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SOUTHERN COMPANY

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U. S. Nuclear Regulatory Commission
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Bulletin 2012 – 01 Response for
Edwin I. Hatch Nuclear Plant Units 1 and 2 (HNP)
Joseph M. Farley Nuclear Plant Units 1 and 2 (FNP)
Vogtle Electric Generating Plant Units 1 and 2 (VEGP)

Ladies and Gentlemen:

On July 27, 2012, the NRC issued Bulletin 2012 – 01, "Design Vulnerability in Electric Power System," (referred herein as the Bulletin). The Bulletin requires that Southern Nuclear Operating Company (SNC) submit written responses within 90 days of the Bulletin.

The Bulletin was issued to:

1. Notify the addressees that the NRC staff is requesting information about the facilities' electric power system designs, in light of the recent operating experience that involved the loss of one of the three phases of the offsite power circuit (single-phase open circuit condition) at Byron Station, Unit 2, to determine if further regulatory action is warranted.

2. Require that the addressees comprehensively verify their compliance with the regulatory requirements of General Design Criterion (GDC) 17, "Electric Power Systems," in Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 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).

3. Require that addressees respond to the NRC in writing, in accordance with 10 CFR 50.54(f).

Enclosures 1, 2 and 3 provide SNC's 90-day responses to the Bulletin for Edwin I. Hatch Nuclear Plant, Joseph M. Farley Nuclear Plant, and Vogtle Electric Generating Plant Units 1 and 2, respectively, and is being submitted in accordance with 10 CFR 50.54(f).

Enclosure 4 contains additional information used to draw some preliminary conclusions about the effects and detection capabilities with regard to open phase and high impedance ground conditions for the SNC fleet. This letter contains no NRC commitments. If you have any questions, please contact Ken McElroy at (205) 992-7369.

Respectfully submitted,

Mark J Ajluni

M. J. Ajluni
Nuclear Licensing Director

Sworn to and subscribed before me this 25th *day of* October, *2012.*

Laura L Crush
Notary Public

My commission expires: 11-2-2013

MJA/SYA/lac

Enclosures:
1. HNP Response to Bulletin 2012 – 01
2. FNP Response to Bulletin 2012 – 01
3. VEGP (Units 1 and 2) Response to Bulletin 2012 – 01
4. Preliminary Determination of Effects and Consequences for Open-Phase and High Impedance Fault Conditions

cc: Southern Nuclear Operating Company
Mr. S. E. Kuczynski, Chairman, President & CEO
Mr. D. G. Bost, Executive Vice President & Chief Nuclear Officer
Mr. T. A. Lynch, Vice President - Farley
Mr. D. R. Madison, Vice President – Hatch
Mr. T. E. Tynan, Vice President – Vogtle
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RType: CFA04.054;CHA02.004;CVC7000

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Bulletin 2012 – 01 Response for
Edwin I. Hatch Nuclear Plant Units 1 and 2 (HNP)
Joseph M. Farley Nuclear Plant Units 1 and 2 (FNP)
Vogtle Electric Generating Plant Units 1 and 2 (VEGP)

Enclosure 1

HNP Response to Bulletin 2012 – 01

Enclosure 1
HNP Response to Bulletin 2012 – 01

Table of Contents

1. 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 230kV system provides offsite power to one three-winding and one two-winding Startup Auxiliary Transformer (SAT) for each unit. These are:

- For Unit 1,
  - SAT 1D which normally feeds (from one secondary winding) division 1 safety related loads from 4.16kV Bus 1E and the second winding feeds division 1 and 2 safety related loads from 4.16kV Bus 1F and 4.16KV bus 1G. During normal plant operation, 4.16kV non-safety related buses 1C and 1D are not supplied by SAT 1D unless unit auxiliary transformer 1A is unavailable.

  - SAT 1C is a two winding transformer and is the alternate supply for non-safety related buses 1A and 1B. It is also the alternate supply for safety related buses 1E, 1F and 1G. During normal plant operations, buses 1A and 1B are supplied from unit auxiliary transformer 1B.

- For Unit 2,
  - SAT 2D which normally feeds (from one secondary winding) division 1 safety related loads from 4.16kV Bus 2E and the second winding feeds division 1 and 2 safety related loads from 4.16kV Bus 2F and 4.16KV bus 2G. During normal plant operation, 4.16kV non-safety related buses 2C and 2D are not supplied by SAT 2D unless unit auxiliary transformer 2A is unavailable.

  - SAT 1C is a two winding transformer and is the alternate supply for non- safety related buses 2A and 2B. It is also the alternate supply for safety related buses 2E, 2F and 2G. During normal plant operations, buses 2A and 2B are supplied from unit auxiliary transformer 2B.

The main generator (24kV) for each unit normally provides power to one three-winding and one two-winding Unit Auxiliary Transformers (UAT) for that unit. These are:

- For Unit 1,
  - UAT 1A is a three winding transformer which feeds non-safety related loads from 4.16kV Buses 1C and 1D.

- UAT 1B is a two winding transformer which normally feeds non-safety related loads from 4.16kV Buses 1A and 1B.

- For Unit 2,
  - UAT 2A is a three winding transformer which feeds non-safety related loads from 4.16kV Buses 2C and 2D.

  - UAT 2B is a two winding transformer which normally feeds non-safety related loads from 4.16kV Buses 2A and 2B.

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

See Attachment 2, Table 4 for SAT 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.

For at power (normal operating condition) configurations, all engineered safety feature (ESF) buses are powered by offsite sources. See Attachment 2, Tables 1 and 2 for ESF bus power sources.

See Attachment 2, Table 3 for ESF bus major loads energized during normal power operations, including their ratings. For further information, see Updated Final Safety Analysis Report (UFSAR) Revision 30 Table 8.3 -1.

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 four SATs, two for each unit (1C and 1D for Unit 1, 2C and 2D for Unit 2), are connected to the Georgia Power Company (GPC) transmission system through separate 230-kV cables with SAT 1C and 2C sharing a common connection. These transformers provide a source of power for startup, shutdown, and after-shutdown requirements for both units. The SATs are capable of supplying power to non-safety related 4.16-kV buses A, B, C and D as well as safety related 4.16-kV emergency buses E, F, and G. During normal operations, 4.16-kV buses E, F, and G for Unit 1 or Unit 2, are powered from the startup auxiliary transformers 1D and 2D, while non-safety related 4kV buses A, B, C, and D are powered from unit auxiliary transformers.

The Class 1E AC system is divided into redundant (separation and independence) load groups so that loss of any one group will not prevent the minimum safety functions from being performed.

Refer to HNP (Revision 30) Unit 2 UFSAR sections 8.1.2, 8.1.4, 8.2.1, 8.3.1.1.1, 8.3.1.2, and Figure 8.3-1 for further information. Unit 1 and 2 UFSAR sections are similar.

The following at power (normal operating condition) configurations have been confirmed to be consistent with the current licensing basis:

1. Unit 1 Offsite Source #1 - Alternate Power to U1 ESF Divisions 1 and 2 buses via 230kV switchyard (SAT 1C)
2. Unit 1 Offsite Source #2 - Power to U1 ESF Division 1 and 2 buses via 230kV switchyard (SAT 1D)
3. Unit 2 Offsite Source #1 - Alternate Power to U2 ESF Divisions 1 and 2 buses via 230kV switchyard (SAT 2C)
4. Unit 2 Offsite Source #2 - Power to U2 ESF Divisions 1 and 2 buses via 230kV switchyard (SAT 2D)

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

2. <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. Also, include the following information:

Consistent with the current licensing basis and GDC 17, the existing protective circuitry was not specifically designed to detect a single open phase of a three phase system. Detection of a single open phase condition is beyond the approved design and licensing basis of the plant.

Although the degraded voltage protection scheme at HNP was not specifically designed to detect and automatically respond to a single open-phase condition on each credited off-site power circuit, preliminary analysis has indicated that existing protective circuitry (as noted in Enclosure 4, Section 2, Table 1) may respond to an open phase or high impedance ground fault condition under certain circumstances by isolating the affected power source/automatically and transferring power to an alternate supply (i.e. standby diesel generator).

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 and General Design Criteria (GDC) 17, existing electrical protective devices are sufficiently sensitive to detect design basis conditions like a loss of voltage or a degraded voltage, but were not specifically designed to detect a single phase open circuit condition.

As noted in Enclosure 4 Section 2, the plant's existing protective devices will automatically protect for some of these conditions. See Attachment 2, Table 5 for undervoltage and other protective 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 HNP 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?

The current plant operating procedures, including operating procedures for off-normal alignments, specifically call for verification of the voltages on all three phases of the ESF buses. Plant procedures require 4kV and 600V ESF phase voltages (phase 1-2, 2-3, and 1-3) to be verified every 7 days.

3. 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 (without ground fault) on a credited off-site power circuit because there are insufficient effects (i.e. current or voltage) to detect a single-phase open circuit for this configuration. For HNP, SAT C is unloaded for Units 1 and 2 during normal plant operation.

The plant response for a loaded power source cannot be calculated without specifying the amount of loading and the specific loads involved. The effects and consequences provided in this document assume normal unit operation and bus configurations.

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.

A high impedance ground will have no immediate effect on plant operation. If the ground current is sufficiently large to affect plant operation, protective relaying will isolate the ground automatically.

1. HNP did not consider in the Current Licensing Basis (CLB) that the Class 1E protection scheme (for the engineered safety feature (ESF) buses) was designed to detect and automatically respond to a single open-phase condition on the credited off–site power source as described in the UFSAR and Technical Specifications.

   The offsite power circuits for each HNP unit consists of two independent circuits with one to each SAT and then to the ESF Class 1E buses. Refer to HNP-2 Revision 30 UFSAR sections 8.1.4 and 8.2.1 and Technical Specification sections 3.8.1 for further information.

2. Since HNP did not consider the ESF bus protection scheme as being capable of detecting and automatically responding to a single open-phase condition, a high impedance ground fault, with or without an open phase condition, was not included in the design criteria for either the loss of voltage or the degraded voltage relay (DVR) scheme design criteria. Since open phase detection was not considered in the HNP design or licensing basis, no design basis calculations or design documents exist that previously considered this condition.

3. Without formalized engineering calculations or engineering evaluations, the electrical consequences of an open phase event or a high impedance fault (including plant by response) can only be evaluated by review of data published by EPRI and Basler, and SNC's own preliminary analysis. All of the data is generic in nature but can provide some indications of the effects to be expected. The difficulty in applying these documents to the HNP specific response is that these are generic assessments and cannot be formally credited as a basis for a precise 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). The models would need to be compiled and analyzed for the HNP specific Class 1E electric distribution system (EDS). A detailed model of a FNP transformer similar in design, capacity, and application along with HNP specific protective relaying design

information has been used to draw some preliminary conclusions about the effects and detection capabilities (refer to Enclosure 4, Section 2).

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.

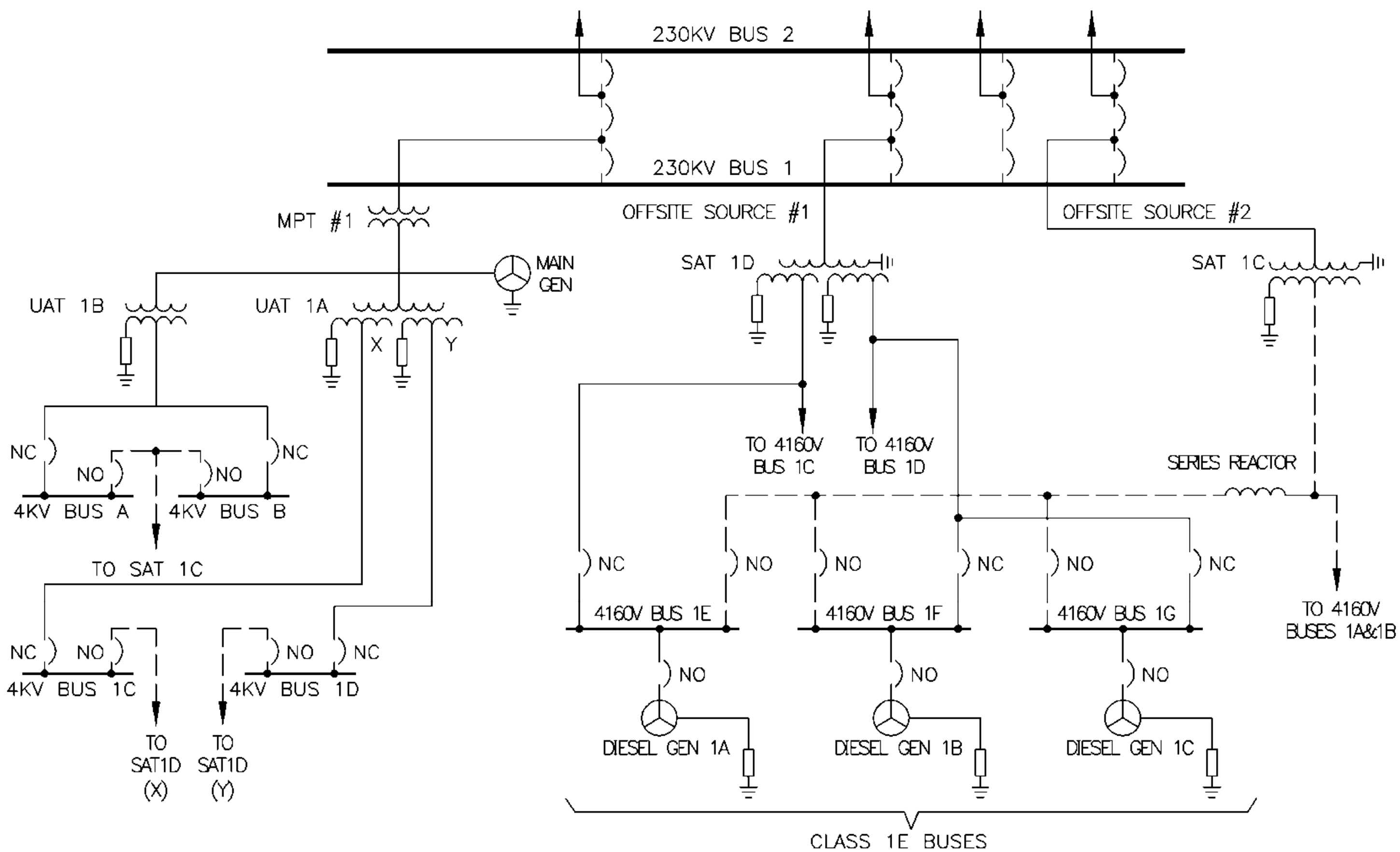
Consistent with the Current Licensing Basis and GDC 17, protective circuitry will separate the ESF buses from a failed offsite source due to a loss of voltage or a sustained balanced degraded grid voltage concurrent with certain design basis accidents. The relay systems were not specifically designed to detect a single open phase of a three phase system. Detection of a single-open phase circuit is beyond the approved design and licensing basis of the plant. No calculations for this scenario have been done.

Consistent with the current station design, protective circuitry will protect from a ground fault condition with all three phases intact.

For high impedance ground faults with no open phase condition, adequate protection is provided and negative sequence currents are minimal (refer to Enclosure 4, Section 2). Due to the nature of the transformer's response during lightly loaded conditions, an open phase condition may go undetected by existing plant protection and there are substantial negative sequence currents (refer to Attachment 4, Section 2, Items G and H). Plant operators have guidance to help promptly diagnose and respond to single open phase conditions.

Attachment 1 of Enclosure 1 - Figure

Simplified One-Line Diagram Plant Hatch Unit 1 (Unit 2 is similar)



Attachment 2 of Enclosure 1- 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)
SAT 1C	Unloaded	Y
SAT 1D	1E, 1F, 1G	Y
SAT 2C	Unloaded	Y
SAT 2D	2E, 2F, 2G	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

ESF Bus	Load	Voltage Level	Rating (HP)
1E	Plant Service Water Pump 1A	4000	700
1F	Plant Service Water Pump 1C or 1D	4000	700
1G	Plant Service Water 1B	4000	700
1E	RHR Service Water 1A	4000	1250
1G	RHR Service Water 1B	4000	1250
1F	RHR Service Water 1C	4000	1250

Note: The table above is typical HNP Units 1 and 2

Table 4 - Offsite Power Transformers

Transformer	Winding Configuration	MVA Size (OA/FOA/FOA)	Voltage Rating (Primary/Secondary)	Grounding Configuration
SAT 1C	Wye-Wye w/Buried Delta Tertiary	15/20/25 @ 55°C rise	H-X 230kV/4.16kV	H – Neutral, Solidly Grounded X – Neutral, Resistance Grounded
SAT 1D	Wye-Wye-Wye w/Buried Delta Tertiary	18/24/30 @ 55°C rise	X - 230kV/4.16kV Y - 230kV/4.16kV	H – Neutral, Solidly Grounded X – Neutral, Resistance Grounded Y – Neutral, Resistance Grounded
SAT 2C	Wye-Wye w/Buried Delta Tertiary	15/20/25 @ 55°C rise	H-X 230kV/4.16kV	H – Neutral, Solidly Grounded X – Neutral, Resistance Grounded
SAT 2D	Wye-Wye-Wye w/Buried Delta Tertiary	18/24/30 @ 55°C rise	X - 230kV/4.16kV Y - 230kV/4.16kV	H – Neutral, Solidly Grounded X – Neutral, Resistance Grounded Y – Neutral, Resistance Grounded

Table 5 - Protective Devices

Protection Zone	Protective Device	Logic	Setpoint (Nominal)	Basis for Setpoint
4 KV Bus 1E	Loss of Voltage Relay	2 of 2	>2800V (at <6.5 sec)	To trip ESF bus upon complete loss of bus voltage.
4 KV Bus 1E	Degraded Grid Relay	2 of 2	>3280V (at <21.5 sec)	To trip ESF bus upon a degraded grid voltage condition.
4 KV Bus 1E	Degraded Grid Alarm	2 of 2	>3825V (at < 65 sec)	To alarm when ESF bus voltage is below the minimum expected.
SAT 1D	X Winding Neutral Ground Relays	1 of 2	480A	To actuate on excessive current in the transformer low side X winding neutral ground connection.
SAT 1D	Y Winding Neutral Ground Relays	1 of 2	480A	To actuate on excessive current in the transformer low side Y winding neutral ground connection.
SAT 1D	H.S. Overcurrent Relay	1 of 3	120A	To actuate on excessive current in the transformer high side windings (1 per phase).
SAT 1D	L.S. Transformer Differential Relay	1 of 3	867A	To actuate on excessive current imbalance between the transformer high side winding and Buses 1E, 1F and 1G (1 per phase).
SAT 1D	Swyd Bus Differential Relay	1 of 3	60A	To actuate on excessive current in the SAT 1D switchyard feeder.

Note: The table above is typical for each of the four offsite circuits (SAT 1C, 1D, 2C and 2D).
Degraded and loss of voltage relay setpoints were obtained from HNP-1 Technical Specifications.

Bulletin 2012 – 01 Response for
Edwin I. Hatch Nuclear Plant Units 1 and 2 (HNP)
Joseph M. Farley Nuclear Plant Units 1 and 2 (FNP)
Vogtle Electric Generating Plant Units 1 and 2 (VEGP)

Enclosure 2

FNP Response to Bulletin 2012 – 01

Enclosure 2
FNP Response to Bulletin 2012 – 01

Table of Contents

1.0 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 230kV system provides offsite power to two three-winding Startup Auxiliary Transformers (SAT) for each unit. These are:

- For Unit 1,
  - SAT 1A which normally feeds (from one secondary winding) A-Train safety related loads from 4.16kV Bus 1F and non-safety related loads from 4.16kV Bus 1D. A second winding feeds non-safety related loads from 4.16kV Bus 1A when Unit Auxiliary Transformers (UAT) 1B is unavailable.

  - SAT 1B which normally feeds (from one secondary winding) B-Train safety related loads from 4.16kV Bus 1G and non-safety related loads from 4.16kV Bus 1E. A second winding feeds non-safety related loads from 4.16kV Buses 1B and 1C when UAT 1B is unavailable.

- For Unit 2,
  - SAT 2A which normally feeds (from one secondary winding) A-Train safety related loads from 4.16kV Bus 2F and non-safety related loads from 4.16kV Bus 2D. A second winding feeds non-safety related loads from 4.16kV Buses 2B and 2C when UAT 2B is unavailable.

  - SAT 2B which normally feeds (from one secondary winding) B-Train safety related loads from 4.16kV Bus 2G and non-safety related loads from 4.16kV Bus 2E. A second winding is capable of feeding non-safety related loads from 4.16kV Bus 2A when UAT 2B is unavailable.

The main generator (22kV) for each unit normally provides power to two three-winding UAT for that unit. These are:

- For Unit 1,
  - UAT 1A which can feed non-safety related loads from 4.16kV Buses 1D and 1E, but does not normally do so.

- UAT 1B which normally feeds non-safety related loads from 4.16kV Buses 1A, 1B and 1C. UAT 1B is currently out of service until a replacement is installed.

- For Unit 2,
  - UAT 2A which can feed non-safety related loads from 4.16kV Buses 2D and 2E, but does not normally do so.
  - UAT 2B which normally feeds non-safety related loads from 4.16kV Buses 2A, 2B and 2C.

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

See Attachment 2, Table 4 for SAT 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.

For at power (normal operating condition) configurations, all engineered safety feature (ESF) buses are powered by offsite sources. See Attachment 2, Tables 1 and 2 for ESF bus power sources.

See Attachment 2, Table 3 for ESF bus major loads energized during normal power operations, including their ratings. For further information, see Updated Final Safety Analysis Report (UFSAR) Revision 24 Table 8.1-1.

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 four SATs, two for each unit (1A and 1B for Unit 1, 2A and 2B for Unit 2), are connected to the Alabama Power Company (APC) transmission system through four separate 230-kV oil-static cables. These transformers provide a source of power for startup, shutdown, and after-shutdown requirements for both units. The SATs are capable of supplying power to non-safety related 4.16-kV buses A, B, C, D, and E as well as safety related 4.16-kV emergency buses F, G, H, J, K, and L. During normal operations, 4.16-kV buses A, B, C, D, and E for Unit 1 and D and E for Unit 2, along with the 4.16-kV emergency buses F, G, H, J, K, and L of each unit, are powered from the startup auxiliary transformers.

Complete separation and independence has been maintained between the two train systems so that any single failure in one train will not prevent the other train from performing its required safety function.

Refer to UFSAR (Rev. 24) sections 8.1.2, 8.2.1.3, 8.2.1.4, 8.3.1.1.1, 8.3.1.2, and Figure 8.2-1 for further information.

The following at power (normal operating condition) configurations have been confirmed to be consistent with the current licensing basis:

1. Unit 1 Offsite Source #1 - Power to U1 ESF Train A buses via 230kV switchyard (SAT 1A)
2. Unit 1 Offsite Source #2 - Power to U1 ESF Train B buses via 230kV switchyard (SAT 1B)
3. Unit 2 Offsite Source #1 - Power to U2 ESF Train A buses via 230kV switchyard (SAT 2A)
4. Unit 2 Offsite Source #2 - Power to U2 ESF Train B buses via 230kV switchyard (SAT 2B)

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

2.0 <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. Also, include the following information:

Consistent with the Current Licensing Basis and General Design Criteria (GDC) 17, the existing protective circuitry was not specifically designed to detect a single open phase of a three phase system. Detection of a single open–phase condition is beyond the approved design and licensing basis of the plant.

Although the degraded voltage protection scheme at FNP was not specifically designed to detect and automatically respond to a single open-phase condition on each credited off-site power circuit, preliminary analysis has indicated that existing protective circuitry (as noted in Enclosure 4, Section 3, Table 1) will respond to an open phase or high impedance ground fault condition under certain circumstances by isolating the affected power source automatically and transferring power to an alternate supply (i.e. standby diesel generator).

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 and GDC 17, existing electrical protective devices are sufficiently sensitive to detect design basis conditions like a loss of voltage or a degraded voltage, but were not specifically designed to detect a single open–phase condition.

As noted in Enclosure 4, Section 3, the plant's existing protective devices will automatically detect some of these conditions. See Attachment 2, Table 5 for undervoltage and other protective 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 FNP 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?

The current plant operating procedures, including operating procedures for off-normal alignments, specifically call for verification of the voltages on all three phases of the ESF buses. Surveillance is provided by readings of three phase-to-phase PT connections (A-B, B-C, C-A). This surveillance is performed by the plant operators twice each shift.

3.0 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 open–phase 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 open–phase (without ground fault) on a credited off-site power circuit because there are insufficient effects (i.e. current or voltage) to detect a single open–phase for this configuration. For FNP, all SATs are normally loaded at > 35% while the unit is operating.

The plant response for a loaded power source cannot be determined without specifying the amount of loading and the specific loads involved. The effects and consequences provided in this document assume normal (at power) unit operation and bus configurations.

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.

A high impedance ground is not expected to have an immediate effect on plant operation. If the ground current is sufficiently large to affect plant operation, protective relaying will isolate the ground automatically.

1. In the Current Licensing Basis (CLB), FNP did not consider that the Class 1E protection scheme (for the engineered safety feature (ESF) buses) was designed to detect and automatically respond to a single-open-phase condition on the credited off-site power sources described in the FSAR and Technical Specifications.

   The offsite power circuits for each FNP unit consists of two independent circuits with one to each SAT and then to its related ESF Class 1E bus. Refer to UFSAR (Rev. 24) section 8.2.1 and Technical Specification (Amend 188/183) sections 3.8.1 for further information.

2. Since FNP did not consider the ESF bus protection scheme as being capable of detecting and automatically responding to a single open–phase condition, a high impedance ground fault, with or without an open phase condition, was not included in the design criteria for either the loss of voltage, or the degraded voltage relay (DVR) scheme design criteria. Since open phase detection was not considered in the FNP design or licensing basis, no design basis calculations or design documents exist that previously considered this condition.

3. Without formalized engineering calculations or engineering evaluations, the electrical consequences of an open phase event or a high impedance fault (including plant response) can only be evaluated by review of data published by EPRI and Basler, and SNC's own preliminary analysis. All of the data is generic in nature but can provide some indications of the effects to be expected. The difficulty in applying these documents to the FNP specific response is that these are generic assessments and cannot be formally credited as a basis for a precise 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). The models would need to be compiled and analyzed for the FNP specific Class 1E electric distribution system (EDS). A detailed model of a FNP transformer similar in design, capacity, and application along with FNP specific protective relaying design information has been used to

draw some preliminary conclusions about the effects and detection capabilities (refer to Enclosure 4, Section 3).

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 FNP does not normally use a common or single offsite circuit to supply redundant ESF busses.

Figure 1 – Simplified One–Line Diagram FNP Unit 1 (Typical of each Unit)

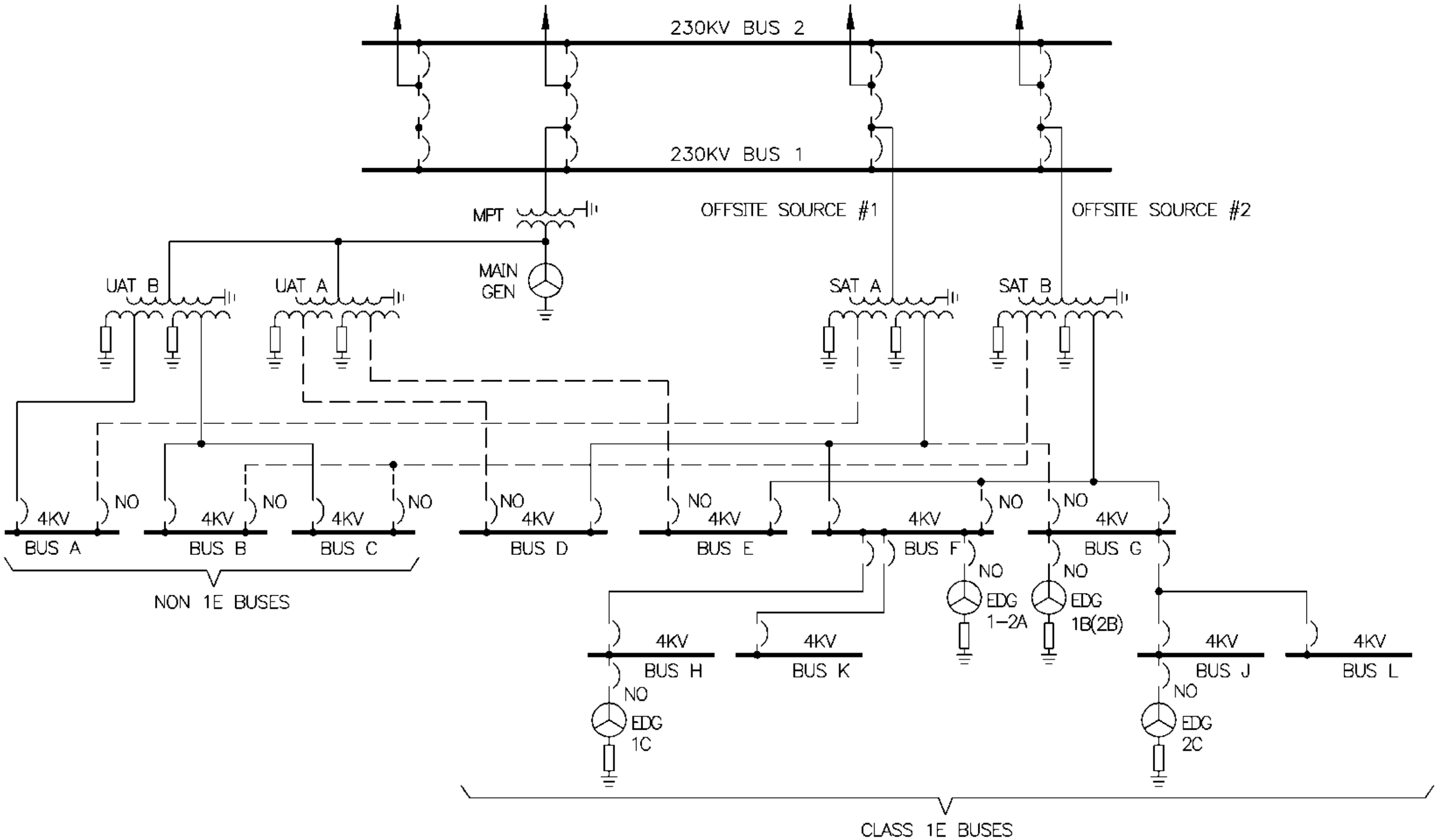


Table 1 - ESF Buses Continuously Powered From Offsite Power Source(s)

Description of ESF Bus Power Source	**ESF Bus Name (normal operating condition).**	**Original licensing basis configuration (Y/N)**
SAT 1A	1F, 1H, 1K	Y
SAT 1B	1G, 1J, 1L	Y
SAT 2A	2F, 2H, 2K	Y
SAT 2B	2G, 2J, 2L	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

ESF Bus	Load	Voltage Level	Rating (HP)
1F	Component Cooling Water Pump 1C	4000	450
1F	Charging/H.H. Safety Injection Pump 1A	4000	900
1H	River Water Pump # 8 (non-ESF load)	4000	600
1H	River Water Pump # 9 (non-ESF load)	4000	600
1K	Service Water Pump 1A	4000	600
1K	Service Water Pump 1B	4000	600
1G	Component Cooling Water Pump 1A	4000	450
1G	Charging/H.H. Safety Injection Pump 1C	4000	900
1J	River Water Pump # 4 (non-ESF load)	4000	600
1J	River Water Pump # 5 (non-ESF load)	4000	600
1L	Service Water Pump 1D	4000	600
1L	Service Water Pump 1E	4000	600
2F	Component Cooling Water Pump 2C	4000	450
2F	Charging/H.H. Safety Injection Pump 2A	4000	900
2H	River Water Pump # 6 (non-ESF load)	4000	600
2H	River Water Pump # 7 (non-ESF load)	4000	600
2K	Service Water Pump 2A	4000	600
2K	Service Water Pump 2B	4000	600
2G	Component Cooling Water Pump 2A	4000	450
2G	Charging/H.H. Safety Injection Pump 2C	4000	900
2J	River Water Pump # 1 (non-ESF load)	4000	600
2J	River Water Pump # 2 (non-ESF load)	4000	600
2L	Service Water Pump 2D	4000	600
2L	Service Water Pump 2E	4000	600

Table 4 - Offsite Power Transformers

Transformer	Winding Configuration	MVA Size (OA/FOA/FOA)	Voltage Rating (Primary/Secondary)	Grounding Configuration
SAT 1A	Wye-Wye-Wye w/Buried Delta Tertiary	26/34.6/43.2 @ 55°C rise	X - 230kV/4.16kV Y - 230kV/4.16kV	H – Neutral, Solidly Grounded X – Neutral, Resistance Grounded Y – Neutral, Resistance Grounded
SAT 1B	Wye-Wye-Wye w/Buried Delta Tertiary	26/34.6/43.2 @ 55°C rise	X - 230kV/4.16kV Y - 230kV/4.16kV	H – Neutral, Solidly Grounded X – Neutral, Resistance Grounded Y – Neutral, Resistance Grounded
SAT 2A	Wye-Wye-Wye w/Buried Delta Tertiary	26/34.6/43.2 @ 55°C rise	X - 230kV/4.16kV Y - 230kV/4.16kV	H – Neutral, Solidly Grounded X – Neutral, Resistance Grounded Y – Neutral, Resistance Grounded
SAT 2B	Wye-Wye-Wye w/Buried Delta Tertiary	26/34.6/43.2 @ 55°C rise	X - 230kV/4.16kV Y - 230kV/4.16kV	H – Neutral, Solidly Grounded X – Neutral, Resistance Grounded Y – Neutral, Resistance Grounded

Table 5 - Protective Devices

Protection Zone	Protective Device	Logic	Setpoint (Nominal)	Basis for Setpoint
4 KV Bus 1F	Loss of Voltage Relay	2 of 3	3255V (78.25% of 4160V)	To trip ESF bus upon complete loss of bus voltage.
4 KV Bus 1F	Degraded Grid Relay	2 of 3	3675V (88.34% of 4160V)	To trip ESF bus upon a degraded grid voltage condition.
4 KV Bus 1F	Degraded Grid Alarm	1 of 1	3850V (92.55% of 4160V)	To alarm when ESF bus voltage is below the minimum expected.
SAT 1A	Swyd. H.S. Overcurrent Relay	1 of 3	1600A Phase Current	To actuate on excessive current in the transformer high side windings (1 per phase).
SAT 1A	Xfmr. H.S. Overcurrent Relay	1 of 3	160A Phase Current	To actuate on excessive current in the transformer high side windings (1 per phase).
SAT 1A	H.S. Neutral Ground Relay	1 of 1	60A Ground Current	To actuate on excessive current in the transformer high side winding ground connection.
SAT 1A	X Winding Neutral Ground Relays	1 of 2	80A Ground Current	To actuate on excessive current in the transformer low side X winding ground connection.
SAT 1A	Y Winding Neutral Ground Relays	1 of 2	80A Ground Current	To actuate on excessive current in the transformer low side Y winding ground connection.
SAT 1A	Transformer Differential Relay	1 of 3	4.6 A, 25% Slope Phase Imbalance	To actuate on excessive current imbalance between the transformer high side winding and Buses 1A, 1D and 1F (1 per phase).

Note: The table above is typical for each of the four offsite circuits (i.e. SAT 1A, 1B, 2A and 2B).

Bulletin 2012 – 01 Response for
Edwin I. Hatch Nuclear Plant Units 1 and 2 (HNP)
Joseph M. Farley Nuclear Plant Units 1 and 2 (FNP)
Vogtle Electric Generating Plant Units 1 and 2 (VEGP)

Enclosure 3

VEGP (Units 1 and 2) Response to Bulletin 2012 – 01

Enclosure 3
VEGP Response to Bulletin 2012 – 01

Table of Contents

1. 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 230kV system provides offsite power to two three-winding Reserve Auxiliary Transformers (RAT) for each unit. These are:

- For Unit 1,
  - RAT 1NXRA (Offsite source # 1) 4.16 KV secondary winding feeds A-Train safety related loads from 4.16kV bus 1AA02. The other secondary winding is 13.8 KV and it is not feeding any loads during plant normal operating condition.
  - RAT 1NXRB (Offsite source # 2) 4.16 KV secondary winding feeds B-Train safety related loads from 4.16kV bus 1BA03. The other secondary winding is 13.8 KV and it is not feeding any loads during plant normal operating condition.

    There is one non-Class 1E 480-V switchgear bus powered through a 4160/480V transformer from each safety–related 4.16 kV bus. Refer to Updated Final Safety Analysis Report (FSAR) Revision 18 section 8.3.1.1.2.E.

    An additional "swing" preferred offsite power source, 13.8 KV/ 4.16 KV (wye/wye) standby auxiliary transformer (SAT), is also available for plant loads in response to emergency conditions or for use during reserve auxiliary transformer (RAT) maintenance. The SAT receives power from the Georgia Power Company Plant Wilson switchyard. The SAT can be connected manually to any of the unit 1 and 2 class 1E buses under administrative procedures. The SAT high side neutral is solidly grounded and the low side neutral is resistance grounded (Refer to UFSAR Rev.18 section 8.2.1.1).

    The SAT is supplied power through a direct buried cable from the Southern Company 230-kV grid or Plant Wilson's onsite combustion turbine electrical generation, both methods via the Plant Wilson switchyard 13.8-kV power system.

- For Unit 2,
  - RAT 2 NXRA (Offsite source # 2) 4.16 KV secondary winding feeds A-Train safety related loads from 4.16kV bus 2AA02. The other secondary winding is 13.8 KV and it is not feeding any loads during plant normal operating condition.

- RAT 2NXRB (Offsite source # 1) 4.16 KV secondary winding feeds B-Train safety related loads from 4.16kV bus 2BA03. The other secondary winding is 13.8 KV and it is not feeding any loads during plant normal operating condition.

  There is one non-Class 1E 480-V switchgear bus powered through a 4160/480V transformer from each safety–related 4.16 kV bus. Refer to UFSAR (Rev.18) section 8.3.1.1.2.E.

  An additional "swing" preferred offsite power source, 13.8 KV/ 4.16 KV (wye/wye) standby auxiliary transformer (SAT), is also available for plant loads in response to emergency conditions or for use during reserve auxiliary transformer (RAT) maintenance. The SAT receives power from the Georgia Power Company Plant Wilson switchyard. The SAT can be connected manually to any of the unit 1 and 2 class 1E buses under administrative procedures. The SAT high side neutral is solidly grounded and the low side neutral is resistance grounded (Refer to UFSAR Rev.18 section 8.2.1.1).

  The SAT is supplied power through a direct buried cable from the Southern Company 230-kV grid or Plant Wilson's onsite combustion turbine electrical generation, both methods via the Plant Wilson switchyard 13.8-kV power system.

The main generator (25kV) for each unit normally provides power to two three-winding Unit Auxiliary Transformers (UAT) and one excitation transformer for that unit. The UAT's are:

- For Unit 1,
  - UAT 1NXAA which feeds 13.8 KV and 4.16 KV non–safety related loads from 13.8 KV bus 1NAA and from 4.16kV buses 1NA01 and 1NA05.
  - UAT 1NXAB which feeds 13.8 KV and 4.16 KV non-safety related loads from 13.8 KV bus 1NAB and from 4.16kV bus 1NA04.
- For Unit 2,
  - UAT 2NXAA which feeds 13.8 KV and 4.16 KV non–safety related loads from 13.8 KV bus 2NAA and from 4.16kV buses 2NA01 and 2NA05.
  - UAT 2NXAB which feeds 13.8 KV and 4.16 KV non–safety related loads from 13.8 KV bus 2NAB and from 4.16kV bus 2NA04.

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

See Attachment 2, Table 4 for RAT and SAT 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.

For at power (normal operating condition) configurations, all ESF buses are powered by offsite sources. See Attachment 2, Table 1.

See Attachment 2, Table 3 for ESF bus major loads energized during normal power operations, including their ratings.

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 four RATs, two for each unit (1NXRA and 1NXRB for Unit 1, 2NXRA and 2NXRB for Unit 2), are connected to the Georgia Power Company (GPC) transmission system through offsite source # 1 and # 2. These transformers provide a source of power for startup, shutdown, and after-shutdown requirements for both units. The RATs are capable of supplying power to non-safety related 4.16-kV buses 1/2 NA01, 1/2 NA05 and 1/2NA04 as well as safety related 4.16 kV emergency buses 1/2AA02 and 1/2BA03. During normal operations, 4.16 kV buses 1AA02 and 1BA03 for Unit 1 and 2AA02 and 2BA03 for Unit 2 are powered from the reserve auxiliary transformers.

SAT ANXRA can be connected to any one of the 4.16KV ESF buses by administrative procedures.

Complete separation and independence has been maintained between the two (offsite sources) train systems so that any single failure in one train will not prevent the other train from performing its required safety function.

Refer to UFSAR sections (Rev. 18) 8.1.2, 8.2.1.2, 8.3.1.1.1, 8.3.1.2 for further information.

The following at power (normal operating condition) configurations have been confirmed to be consistent with the current licensing basis:

1. Unit 1 offsite Source #1 - Power to U1 ESF Train A bus (1AA02) via 230kV switchyard (RAT 1NXRA)
2. Unit 1 offsite Source #2 - Power to U1 ESF Train B bus (1BA03) via 230kV switchyard (RAT 1NXRB)
3. Unit 2 offsite Source #2 - Power to U2 ESF Train A bus (2AA02) via 230kV switchyard (RAT 2NXRA)
4. Unit 2 offsite Source #1 - Power to U2 ESF Train B bus (2BA03) via 230kV switchyard (RAT 2NXRB)

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

2. 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. Also, include the following information:

Consistent with the current licensing basis and GDC 17, existing protective circuitry was not specifically designed to detect a single open phase of a three phase system. Detection of a single open phase condition is beyond the approved design and licensing basis of the plant.

Although the degraded voltage protection scheme at VEGP was not specifically designed to detect and automatically respond to a single open-phase circuit condition on each credited off-site power circuit, preliminary analysis has indicated that existing protective circuitry (as noted in Enclosure 4, Section 4, Table 1) will respond to an open phase or high impedance ground fault condition under certain circumstances by isolating the affected power source automatically and transferring power to an alternate supply (i.e. standby diesel generator).

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 and GDC 17, existing electrical protective devices are sufficiently sensitive to detect design basis conditions like a loss of voltage or a degraded voltage, but were not specifically designed to detect a single open-phase condition.

As noted in Enclosure 4, Section 4, Table 1, the plant's existing protective devices will automatically detect some of these conditions. See Attachment 2, Table 5A and 5B for undervoltage and other protective 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 VEGP 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?

After a review of the plant operating procedures, specifics steps require verification of all three phase voltages on ESF 480V buses on every shift and no verification of voltage on the 4.16 KV ESF buses.

3. 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 open-phase 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 open-phase (without ground fault) on a credited off-site power circuit because there are insufficient effects (i.e current or voltage) to detect a single open-phase open circuit for this configuration. For VEGP all RAT’s are normally loaded anywhere from 7% to 21% of FA rating (25MVA) while the unit is operating.

The plant response for a loaded power source cannot be determined without specifying the amount of loading and the specific loads involved. The effects and consequences provided in this document assume normal (at power) unit operation and bus configurations.

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.

A high impedance ground will have no immediate effect on plant operation. If the ground current is sufficiently large to affect plant operation, protective relaying will isolate the ground automatically.

1. In the Current Licensing Basis (CLB), VEGP did not consider that the class 1E protection scheme (for the engineered safety feature (ESF) buses) was designed to detect and automatically respond to a single open-phase condition on the credited off-site power sources described in the UFSAR and Technical Specifications.

The offsite power sources for each VEGP unit consists of two independent circuits one from each RAT and then to its related ESF Class 1E bus. Refer to UFSAR (Rev.18) section 8.2.1.2 and Technical Specification (Admin 167/149) sections 3.8.1 and 3.8.2 for further information.

2. Since VEGP did not consider the ESF bus protection scheme as being capable of detecting and automatically responding to a single open-phase condition, a high impedance ground fault, with or without an open phase condition was not included in the design criteria for either the loss of voltage, or the degraded grid relay (DGG) scheme design criteria. Since open-phase detection was not considered in the VEGP design or licensing basis, no design basis calculations or design documents exist that previously considered this condition.

3. Without formalized engineering calculations or engineering evaluations, the electrical consequences of an open-phase event or a high impedance fault (including plant response) can only be evaluated by review of the data published by EPRI and Basler, and SNC's own preliminary analysis. All of the data is generic in nature but can provide some indications of the effects to be expected. The difficulty in applying these documents to the VEGP 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). The models would need to be compiled and analyzed for the VEGP specific Class 1E electric distribution system (EDS). A detailed model of a Joseph M. Farley Nuclear Plant (FNP) transformer similar in design, capacity and application has been used to draw some preliminary conclusions about the effects and detection capabilities as noted in Enclosure 4 Section 4.

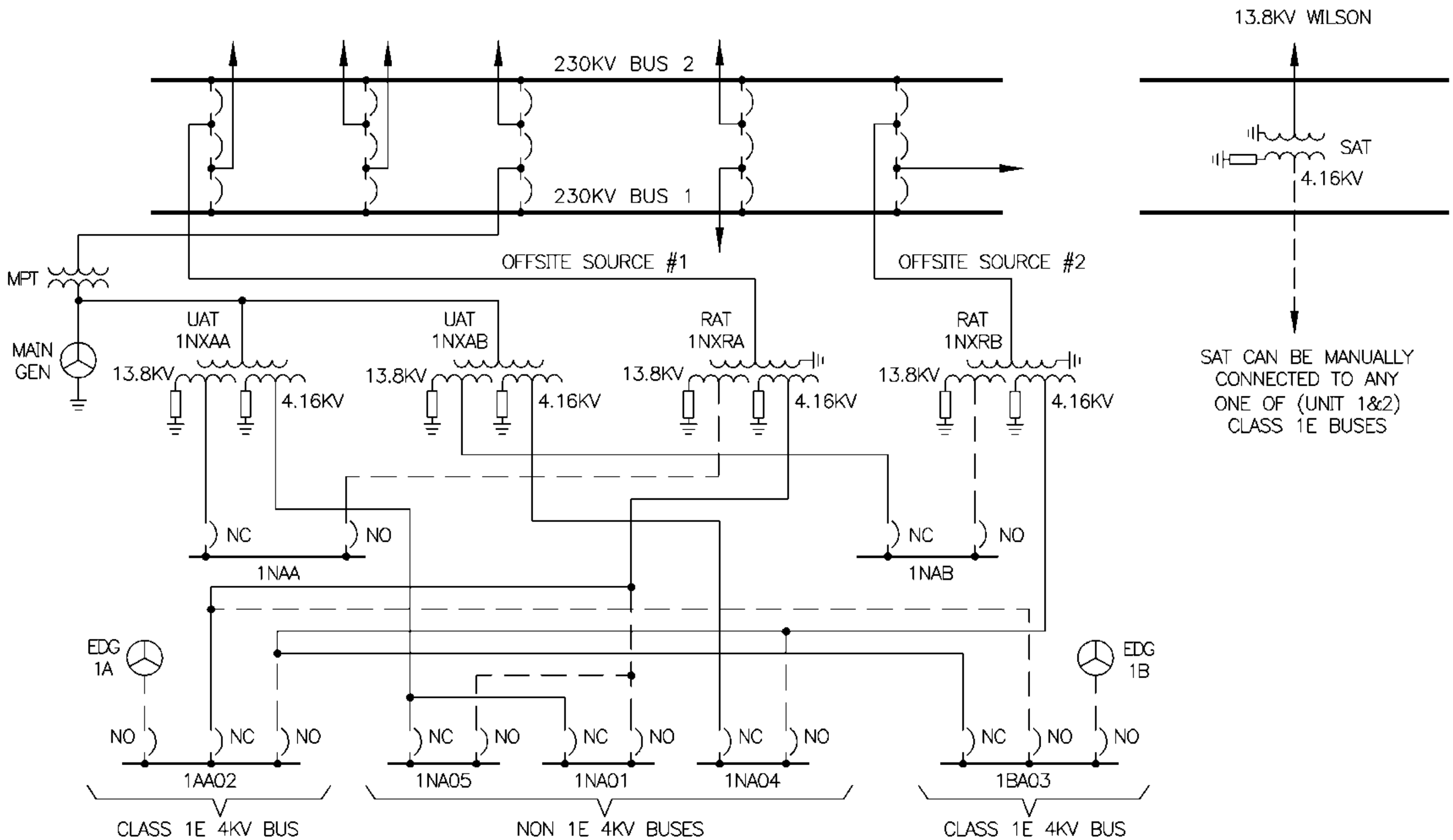
4. When SAT is connected to feed any one of the 4.16 kV ESF bus, degraded grid relay, under voltage and negative sequence relay operations are same as when the ESF bus is fed from any RAT.

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 VEGP does not use a common or single offsite circuit to supply redundant ESF busses.

Attachment 1 of Enclosure 3 - Figure

Simplified One-Line Diagram VEGP Unit 1 (Typical of each Unit)



Attachment 2 of Enclosure 3 - 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)**
RAT 1NXRA	1AA02	Y
RAT 1NXRB	1BA03	Y
RAT2NXRA	2AA02	Y
RAT 2NXRB	2BA03	Y
SAT ANXRA	1AA02 OR 2AA02 OR 1BA03 OR 2 BA03	N

SAT ANXRA can be connected to any one of the 4.16KV ESF buses by administrative procedures.

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

ESF bus	Load	Voltage Level	Rating (HP)
1AA02	Component Cooling Water Pump 1	4000	300
1AA02	Component Cooling Water Pump 3	4000	300
1AA02	Nuclear service Cooling water pump 1	4000	700
1AA02	Nuclear service Cooling water pump 3	4000	700
1AA02	Centrifugal Charging pump 2	4000	690
1AA02	Auxiliary Component cooling Water 1	4000	600
1BA03	Component Cooling Water Pump 2	4000	300
1BA03	Component Cooling Water Pump 4	4000	300
1BA03	Nuclear service Cooling water pump 2	4000	700
1BA03	Nuclear service Cooling water pump 4	4000	700

List of loads on Unit 1 class 1E 4.16 KV buses. Unit 2 loads are same as Unit 1.

Table 4 - Offsite Power Transformers

Transformer	Winding Configuration	MVA Size (OA/FOA/FOA)	Voltage Rating (Primary/Secondary)	Grounding Configuration
RAT 1NXRA	Wye-Wye-Wye w/Buried Delta Tertiary	36/48/60 @ 55°C rise	X - 230kV/13.8kV Y - 230kV/4.16kV	H – Neutral, Solidly Grounded X – Neutral, Resistance Grounded Y – Neutral, Resistance Grounded
RAT 1NXRB	Wye-Wye-Wye w/Buried Delta Tertiary	36/48/60 @ 55°C rise	X - 230kV/13.8kV Y - 230kV/4.16kV	H – Neutral, Solidly Grounded X – Neutral, Resistance Grounded Y – Neutral, Resistance Grounded
RAT 2NXRA	Wye-Wye-Wye w/Buried Delta Tertiary	36/48/60 @ 55°C rise	X - 230kV/13.8kV Y - 230kV/4.16kV	H – Neutral, Solidly Grounded X – Neutral, Resistance Grounded Y – Neutral, Resistance Grounded
RAT 2NXRB	Wye-Wye-Wye w/Buried Delta Tertiary	36/48/60 @ 55°C rise	X - 230kV/13.8kV Y - 230kV/4.16kV	H – Neutral, Solidly Grounded X – Neutral, Resistance Grounded Y – Neutral, Resistance Grounded
SAT ANXRA	Wye-Wye	10/12.5 OA/FA @65 °C rise	13.8kV/4.16kV	13.8 kV Neutral, solidly grounded 4.16 kV Neutral, resistance Grounded

Table 5A - Protective Devices

Protection Zone	Protective Device	Logic	Setpoint (Nominal)	Basis for Setpoint
4 KV bus 1AA02	Loss of Voltage Relay	2 of 4	2975V (71.51% of 4160V)	To trip ESF bus 1AA02 when the voltage on bus 1AA02 is 2975V or less for 10 seconds.
4 KV bus 1AA02	Degraded Grid Relay	2 of 4	3746V (90.05% of 4160V)	To trip ESF bus 1AA02 when the voltage on bus 1AA02 is 3746V or less for 20 seconds.
4 KV bus 1AA02	Degraded Grid Alarm	2 of 4	3873V (93.1% of 4160V)	To alarm when ESF bus voltage is below 3983V for 10 seconds.
RAT 1NXRA	H.S. Neutral Ground Relay	1 of 2	144A	To actuate on excessive current in the transformer high side winding ground connection.
RAT 1NXRA	X Winding Neutral Ground Relays	1 of 1	600A	To actuate on excessive current in the transformer low side X winding ground connection.
RAT 1XRAA	Y Winding Neutral Ground Relays	1 of 1	600A	To actuate on excessive current in the transformer low side Y winding ground connection.
RAT 1NXRA	H.S. Overcurrent Relay	1 of 3	240A	To actuate on excessive current in the transformer high side windings (1 per phase).
RAT 1NXRA	Transformer Differential Relay	1 of 3		To actuate on excessive current imbalance between the transformer high side winding and buses 1AA02, 1NA01 and 1NA05 (1 per phase).
RAT 1NXRA	Swyd Ground Overcurrent Relay	1 of 1	450A	To actuate on excessive current in the 1NXRA switchyard feeder.
RAT 1NXRA	Swyd bus Differential Relay	1 of 3	150V	To actuate on excessive current in the 1NXRA switchyard feeder bus (1 per phase).
4 KV bus 1AA02	Under Volt and Neg Seq Relay	1 of 2	105V 5%	Sends alarm when the 4 KV bus voltage is 3675V or less Sends alarm when the negative sequence voltage is 5% or greater on the 4KV bus

Each class 1E 4.16 kV (ESF) bus is protected with similar protective devices when the ESF buses are fed from RATs 1/2 NXRA or 1/2 NXRB.

Table 5B – List of Protective Devices when a 4.16 kV ESF bus is fed from SAT ANXRA

Protection Zone	Protective Device	Logic	Setpoint (Nominal)	Basis for Setpoint
4 KV bus 1AA02	Loss of Voltage	2 of 4	2975V (71.51% of 4160V)	To trip ESF bus 1AA02 when the voltage on bus 1AA02 is 2975V or less for 10 seconds.
4 KV bus 1AA02	Degraded Grid Relay	2 of 4	3746V (90.05% of 4160V)	To trip ESF bus 1AA02 when the voltage on bus 1AA02 is 3746V or less for 20 seconds.
4 KV bus 1AA02	Degraded Grid Alarm	2 of 4	3873V (93.1% of 4160V)	To alarm when ESF bus voltage is below 3983V for 10 seconds.
SAT ANXRA	Transformer Differential Relay	1 of 3		To actuate on excessive current imbalance between the transformer high side winding and 4.16 kV buses.
SAT ANXRA	H.S. Back up Overcurrent relay	1 of 3	600	To actuate on excessive current in the transformer high side windings (1 per phase).
SAT ANXRA	L.S. Back up Overcurrent relay	1 of 1	6000	To actuate on excessive current in the transformer low side windings.
SAT ANXRA	L.S. Ground Overcurrent relay	1 of 1	400	To actuate on excessive current in the transformer low side ground connection
4 KV bus 1AA02	Under Volt and Neg Seq Relay	1 of 2	105V 5%	Sends alarm when the 4 KV bus voltage is 3675V or less Sends alarm when the negative sequence voltage is 5% or greater on the 4KV bus

Bulletin 2012 – 01 Response for
Edwin I. Hatch Nuclear Plant Units 1 and 2 (HNP)
Joseph M. Farley Nuclear Plant Units 1 and 2 (FNP)
Vogtle Electric Generating Plant Units 1 and 2 (VEGP)

Enclosure 4

Preliminary Determination of Effects and Consequences for Open-Phase and High Impedance Fault Conditions

Enclosure 4
Preliminary Determination of Effects and Consequences for Open-Phase and High Impedance Fault Conditions

Table of Contents

Section 1 Analysis Description

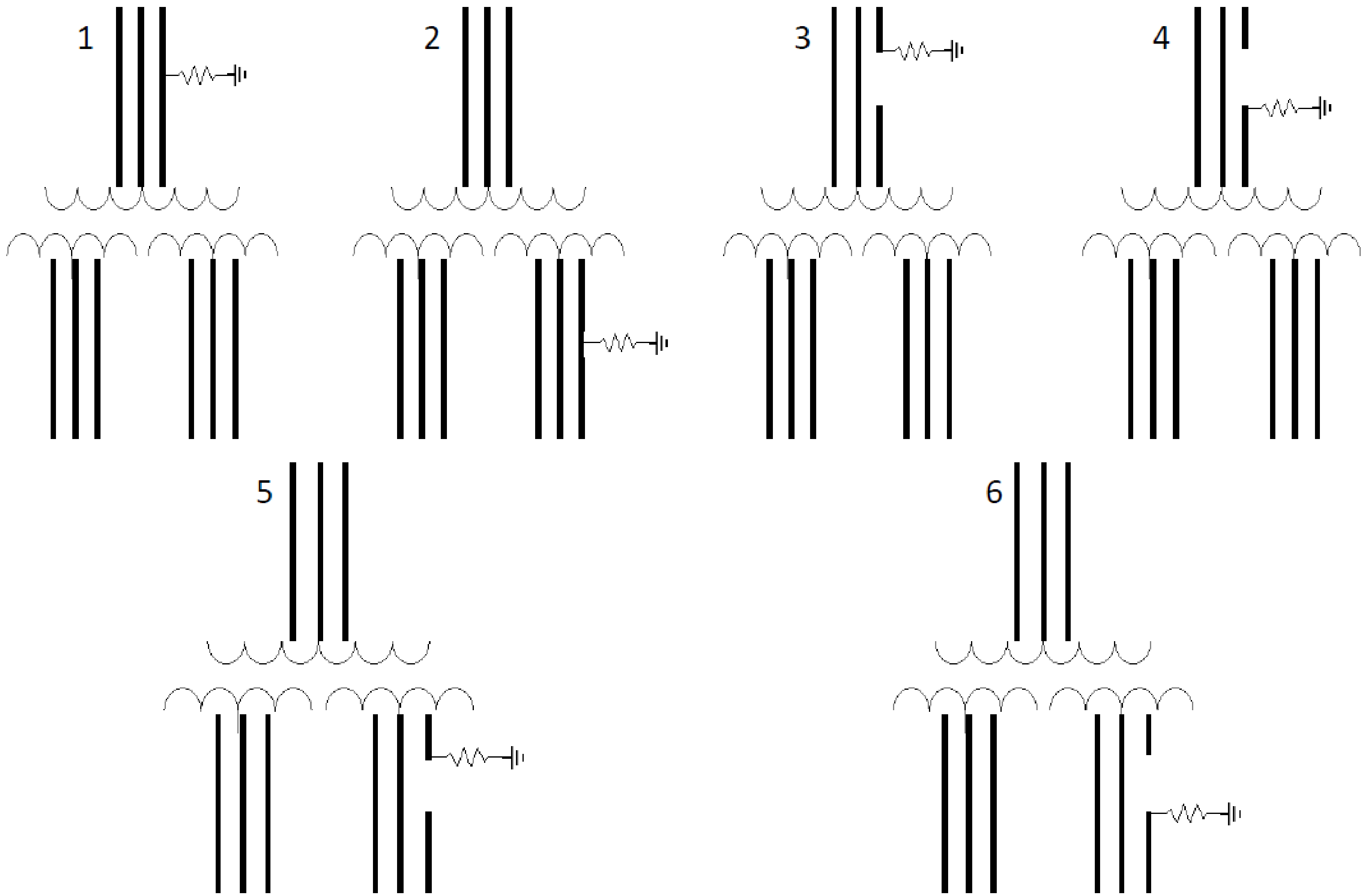
A detailed model of a FNP transformer similar in design, capacity, and application to those at each plant along with plant (FNP, HNP, or VEGP) specific protective relaying design information has been used to draw some preliminary conclusions about the effects and detection capabilities with regard to open phase and high impedance ground conditions. In addition to an open phase on the transformer primary or secondary, see Figure 1 “Study Cases 1 through 6” for a pictorial representation of each of the six high impedance ground fault cases evaluated for each plant.

Although the SNC analysis uses actual data for a SAT in service, these are generic assessments and cannot be formally credited as a basis for a precise response. Based on this preliminary analysis, the effects for each case are summarized in the following Tables:

- Section 2, Table 1 - HNP Existing Protective Devices That Automatically Trip Under the Listed Fault Condition
- Section 3, Table 1 - FNP Existing Protective Devices That Automatically Trip Under the Listed Fault Condition
- Section 4, Table 1 - VEGP Existing Protective Devices That Automatically Trip Under the Listed Fault Condition (when ESF buses are fed from RATs)

The effects and consequences provided in this document assume normal (at power) unit operation and bus configurations.

Figure 1 – Study Cases 1 through 6



Section 2 <u>Edwin I. Hatch Nuclear Plant Electrical System Effects and Consequences</u>

Based on the preliminary studies noted above, the following situations were evaluated with the expected ESF bus effects and protective device actuations as noted:

A. For transformer high-side open phase (without ground fault): Automatic protective actions may not occur when SATs are loaded at less than 30% of the FOA rating. This could occur during normal operation when SAT 1D is at minimum loading near 10% of OA rating. No significant effects on Class 1E bus loads due to negative sequence currents being minimal.

B. For transformer low side open phase (without ground fault): Automatic protective actions may not occur when SATs are loaded to less than 30% of FOA rating. This also would occur during normal plant operation when SAT 1D is at a loading near 10% of OA rating. Significant negative sequence currents can impact Class 1E bus loads during light loading.

Note: During normal plant operation SAT C for Units 1 and 2 is unloaded and cannot detect the open phase conditions.

C. For transformer high-side ground fault (no open phase) – Case 1: Automatic protective actions may not occur for faults >2213Ω (<60A). Otherwise switchyard differential relaying provides protection trips. No significant effects on Class 1E bus loads due to minimal negative sequence currents.

D. For transformer low-side ground fault (no open phase) – Case 2: Automatic protective actions may not occur for faults >4.5Ω (<480A). Otherwise Low side ground relaying and switchyard differential relaying provide protection. No significant effects on Class 1E bus loads due to negative sequence currents being minimal.

E. For transformer high-side open phase with switchyard side ground fault – Case 3: Automatic protective actions may not occur for faults > 2000 Ω (<60A). Otherwise switchyard differential relaying provides protection. No significant effects on Class 1E bus loads due to negative sequence currents being minimal.

F. For transformer high-side open phase with transformer-side ground fault – Case 4: Automatic protective actions may not occur for faults >220 Ω (<867A). Negative sequence currents can impact Class 1E bus loads (56% negative sequence current). Otherwise transformer differential provides protection trips for light and medium loadings.

G. For transformer low-side open phase with transformer-side ground fault – Case 5: Automatic protective actions may not occur for faults > 4.5Ω (<480A). Significant negative sequence currents can impact Class 1E bus loads during light loading. Otherwise Low side ground relay provides protection.

H. For transformer low-side open phase with bus-side ground fault – Case 6: Automatic protective actions may not occur for faults >4.5Ω (<867A). For full loading, the low side ground relay and switchyard overcurrent relay provide protection. Negative sequence currents can impact Class 1E bus loads during light loading (75% negative sequence currents).

Based on this preliminary analysis for normal plant operation, the vulnerability to significant negative sequence current could occur during the following conditions:

- A transformer low-side open-phase (without ground fault) during light loading.
- A transformer low-side open-phase with transformer-side ground fault during light loading.
- A transformer low-side open-phase with bus-side ground fault during light loading.

Section 2, Table 1 – HNP Existing Protective Devices That Automatically Trip Under the Listed Fault Condition

Fault / Device	Case 1 No Open HS Gnd	Case 2 No Open LS Gnd	Case 3 HS Open Swyd Side Gnd	Case 4 HS Open Xfmr Side Gnd	Case 5 LS Open Xfmr Side Gnd	Case 6 LS Open Bus Side Gnd
Bus DGV (3675V)	3 of 3 ph @ <2Ω, full load			3 of 3 ph. @ full load	3 of 3 ph. @ full load	3 of 3 ph. @ full load
Xfmr HS OC (120A)	<1000 Ω, full load		<3000Ω, full load	<220 Ω, medium and full loadings	<4.5 Ω, full load	<4.5 Ω, full load
LS Gnd Relay (480A)		< 4.5Ω (480A), all postulated loadings			<4.5Ω, all postulated loadings	<4.5Ω, full load
Xfmr HS Diff (HNP)	<2213 Ω, all postulated loadings		<2000Ω, all postulated loadings			
Xfmr LS Diff		<1Ω, light loadings	<3000Ω, med and full loadings	<220Ω, light and med loadings		

- For an open phase on the transformer high side with no ground fault, the LS differential relay will trip for loading > 30%.
- For an open phase on the transformer low side with no ground fault, 2 of 2 DGV relays will trip for full loading conditions.

Section 3 Joseph M. Farley Nuclear Plant Electrical System Effects and Consequences

Based on the preliminary analysis noted above, the following situations were evaluated. The ESF bus effects and protective actions expected are noted.

A. For transformer high-side open phase (without ground fault): Automatic protective actions may not occur when the SATs are loaded at less than 30% of the FOA rating. This could occur during outages when the minimum loading could be near 10%.

B. For transformer low-side open phase (without ground fault): Existing automatic protective relaying prevents undesirable effects on Class 1E bus loads.

C. For transformer high-side ground fault (no open phase) – Case 1: Automatic protective actions may not occur for faults of >83Ω (<1600A) , however, there are no significant effects on Class 1E bus loads due to negative sequence currents (minimal negative sequence current).

D. For transformer low-side ground fault (no open phase) – Case 2: Automatic protective actions may not occur for faults of >25Ω (<80A), however, there are no significant effects on Class 1E bus loads due to negative sequence currents (minimal negative sequence current).

E. For transformer high-side open phase with switchyard-side ground fault – Case 3: Automatic protective actions may not occur for loading <30%, however load is normally >35%, and trip would occur.

F. For transformer high-side open phase with transformer-side ground fault – Case 4: Existing automatic protective relaying prevents undesirable effects on Class 1E bus loads.

G. For transformer low-side open phase with transformer-side ground fault – Case 5: Existing automatic protective relaying prevents undesirable effects on Class 1E bus loads.

H. For transformer low-side open phase with bus-side ground fault – Case 6: Existing automatic protective relaying prevents undesirable effects on Class 1E bus loads.

Based on this preliminary analysis for normal plant operation, there is no vulnerability to significant negative sequence currents during the above conditions.

In summary, while all postulated open phase or high impedance ground fault cases may not have automatic protection, an open-phase condition could result in a loss of function to only one of the two protective trains. Given the low probability and existing protective features already installed, such conditions would be no worse than any already assumed such as a train loss due to a bus fault. Only a single train is affected.

Section 3, Table 1 – FNP Existing Protective Devices That Automatically Trip Under the Listed Fault Condition

Fault / Device	Case 1 No Open HS Gnd	Case 2 No Open LS Gnd	Case 3 HS Open Swyd Side Gnd	Case 4 HS Open Xfmr Side Gnd	Case 5 LS Open Xfmr Side Gnd	Case 6 LS Open Bus Side Gnd
Bus DGV (3675V)	2 of 3 ph. @ <3Ω		2 of 3 ph. @ <3Ω	2 of 3 ph.	2 of 3 ph.	2 of 3 ph.
Swyd HS OC (1600A)	<83Ω		<83Ω			
Xfmr HS OC (160A)				>30% load		
HS Gnd Relay (60A)	<8Ω		>30% load	All Ω		
LS Gnd Relay (80A)		<25Ω (80A)			<25Ω	<20Ω
Xfmr Diff			>30% load	<30% load		

- For an open phase on the transformer <u>high</u> side with <u>no</u> ground fault, the HS ground relay and transformer differential relay will trip for loading > 30%.
- For an open phase on the transformer <u>low</u> side with <u>no</u> ground fault, 2 of 3 DGV relays will trip for all loading conditions.

Section 4 <u>Vogtle Electric Generating Plant Electrical System Effects and Consequences</u>

Based on the preliminary analysis noted, the following situations assuming that all the ESF buses are fed from their respective RATs were evaluated. The ESF bus effects and protective actions expected are noted. No analysis has been made assuming an ESF bus is fed from a SAT.

A. For transformer high-side open phase (without ground fault): RATs are loaded to less than 30% of the FA rating during normal operating condition except during unit start up. Automatic protective actions may not occur when RATs are loaded at less than 30% of the FA rating. No significant effects on Class 1E bus loads due to negative sequence currents being minimal.

B. For transformer low-side open phase (without ground fault): Existing automatic protective relaying prevents undesirable effects on Class 1E bus loads.

C. For transformer high-side ground fault (no open phase) – Case 1: Automatic protective actions may not occur for faults >2000Ω. Otherwise switchyard (bus) differential relay and degraded grid relay provides protection under some loading conditions. No significant effects on Class 1E bus loads due to negative sequence currents being minimal.

D. For transformer low-side ground fault (no open phase) – Case 2: Automatic protective actions may not occur for faults >4.5Ω (<600A). Otherwise Low side ground relay and RAT differential relay provides protection. No significant effects on Class 1E bus loads due to negative sequence currents being minimal.

E. For transformer high-side open phase with switchyard-side ground fault – Case 3: Automatic protective actions may not occur for faults >2000Ω .Otherwise switchyard bus differential relay, DGG relay and RAT differential relay provides protection under some loading conditions. No significant effects on Class 1E bus loads due to negative sequence currents being minimal.

F. For transformer high-side open phase with transformer-side ground fault – Case 4: Existing automatic protective relaying prevents undesirable effects on Class 1E bus loads.

G. For transformer low-side open phase with transformer-side ground fault – Case 5: Existing automatic protective relaying prevents undesirable effects on Class 1E bus loads.

H. For transformer low-side open phase with bus-side ground fault – Case 6: Existing automatic protective relaying prevents undesirable effects on Class 1E bus loads.

Based on this preliminary analysis for normal plant operation, there is no vulnerability to significant negative sequence currents during the above conditions.

In summary, while all open phase cases may not have automatic protection, an open-phase condition could result in a loss of function to only one of the two protective trains. Given the low probability and measures already taken, such a condition would be no worse than any already assumed such as a train loss due to a bus fault.

Section 4, Table 1 – VEGP Existing Protective Devices That Automatically Trip Under the Listed Fault Condition (when ESF buses are fed from RATs)

Fault / Device	Case 1 No Open HS Gnd	Case 2 No Open LS Gnd	Case 3 HS Open Swyd Side Gnd	Case 4 HS Open Xfmr Side Gnd	Case 5 LS Open Xfmr Side Gnd	Case 6 LS Open Bus Side Gnd
Bus DGG 3746V	Operate @ <2.0Ω			Operate @all loads	Operate @all loads	Operate @all loads
Swyd HS Gnd OC	Operate @ <300 Ω		Operate @ <250 Ω			
Xfmr HS OC (240A)						
HS Gnd Relay (144A)	Operate @<2.5Ω			Operate @all loads		
LS Gnd Relay (600A)		< 4.5Ω (600A), all loads			<4.5Ω, all loads	<4.5Ω, full loads
HS Diff (swyd Bus 150V)	<1100 Ω, light loadings		<2000Ω, all loads			
Xfmr Diff		<1Ω, light loads				

- For an open phase on the transformer high side with no ground fault, the RAT differential relay and DGG relay will trip for loading > 30%.For an open phase on the transformer low side with no ground fault, DGG relays will trip for all loading conditions.
- No evaluations are done when an ESF bus is fed from SAT.