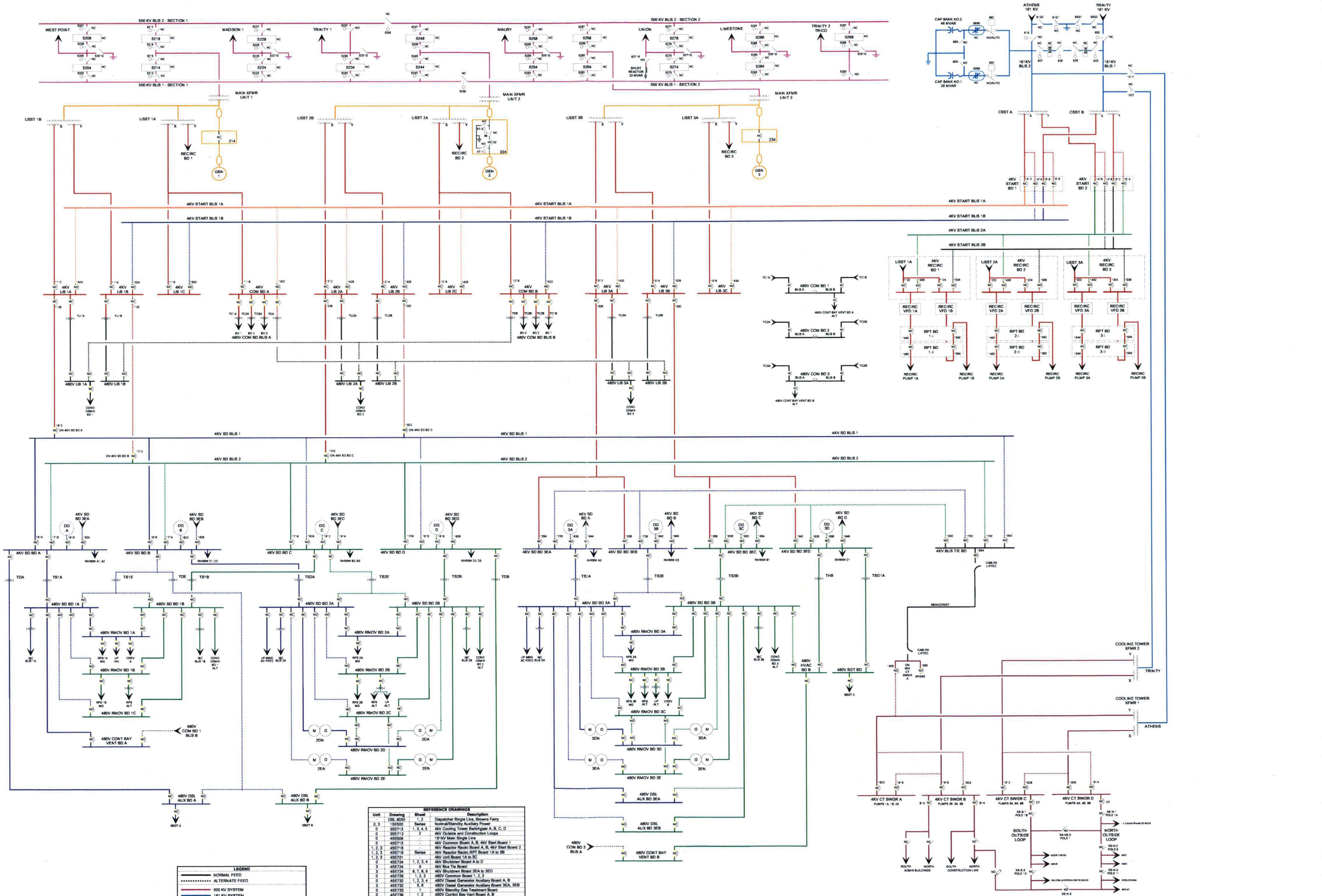
2.e. If a common or single offsite circuit is used to supply redundant ESF buses, explain why a failure, such as a single-phase open circuit or high impedance ground fault condition, would not adversely affect redundant ESF buses.

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

Attachment 1

Simplified One-Line Diagram

(See next page)



E1-8

REFERENCE DRAWINGS			
Unit	**Drawing**	**Sheet**	**Description**
-	DSL-6055	1, 2	Dispatcher 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

- NORMAL FEED
- ALTERNATE FEED
- 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

INFORMATION ONLY

AC ELECTRICAL DISTRIBUTION SYSTEM
BROWNS FERRY NUCLEAR PLANT

PIP-02-03 REVISION 09/10/2009

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 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")
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
90-Day Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System"

Overview:

- System Description - Items 2., 1.d, 2.a, 2.c
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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.

Preferred electric power (normal power supply) to the emergency buses at the Sequoyah Nuclear Plant (SQN) is supplied by two physically and electrically independent circuits from the SQN 161 kilovolt (kV) switchyard through separate common station service transformers (CSSTs).

The SQN CSSTs are currently arranged with CSST A and CSST C providing power to the plant through the Start Buses. CSST A supplies Start Buses 1A and 2A and CSST C supplies Start Buses 1B and 2B. CSST B is a spare transformer with two sets of secondary windings that can be used to power two of the Start Buses, with each Start Bus on a separate secondary winding. Normal unit power from the Start Buses to the 6.9 kV Unit Boards and Class 1E 6.9 kV Shutdown Boards is provided as follows:

- Start Bus 1A supplies 6.9 kV Shutdown Board 1B-B via Unit Board 1C;
- Start Bus 1B supplies 6.9 kV Shutdown Board 1A-A via Unit Board 1B;
- Start Bus 2A supplies 6.9 kV Shutdown Board 2B-B via Unit Board 2C; and
- Start Bus 2B supplies 6.9 kV Shutdown Board 2A-A via Unit Board 2B.

This lineup provides two immediate access offsite circuits to each unit (one to each load group).

SQN Updated Final Safety Analysis Report (UFSAR) Section 8.2.1.1 describes the two General Design Criterion (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 physically and functionally independent circuits for energizing safety related load groups. The preferred power system consists of the three 161 6.9 kV CSST's (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 overhead conductors, buses, cable, and distribution equipment that interconnect the CSST's with the 6.9 kV shutdown boards. Preferred electric power (normal power supply) to the emergency buses and to start up and shut down the generating units at SQN is supplied by two physically and electrically independent circuits from the SQN 161 kV switchyard through separate transformers to the onsite electrical distribution system. The Engineered Safety Features (ESF) buses are normally powered from offsite power via CSST connections to the 161 kV switchyard.

The main generators supply electrical power through isolated-phase buses to the main step-up transformers. During normal operation, startup, and shutdown, auxiliary power is supplied from the 161 kV system through the CSSTs. The standby onsite power is supplied by four diesel generators.

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 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.

At normal (at power) operating condition configuration the ESF buses are powered by offsite power sources. 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 184 and 176, respectively, issued on July 11, 1994, and their associated safety evaluations. The design changes associated with these amendments included revising the Electrical Power Systems surveillance requirements wording to reflect the use of the new CSSTs with auto load tap changers as the normal power supply for the 6.9 kV unit boards.

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 (ML12146A385), to restore the original USST operating configuration, with modifications, is currently under NRC review. TVA requested approval of the amendment by December 1, 2012, to support SQN Unit 2 plant startup following its USST modification during the fall 2012 refueling outage. The SQN Unit 1 USST modification is planned during the fall 2013 refueling outage.

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 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. The relay systems were not specifically designed to detect an open single phase of a three phase system. Detection of a single-open phase condition is beyond the approved design basis of the plant and is not considered to be part of the licensing basis of the plant as reflected in the documents specified in item 2.c.

Normal Plant Operation Considerations:

During normal plant operation the ESF buses are powered from the CSST. An ungrounded open phase on the high side of the CSST (161 kV) is highly unlikely due to the use of overhead transmission lines. Since the overhead transmission lines have sufficient distance between connection points, grounding would be ensured during any line failure (i.e., transmission line lengths are longer than the height of suspension). In the case of a grounded open phase on the high side of the CSST, the voltage on two phases would be reduced. Although the degraded voltage protection scheme at SQN was not designed to detect and automatically respond to a single-phase open circuit condition on a credited off-site power circuit, preliminary studies have shown that the undervoltage protection, specifically the loss of voltage relay, will respond to a grounded single-phase open circuit condition by isolating the affected power source in 1.25 seconds and automatically transfer power to the emergency diesel generator.

In addition to the normal plant configuration, the CSST internal winding configuration includes a buried delta winding and the ESF equipment is ungrounded. The ESF bus and off-site circuit grounding protection has been reviewed with regard to ground faults. Since there is a deliberate ground current path, each medium voltage motor and transformer feeder circuit is protected by ground overcurrent relays which will trip that circuit's feeder breaker. The CSST neutral resistor has an overcurrent relay and a neutral ground relay which will trip the 161 kV breakers which supply the CSST from the 161 kV system.

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 balanced degraded voltage, but were not designed to detect a single phase open circuit condition. 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.

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.

Not Applicable - the ESF buses at SQN 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?

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.

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.

Installed relays were not designed to detect single phase open circuit conditions. Existing loss of voltage and degraded voltage relays may respond depending on load and possible grounds. In general, there will be no plant response for an unloaded power source in the event of a single-phase open circuit on a credited off-site power circuit because there is insufficient current to detect a single-phase open circuit for this configuration. Note: SQN ESF buses are not currently aligned to USSTs.

The plant response for a loaded power source cannot be calculated without specifying the amount of loading and the specific loads involved.

Loading differences for a high impedance ground will have no effect on plant operation. If the ground is sufficiently large (i.e. low impedance ground) to affect plant operation, protective relaying will isolate the ground automatically.

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 SQN Current Licensing Basis (CLB) documents specified in item 2.c do not credit the design of the Class 1E protection scheme (for the ESF buses) to detect and automatically respond to a single-phase open circuit condition or high impedance ground fault condition on the credited off-site power source as described in the UFSAR and Technical Specifications.

The offsite power circuits at the SQN consists of two independent circuits from the CSSTs to the 6.9 kV Shutdown Board(s). See response in "System Description", item 2.

Since SQN does not credit the ESF bus protection scheme as being capable of detecting and automatically responding to a single phase open circuit condition or high impedance ground fault condition, an open phase fault was not included in the design criteria for the loss of voltage, the degraded voltage relay scheme or loss of voltage protection system design criteria. Since open phase detection was not credited in the SQN design or licensing basis of the plant as reflected in the documents specified in item 2.c, no design basis calculations or design documents exist that previously considered this condition.

Without formalized engineering calculations or engineering evaluations, the electrical consequences of this type of open phase event or high impedance ground fault condition (including plant response), can only be evaluated to the extent of that information published by Electric Power Research Institute (EPRI) and Basler, which is limited to a generic overview. The difficulty in applying these documents to the SQN specific response is that the EPRI/Basler information is based on generic assessments and cannot be formally credited as a basis for an individual site's accurate response without the development of detailed plant specific models. Information such as transformer magnetic circuit models, electric distribution models, motor models; positive, negative, and zero sequence impedances (voltage and currents), and the models would need to be compiled and analyzed for the SQN specific Class 1E electric distribution system.

While the specific consequences of a single phase open circuit on the credited offsite power circuit have not been determined, preliminary studies indicate that SQN's transformer configuration, ESF train connection to offsite power supplies and the 2 out of 3 undervoltage protection eliminate the possibility of the same consequences for the event that occurred at Byron.

Preliminary results indicate that in the ungrounded open circuit condition, the degraded voltage protection may actuate, causing the effected ESF buses to disconnect from the offsite power source in 300 seconds. However, this cannot be confirmed until the model and critical parameters have been developed and accurate values obtained. TVA recognizes the significance of the consequences of the Byron event and is participating in the ongoing effort to develop parameters, led by the nuclear industry and coordinated with the Nuclear Energy Institute.

Should the open phase condition occur at SQN, only one train of ESF buses would be affected. To enhance reliability, increased operator awareness of the potential consequences (i.e. what happened at Byron) and increased surveillance of off-site power sources are being evaluated.

The effects on ESF equipment, with regard to high impedance grounds while all three phases remain intact, have been evaluated using known electrical engineering theory.

- The effect of a high impedance ground on the primary side of the CSST will have no impact on the ESF system. Zero sequence current will be unable to pass to the secondary side of the transformer due to a buried delta winding inside the transformer. Additionally, the phase to phase voltage differences in the system, due to a high impedance ground, should be unaffected.
- The effect of a high impedance ground on the secondary side of the CSST will have no impact on the ESF system. The medium voltage ESF buses are ungrounded and cannot be affected by any zero sequence current produced by a high impedance ground. Additionally, the phase to phase voltage differences in the system, resulting from a high impedance ground, should be unaffected.

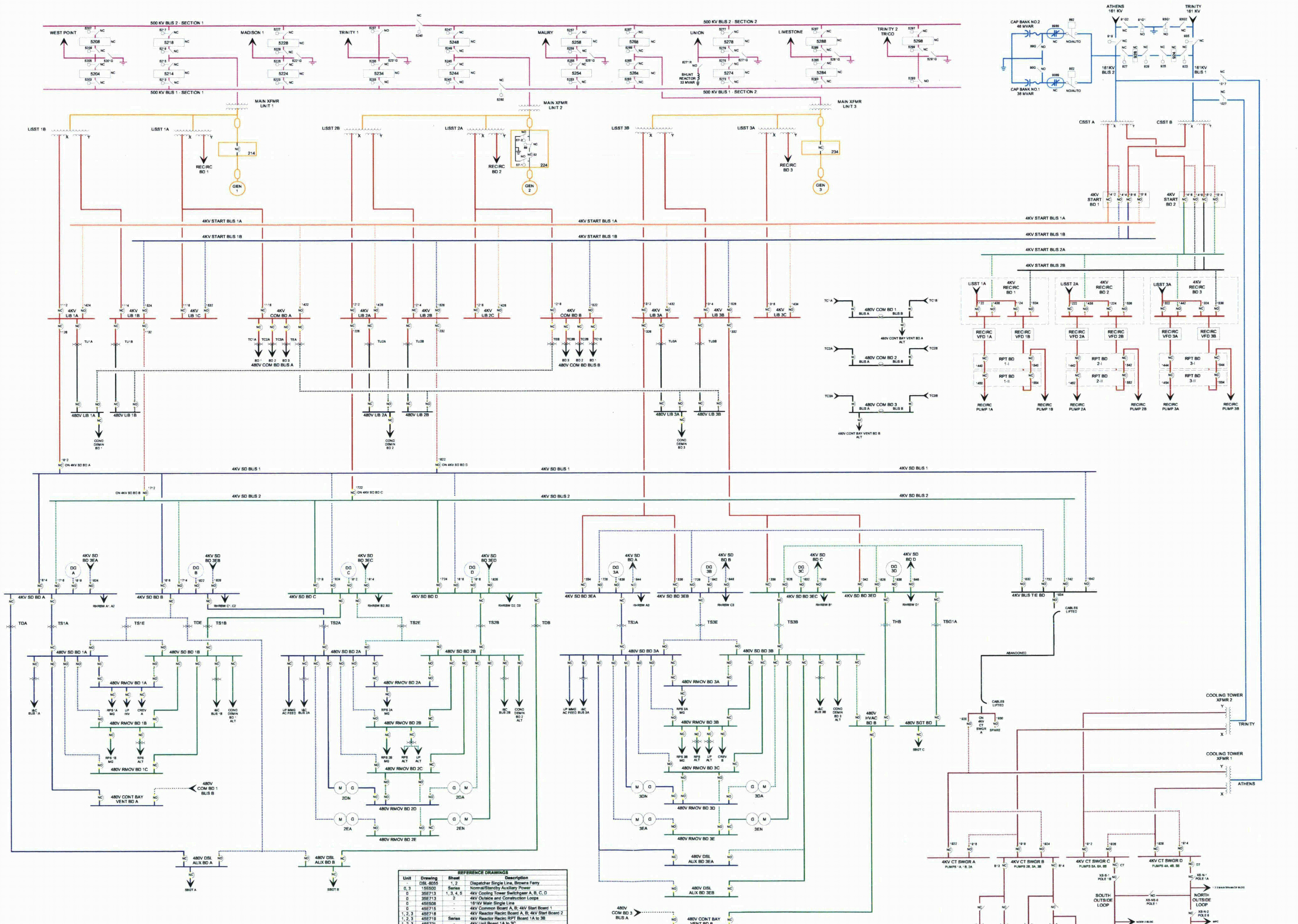
2.e. If a common or single offsite circuit is used to supply redundant ESF buses, explain why a failure, such as a single-phase open circuit or high impedance ground fault condition, would not adversely affect redundant ESF buses.

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

Attachment 1

Simplified One-Line Diagram

(See next page)



REFERENCE DRAWINGS			
Unit	**Drawing**	**Sheet**	**Description**
-	DSL-6055	1, 2	Dispatcher 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

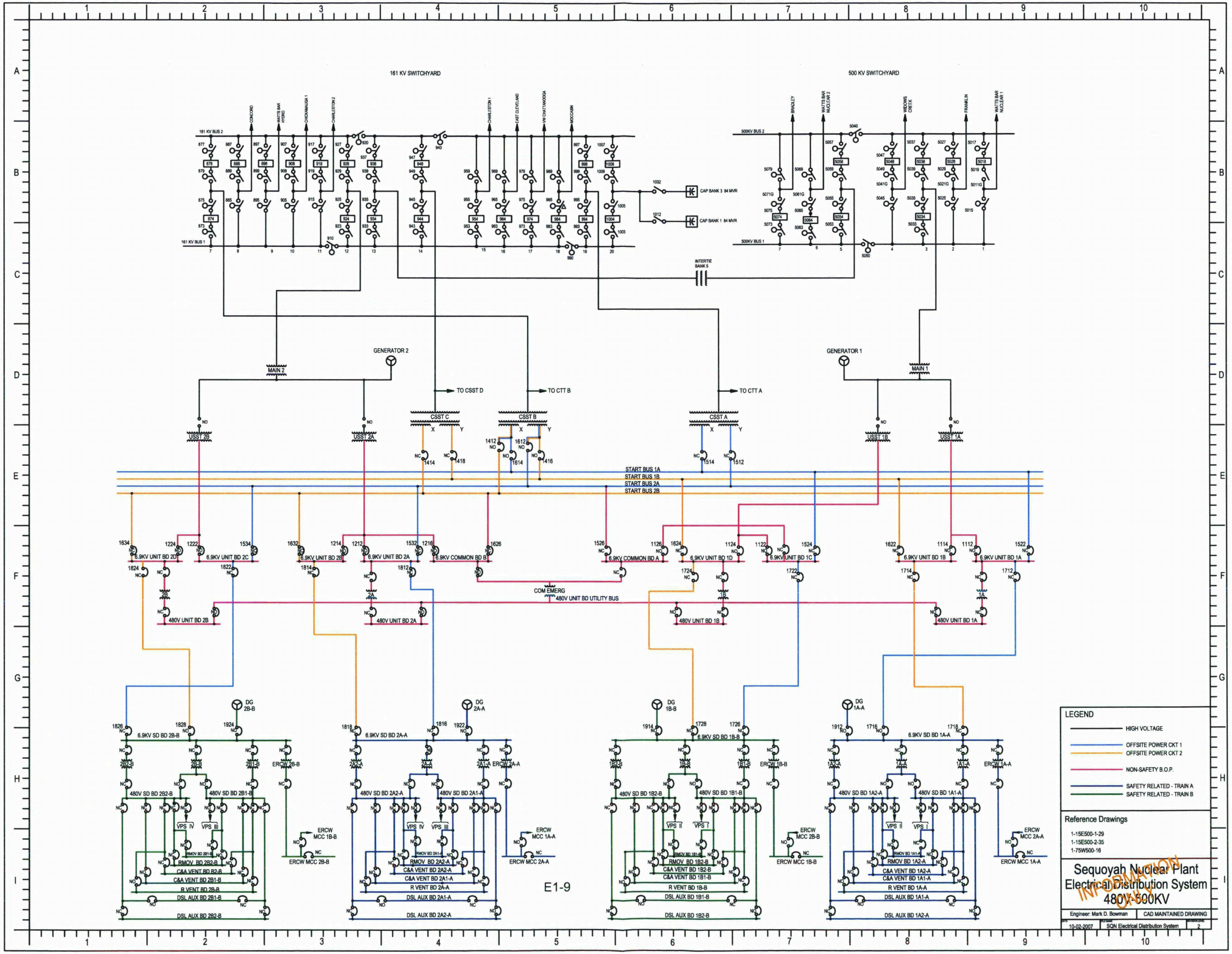
- NORMAL FEED
- ALTERNATE FEED
- 500 KV SYSTEM
- 161 KV SYSTEM
- 22 KV MAIN GENERATOR
- 4KV NON-DIVISIONAL
- 4KV START BUS 1A
- 4KV START BUS 1B OR 4KV & 480V DIV I
- 4KV START BUS 2A OR 4KV & 480V DIV II
- 4KV START BUS 2B OR 480V NON-DIVISIONAL

INFORMATION ONLY

E1-8

AC ELECTRICAL DISTRIBUTION SYSTEM
BROWNS FERRY NUCLEAR PLANT

PIP-02-03 REVISION 09/10/2009


161 KV SWITCHYARD
500 KV SWITCHYARD
GENERATOR 2
GENERATOR 1
MAIN 2
MAIN 1
TO CSST D
TO CTT B
TO CTT A
CSST C
CSST B
CSST A
USST 2B
USST 2A
USST 1B
USST 1A
START BUS 1A
START BUS 1B
START BUS 2A
START BUS 2B
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
COM EMERG
480V UNIT BD UTILITY BUS
480V UNIT BD 2B
480V UNIT BD 2A
480V UNIT BD 1B
480V UNIT BD 1A
DG 2B-B
DG 2A-A
DG 1B-B
DG 1A-A
6.9KV SD BD 2B-B
6.9KV SD BD 2A-A
6.9KV SD BD 1B-B
6.9KV SD BD 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
ERCW MCC 2B-B
ERCW MCC 2A-A
ERCW MCC 1B-B
ERCW MCC 1A-A
DSL AUX BD 2B1-B
DSL AUX BD 2B2-B
DSL AUX BD 2A1-A
DSL AUX BD 2A2-A
DSL AUX BD 1B1-B
DSL AUX BD 1B2-B
DSL AUX BD 1A1-A
DSL AUX BD 1A2-A
E1-9
LEGEND
HIGH VOLTAGE
OFFSITE POWER CKT 1
OFFSITE POWER CKT 2
NON-SAFETY B.O.P.
SAFETY RELATED - TRAIN A
SAFETY RELATED - TRAIN B
Reference Drawings
1-15E500-1-29
1-15E500-2-35
1-75W500-16
Sequoyah Nuclear Plant
Electrical Distribution System
480V-500KV
INFORMATION ONLY
Engineer: Mark D. Bowman
CAD MAINTAINED DRAWING
10-02-2007
SQN Electrical Distribution System
2

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)
Common Station Service Transformer C (CSST C) via Unit Board 1B and Start Bus 1B	Shutdown Board 1A-A	N
Common Station Service Transformer A (CSST A) via Unit Board 1C and Start Bus 1A	Shutdown Board 1B-B	N
Common Station Service Transformer A (CSST A) via Unit Board 2A and Start Bus 2A	Shutdown Board 2A-A	N
Common Station Service Transformer C (CSST C) via Unit Board 2D and Start Bus 2B	Shutdown Board 2B-B	N

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)
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
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")
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
90-Day Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System"

Overview:

- 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
- 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

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 (WBH) switchyard over two separate transmission lines, each connecting to two 161-6.9 kV common station service transformers (CSSTs) at Watts Bar Nuclear Plant (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 Updated Final Safety Analysis Report (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 or a sustained, balanced degraded grid voltage. The relay systems were not specifically designed to detect an open single phase of a three phase system. Detection of a single-open phase condition is beyond the approved design basis of the plant and is not considered to be part of the licensing basis of the plant as reflected in the document specified in item 2.c.

Normal Plant Operation Considerations:

The Class 1E power system is normally supplied from offsite power through CSSTs C and D. An ungrounded open phase on the high side of the CSST (161 kV) is highly unlikely due to the use of overhead transmission lines, preventing a phase from opening without also shorting to ground. Since the overhead transmission lines have sufficient distance between connection points, grounding would be ensured during any line failure (i.e., transmission line lengths are longer than the height of suspension). In the case of a grounded open phase on the high side of the CSST, the voltage on two phases would be reduced. Although the degraded voltage protection scheme at WBN was not designed to detect and automatically respond to a single-phase open circuit condition on a credited off-site power circuit, preliminary studies have shown that the undervoltage protection, specifically the loss of voltage relay, will respond to a grounded single-phase open circuit condition by isolating the affected power source in 0.75 seconds and automatically transferring power to the emergency diesel generator.

In addition to the normal plant configuration, the CSST internal winding configuration includes a buried delta winding and the ESF equipment is ungrounded. The ESF bus and off-site circuit grounding protection has been reviewed with regard to ground faults. Since there is a deliberate ground current path, each medium voltage motor and transformer feeder circuit is protected by ground overcurrent relays which will trip that circuit's feeder breaker. The CSST neutral resistor has an overcurrent relay and a neutral ground relay which will trip the 161 kV breakers which supply that CSST from the 161 kV system. Under normal operating conditions the WBN main generator supplies electrical power through isolated-phase buses to the main step-up transformers and through the unit station service transformers to the non-safety auxiliary power system.

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 a balanced degraded voltage, but were not designed to detect a single phase open circuit condition. 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.

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.

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.

Installed relays were not designed to detect single phase open circuit conditions. Existing loss of voltage and degraded voltage relays may respond depending on load and possible grounds. In general, there will be no plant response for an unloaded power source in the event of a single-phase open circuit on a credited off-site power circuit because there is insufficient current to detect a single-phase open circuit for this configuration. Note: WBN ESF buses are not currently aligned to unit station service transformers.

The plant response for a loaded power source cannot be calculated without specifying the amount of loading and the specific loads involved.

Loading differences for a high impedance ground will have no effect on plant operation. If the ground is sufficiently large (i.e. low impedance ground) to affect plant operation, protective relaying will isolate the ground automatically.

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.

WBN does not credit in the Current Licensing Basis (CLB) document specified in item 2.c that the Class 1E protection scheme (for the ESF buses) was designed to detect and automatically respond to a single-phase open circuit condition or high impedance ground fault condition on the credited off-site power source as described in the UFSAR and Technical Specifications.

Preferred offsite power at WBN is supplied from TVA's 161 kV transmission grid at WBH Plant switchyard over two separate transmission lines, each connecting to two 161 - 6.9 kV common station service transformer (CSSTs) at WBN. See response in "System Description", item 2.

Since WBN does not credit the ESF bus protection scheme as being capable of detecting and automatically responding to a single phase open circuit condition or high impedance ground fault condition, an open phase fault was not included in the design criteria for the loss of voltage, the degraded voltage relay scheme or loss of voltage protection system design criteria. Since open phase detection was not credited in the WBN design or licensing basis of the plant as reflected in the document specified in item 2.c, no design basis calculations or design documents exist that previously considered this condition.

Without formalized engineering calculations or engineering evaluations, the electrical consequences of such an open phase event or high impedance ground fault condition (including plant response), can only be evaluated to the extent of what has already been published by Electric Power Research Institute (EPRI) and Basler; which is a generic overview. The difficulty in applying these documents to the WBN specific response is that these are generic assessments and cannot be formally credited as a basis for an accurate response. The primary reason is that detailed plant specific models would need to be developed (e.g., transformer magnetic circuit models, electric distribution models, motor models; including positive, negative, and zero sequence impedances (voltage and currents), and the models would need to be compiled and analyzed for the WBN specific Class 1E electric distribution system).

While the specific consequences of a single phase open circuit on the credited offsite power circuit have not been determined, preliminary studies have revealed that WBN's transformer configuration, ESF train connection to offsite power supplies and 2 out of 3 undervoltage protection eliminate the possibility of the same consequences for the event that occurred at Byron.

Preliminary results indicate that in the ungrounded open circuit condition, the degraded voltage protection may actuate, causing the effected ESF buses to disconnect from the offsite power source in 10 seconds. However, this cannot be confirmed until the model and critical parameters have been developed and accurate values obtained. TVA recognizes the significance of the consequences of the Byron event and is participating in the ongoing effort to develop parameters, led by the nuclear industry and coordinated with the Nuclear Energy Institute.

Should the open phase condition occur at WBN, only one train of ESF buses would be affected. To enhance reliability, increased operator awareness of the potential consequences (i.e. what happened at Byron) and increased surveillance of off-site power sources are being evaluated.

The effects on ESF equipment, with regard to high impedance grounds while all three phases remain intact, have been evaluated using known electrical engineering theory.

- The effect of a high impedance ground on the primary side of the CSST will have no impact on the ESF system. Zero sequence current will be unable to pass to the secondary side of the transformer due to a buried delta winding inside the transformer. Additionally, the phase to phase voltage differences in the system, due to a high impedance ground, should be unaffected.
- The effect of a high impedance ground on the secondary side of the CSST will have no impact on the ESF system. The medium voltage ESF buses are ungrounded and cannot be affected by any zero sequence current produced by a high impedance ground. Additionally, the phase to phase voltage differences in the system, resulting from a high impedance ground, should be unaffected.

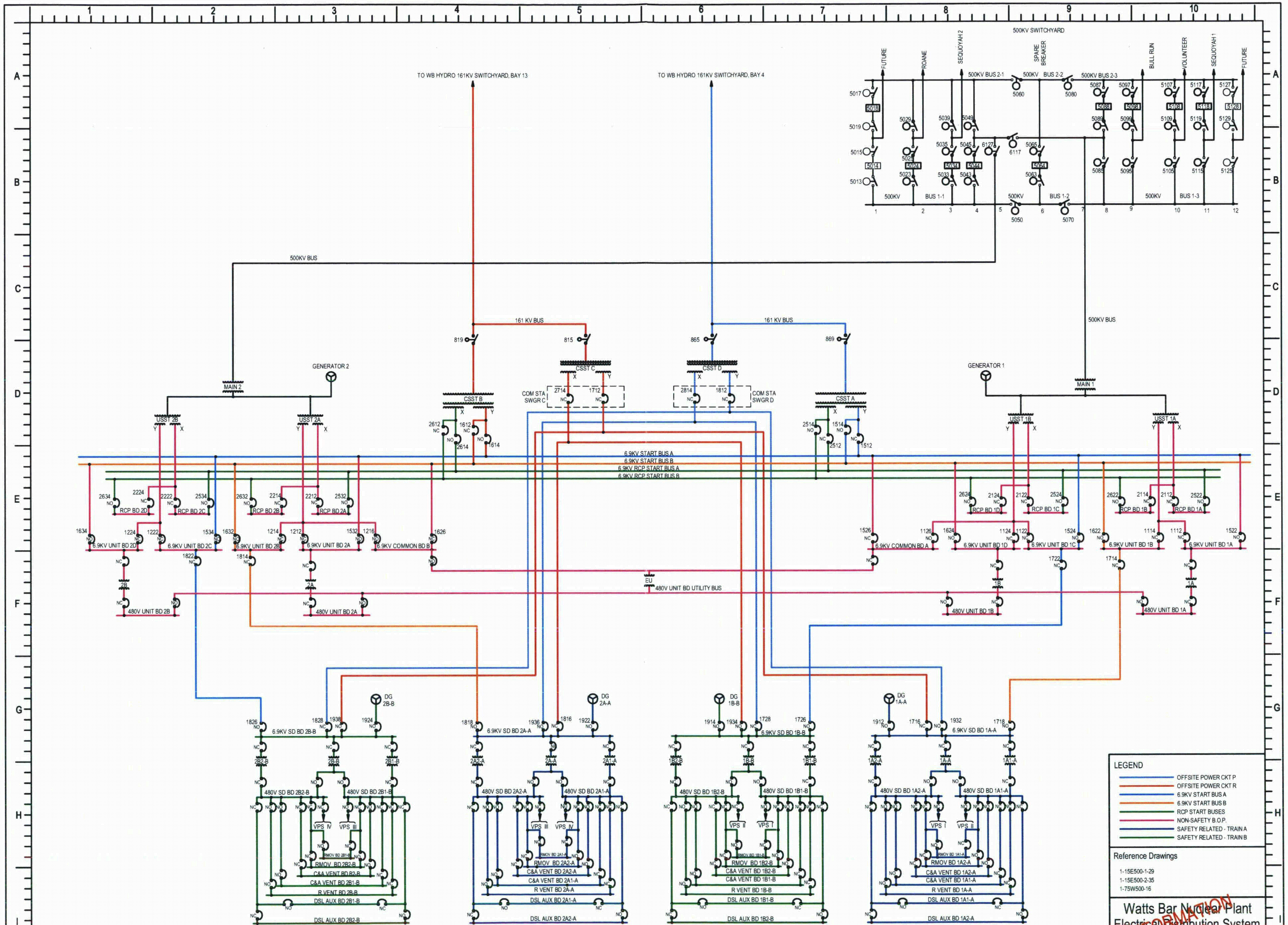
2.e. If a common or single offsite circuit is used to supply redundant ESF buses, explain why a failure, such as a single-phase open circuit or high impedance ground fault condition, would not adversely affect redundant ESF buses.

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

Attachment 1

WBN Simplified One-Line Diagram

(See next page)



500KV SWITCHYARD
FUTURE
ROANE
SEQUOYAH 2
SPARE BREAKER
BULL RUN
VOLUNTEER
SEQUOYAH 1
500KV BUS 2-1
500KV BUS 2-2
500KV BUS 2-3
500KV BUS 1-1
500KV BUS 1-2
500KV BUS 1-3
TO WB HYDRO 161KV SWITCHYARD, BAY 13
TO WB HYDRO 161KV SWITCHYARD, BAY 4
500KV BUS
161 KV BUS
GENERATOR 2
GENERATOR 1
MAIN 2
MAIN 1
CSST A
CSST B
CSST C
CSST D
COM STA SWGR C
COM STA SWGR D
USST 2A
USST 2B
USST 1A
USST 1B
6.9KV START BUS A
6.9KV START BUS B
6.9KV RCP START BUS A
6.9KV RCP START BUS B
RCP BD 2A
RCP BD 2B
RCP BD 2C
RCP BD 2D
RCP BD 1A
RCP BD 1B
RCP BD 1C
RCP BD 1D
6.9KV UNIT BD 2A
6.9KV UNIT BD 2B
6.9KV UNIT BD 2C
6.9KV UNIT BD 2D
6.9KV UNIT BD 1A
6.9KV UNIT BD 1B
6.9KV UNIT BD 1C
6.9KV UNIT BD 1D
6.9KV COMMON BD A
6.9KV COMMON BD B
480V UNIT BD UTILITY BUS
480V UNIT BD 2A
480V UNIT BD 2B
480V UNIT BD 1A
480V UNIT BD 1B
DG 2B-B
DG 2A-A
DG 1B-B
DG 1A-A
6.9KV SD BD 2B-B
6.9KV SD BD 2A-A
6.9KV SD BD 1B-B
6.9KV SD BD 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 2B2-B
RMOV BD 2A2-A
RMOV BD 1B2-B
RMOV BD 1A2-A
C&A VENT BD 2B2-B
C&A VENT BD 2B1-B
C&A VENT BD 2A2-A
C&A VENT BD 2A1-A
C&A VENT BD 1B2-B
C&A VENT BD 1B1-B
C&A VENT BD 1A2-A
C&A VENT BD 1A1-A
R VENT BD 2B-B
R VENT BD 2A-A
R VENT BD 1B-B
R VENT BD 1A-A
DSL AUX BD 2B1-B
DSL AUX BD 2B2-B
DSL AUX BD 2A1-A
DSL AUX BD 2A2-A
DSL AUX BD 1B1-B
DSL AUX BD 1B2-B
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
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
10-02-2007
WBN Electrical Distribution System
0

E1-9

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)
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")
CSST C or CSST D	Transformer Neutral Ground Relay	N/A	240A	To provide protection for the neutral resistor for the 10 second rating.