October 25, 2012

L-2012-391
10 CFR 50.4
10 CFR 50.54(f)

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Re: St. Lucie Units 1 and 2
Docket Nos. 50-335 and 50-389
FPL Response to NRC Bulletin 2012-01
Design Vulnerability in Electric Power Systems

References:

1. NRC Bulletin 2012, "Design Vulnerability in Electric Power Systems," dated July 27, 2012 (ML12074A115)

On July 27, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued Bulletin 2012-01, "Design Vulnerability in Electrical Power Systems," (reference 1), requesting the addressees to provide information about the facilities' electric power system designs and to verify their compliance with various design criteria. The requested information in NRC Bulletin 2012-01 is included in the attachment to this letter.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on October 25, 2012.

Respectfully submitted,

Joseph Jensen
Site Vice President
St. Lucie Plant

JJ/KWF

Attachment

IE76
NRR

**NRC Bulletin 2012-01 Response**

## Bulletin Response

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## Background

On January 30, 2012, Byron Station Unit 2 automatically scrammed from l00 percent power on reactor coolant pump (RCP) bus undervoltage. This event resulted in the declaration of an Unusual Event. The NRC NRR Event Notice EN47636, "Design Vulnerability In 4160 Volt Bus Undervoltage Scheme" was issued on February 6, 2012, to alert the industry that other nuclear sites may have a similar vulnerability to a loss-of-phase event, as discovered at Byron Unit 2. The NRC Information Notice 2012-13, "Design Vulnerability in Electric Power System", was issued on March 1, 2012, to provide further guidance towards addressing this concern.

On July 27, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued Bulletin 2012-01, "Design Vulnerability in Electrical Power System", requesting the addressees to provide information about the facilities' electric power system designs and to verify their compliance with various design criteria

Note that there are significant "Off-Site" power sources configuration/design differences between St. Lucie and Byron stations as shown below:

- At Byron Unit 2, the safety-related electrical equipment is continually fed from the offsite power source; therefore, a failure in the feeder line between the switchyard and the offsite power transformer immediately affected the safety-related equipment and plant operation. In contrast, at St. Lucie, the offsite transformers, though energized are not loaded. All onsite buses (safety-related buses included) are fed from the Unit generator through the Unit Auxiliary Transformers.
- At Byron Unit 2, both onsite redundant Class 1E safety-related trains of electrical power and equipment loads are connected to the same "Off-site" power transformer. Therefore, a failure of the one feeder line affected both safety-related trains of electrical equipment immediately and concurrently. In contrast, St. Lucie maintains two full independent trains "A" and "B" feeder lines from the switchyard to the "Off-site" transformers. The separation continues with non-segregated bus ducts from the transformers to their respective Class 1E safety-related trains; therefore, one failure would only affect the "Off-site" portion of one train, because the "Off-site" transformers are independent.
- Byron Unit 2 switchyard had not been "hardened" to resist stress from the environment/weather. In contrast, the St. Lucie Units 1 and 2 switchyard has been designed for severe weather. St. Lucie's switchyard endured three Category 1 and 2 hurricanes (since 2004 hurricane season) without incident. Subsequently, St Lucie's switchyard has undergone a switchyard hardening and improvement project.

## 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).***

The transmission grid connections that provide offsite power to the St. Lucie switchyard consist of three 230-kV transmission lines from the Midway Receiving station. The three 230-kV transmission lines are connected to the ST. LUCIE switchyard as shown in the Simplified One-Line Diagram. These transmission lines are designed and built to provide the electrical and structural independence necessary to ensure continuity of offsite electrical power to the station switchyard. The switchyard is comprised of five independent Bays (1A, 1, 2, 3 and 4), which interconnect west and east switchyard buses. This five bay 230-kV switchyard provides independent switching capability for each of the Main Generator outputs Unit 1 and 2, Preferred Power Source feeds (one feeder line for each ESF train: ESF train "A" Start-Up Transformers (SUTs) 1A and 2A; ESF train "B" SUTs 1B and 2B), and the three 230-kV transmission lines.

During normal Unit operation, both St. Lucie Units 1 and 2 Class 1E safety-related 4-kV buses receive power directly from their associated Main Generators via the Unit Auxiliary Transformers (UAT, one for each ESF train). Each enclosed isolated-phase buswork is used to transfer power from the Main Generator to the UATs, with enclosed non-segregated buswork used to transfer power from the UATs to the non-safety-related (NNS) 4-kV and 6.9-kV buses/switchgear. The Class 1E safety-related 4-kV buses are fed by their associated NNS 4-kV buses as shown in the Simplified One-Line Diagram.

There are two SUTs per Unit (SUTs 1A and 1B: SUTs 2A and 2B), which remain energized, when the ESF buses are powered via the UATs. However, while the Units are in this normal operation configuration, the SUTs remain unloaded.

As the safety-related buses are normally powered from the Main Generator through the UATs, they are isolated from any potential anomalies on the SUT circuits in this configuration. Therefore, the Class 1E vital (essential) buses have no immediate vulnerability to a loss of a single phase from exposed overhead transmission circuit leading from the Switchyard to the SUTs under normal operating conditions. The ESF bus configuration is shown in the simplified electrical distribution one-line-diagram as shown in the Simplified One-Line Diagram.

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

The offsite power transformers (SUTs or SUT), are three winding transformers (one secondary Wye winding for the 6.9 KV large motor bus and one secondary winding for the 4.16 KV auxiliary distribution system). The primary-side (230-kV) Wye neutral is directly grounded while both of the secondary windings are grounded through a neutral grounding transformer. For voltage ratings, power ratings, and tap settings see Table 4.

***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. When the St. Lucie Units 1 and 2 are operating in power-generation Mode 1 (normal operating configuration), the ESF buses are NOT powered by offsite sources (SUT). At the St. Lucie power station, each Unit operates with auxiliary power provided by two UATs. One UAT will supply power to the "A" Class 1E safety-related 4 kV buses and the other UAT will supply power to the "B" Class 1E safety-related 4 kV buses. Under normal operating conditions, the two offsite power transformers (SUT) on each Unit are energized but unloaded; therefore, they do not provide power to safety or non-safety loads.

The two offsite transformers (SUT) are fed from different bays in the 230 KV Switchyard by separate overhead power lines. Specifically, the offsite circuits leading to the SUTs are grouped by "A" and "B" trains, such that the 1A and 2A SUTs are fed from Switchyard Bay 2, and the 1B and 2B SUTs are fed from Bay 4 as shown in the Simplified One-Line Diagram.

*See Tables 1 and 2 for ESF bus power sources.
*See 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 operating configurations of the St. Lucie Units 1 and 2 ESF buses have been confirmed to be consistent with the current licensing basis. As Unit 1 initiated power generation operation in the Year 1976, followed by Unit 2 joining "At Power" operation in 1983, some offsite to power-block circuit changes were implemented (as noted later in this discussion), which met the Unit 2 (and overall station) licensing basis. However, the basic configuration approach and methodology remained effectively the same.

The normal source of auxiliary AC power during start-up or shutdown is from the incoming off-site transmission lines through the 230 KV switchyard and SUTs (SUT 1A and SUT 1B for Unit 1: SUT 2A and SUT 2B for Unit 2). The SUTs step down the 230 KV (Nominal) incoming line voltage to 6.9 KV and 4.16 KV for auxiliary system use. During normal plant operations, AC power is provided from the Main Generator through the UATs (UAT 1A and UAT 1B for Unit 1: UAT 2A and UAT 2B for Unit 2). The UATs step down the Main Generator output voltage from 22kV to 6.9 KV and 4.16 KV for the auxiliary system use.

When the Unit is stable after start-up, the control room operator performs a normal/manual transfer of power to supply each trains' 6.9 KV and 4.16 KV auxiliary buses from the SUTs to the UATs. Normal/manual switching between the UATs and SUTs will be initiated by the operator from the control room. At normal power, the UATs are energized to power all Unit auxiliary equipment loads. While the SUTs are energized, they remain unloaded. In the event of a Unit trip or other automatic protective relay response, a fast dead-bus transfer of power from the UAT(s) to the SUT(s) would be initiated as required.

The Normal Operating Line-up ("At Power") of the Auxiliary Power System trains and their power feeds as explained here and as shown in the Simplified One-Line Diagram have been confirmed to be consistent with the current licensing basis. The following shows the power supply to bus line-ups of the Auxiliary Power System during start-up and at power (normal operating condition):

1. Unit 1 Start-Up Mode (or shutdown) bus alignment configuration:
   a. The Power to "A" Train ESF 4KV SWGR 1A3 is provided from the 230KV switchyard though SUT 1A. Specifically, ESF 4KV SWGR 1A3 is fed from 4KV SWGR 1A2, which is fed from 4KV SWGR 2A4, which is fed from the SUT 1A, which is fed from 230KV Switchyard Bay 2.
   b. The Power to "B" Train ESF 4KV SWGR 1AB and ESF 4KV SWGR 1B3 is provided from the 230KV switchyard though SUT 1B. Specifically ESF 4KV SWGR 1AB is fed from ESF 4KV SWGR 1B3, which is fed from 4KV SWGR 2B4, which is fed from the SUT 1B, which is fed from 230KV Switchyard Bay 4.
      i. Note: The Unit 1 ESF SWGR 1AB is a swing bus, which can be aligned to either ESF 4KV SWGR 1A3 or ESF 4KV SWGR 1B3. However, it is normally aligned to the ESF 4KV SWGR 1B3.

2. Unit 1 "At Power" (normal operating) bus alignment configuration:
   a. The Power to "A" Train ESF 4KV SWGR 1A3 is provided from the 22KV Main Generator Output via the "Isophase Bus" though the UAT 1A. Specifically, ESF 4KV SWGR 1A3 is fed from 4KV SWGR 1A2, which is fed from the UAT 1A, which is fed from the 22KV Main Generator Output.
   b. The Power to "B" Train ESF 4KV SWGR 1AB and ESF 4KV SWGR 1B3 is provided from the 22KV Main Generator Output via the "Isophase Bus" though the UAT 1B. Specifically, ESF 4KV SWGR 1AB is fed from ESF 4KV SWGR 1B3 which is fed from 4KV SWGR 1B2, which is fed from the UAT 1B, which is fed from the 22KV Main Generator Output.
      i. Note: The Unit 1 ESF SWGR 1AB is a swing bus, which can be aligned to either ESF 4KV SWGR 1A3 or ESF 4KV SWGR 1B3. However, it is normally aligned to the ESF 4KV SWGR 1B3.

3. Unit 2 Start-Up Mode (or shutdown) bus alignment configuration:
   a. The Power to "A" Train ESF 4KV SWGR 2AB and ESF 4KV SWGR 2A3 is provided from the 230KV switchyard though SUT 2A. Specifically, ESF 4KV SWGR 2AB is fed from ESF 4KV SWGR 2A3 which is fed from 4KV SWGR 2A4, which is fed from the SUT 2A, which is fed from the 230KV Switchyard Bay 2.
      i. Note: The Unit 2 ESF SWGR 2AB is a swing bus, which can be aligned to either ESF 4KV SWGR 2A3 or ESF 4KV SWGR 2B3. However, it is normally aligned to the ESF 4KV SWGR 2A3.
   b. The Power to "B" Train ESF 4KV SWGR 2B3 is provided from the 230KV switchyard though SUT 2B. Specifically ESF 4KV SWGR 2B3 is fed from 4KV SWGR 2B2 which is fed from 4KV SWGR 2B4 which is fed from the SUT 2B which is fed from the 230KV Switchyard Bay 4.

4. Unit 2 "At Power" (normal operating) bus alignment configuration:
   a. The Power to "A" Train ESF 4KV SWGR 2AB and ESF 4KV SWGR 2A3 is provided from the 22KV Main Generator Output via the "Isophase Bus" though UAT 2A. Specifically, ESF 4KV SWGR 2AB is fed from ESF 4KV SWGR 2A3, which is fed from 4KV SWGR 2A2, which is fed from the UAT 2A, which is fed from the 22KV Main Generator Output.
      i. Note: The Unit 2 ESF SWGR 2AB is a swing bus, which can be aligned to either ESF 4KV SWGR 2A3 or ESF 4KV SWGR 2B3. However, it is normally aligned to the ESF 4KV SWGR 2A3.
   b. The Power to "B" Train ESF 4KV SWGR 2B3 is provided from the 22KV Main Generator Output via the "Isophase Bus" though UAT 2B. Specifically, ESF 4KV SWGR 2B3 is fed from 4KV SWGR 2B2, which is fed from the UAT 2B, which is fed from the 22KV Main Generator Output.

The operating configurations for Unit 1 (both start-up and "At Power") are consistent with its current licensing basis (see UFSAR excerpts Table 6A). The original Unit 1 licensing basis (see PSAR excerpts Table 6C) was consistent with the current operating methodology (Normal "At-Power" operation is from the UAT with the SUTs used for Start-up, Shutdown and station trips). When Unit 1 was commissioned in 1976, the Unit 2 4KV SWGR 2A4 and 4KV SWGR 2B4 buses were not installed but the 4KV connection from the SUTs was terminated on the 4KV SWGR 1A2 and 4KV SWGR 1B2 buses in the same manner. The addition of the interconnecting switchgear (4KV SWGR 2A4 and 4KV SWGR 2B4) created no appreciable change to the operation or method of operation of the two off site power sources ("A" train SUT 1A and "B" train SUT 1B). The interconnecting 4KV switchgear has NO loads attached.

Unit 2 was commissioned in 1983. However, before Unit 2 began power generation, the offsite power overhead lines to the SUTs (both Unit 1 and Unit 2) were configured in the same manner as they are today. The Unit 1 UFSAR had already been changed to show the interaction with the two new interconnecting buses (4KV SWGR 2A4 and 4KV SWGR 2B4). The operating configurations (both start-up and "At Power") are consistent with the current and original Unit 2 licensing basis (see UFSAR excerpts Table 6B).

## 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 Class 1E safety-related protective circuitry will separate the ESF buses from a connected failed offsite source, due to a loss of voltage or a sustained, balanced degraded grid voltage concurrent with certain design basis accidents. However, the offsite and the onsite protective relay systems were not specifically designed to detect an open single phase of a three phase system. Similarly, there is no offsite Switchyard protective relaying, which can detect or protect from the loss of a single phase in the circuit from the Switchyard to the SUTs. Detection of a single-open phase condition is beyond the approved design and licensing basis of the plant.

Existing Voltage Protection Relay Schemes Ability to Detect/Protect from a Loss of Phase

The onsite Class 1E Technical Specification protective relay schemes were required to meet certain requirements for Loss of Voltage (LV) and Degraded Voltage protection. Specifically, in order to prevent a spurious isolation from the preferred offsite power source, Technical Specification degraded grid voltage protective relay schemes were required to use redundant relays, which would require 2 relays to concurrently sense and actuate, in order to initiate isolation from the grid, load-shedding and automatic load-sequencing on the Emergency Diesel Generators (Ref. Table 5A).

For Unit 1, the Technical Specification Loss of Voltage (LV) and Degraded Voltage (DV) relay schemes utilize a "2-out-of-2" logic, which monitor the "B" to "A" and "B" to "C" phase pairs only, which is similar to the Byron Unit 2 design. As the only common phase that these 2 relays monitor is the "B" phase, these Class 1E relays are only capable of detecting/protecting the loss of the "B" phase. In addition, between the Unit 1 ESF 4-kV Buses and the SUTs, there is a single non-safety-related (NNS) inverse-time LV detection relay which monitors across the "A" to "B" phase pair on the NNS 4-kV bus, which provides power to the associated ESF bus. However, it uses a 1-out-1 logic, which should be capable of detecting the loss of voltage on both the "B" and "A" phases. Due to the inverse-time nature of this LV relay, it is relatively insensitive to spurious tripping. Therefore, at St. Lucie Unit 1, the equipment on the ESF buses would be unprotected for the loss of a "C" phase only. Note that when in normal power operation, with the ESF buses receiving power from the UATs, these relays are monitoring the UATs source voltages (Generator). These relays will only detect the SUT circuit voltage, when power is being provided by the SUTs.

For Unit 2, the Technical Specification Loss of Voltage (LV) and Degraded Voltage (DV) relay schemes utilize a "2-out-of-3" logic, which monitor the "A" to "B", the "B" to "C", and "C" to "A" phase pairs. With this configuration, there are a sufficient number of sensing relays with the logic configured in such a manner to ensure that each phase-pair combination has 2 relays paired to be capable of detecting the loss of the "A", "B" or "C" phases. Therefore, the St. Lucie Unit 2 ESF equipment should be protected from the loss of an "A", B" or "C" phase. Note that when in normal power operation, with the ESF buses receiving power from the UATs, these relays are monitoring the UATs source voltages (Generator). These relays will detect the SUT circuit voltage, when power is being provided by the SUTs.

Review of the Existing Ground Detection Relay Schemes for High-Impedance Ground Faults

Ground detection schemes were reviewed for both the Switchyard 230 kV and plant auxiliary distribution system voltage levels.

Review of 230-kV Switchyard and SUT High-Impedance Ground Fault:

The St. Lucie Units 1 and 2 SUTs are a WYE-WYE configuration and grounded on both sides. The transformers are bolted ground on the neutral of the primary (230kV) winding and are grounded through distribution transformers with grounding resistors on both the secondary (6.9 kV) and the tertiary (4.16 kV) winding neutrals.

At St. Lucie Units 1 and 2, there are no protective devices specifically installed for high-impedance ground fault detection on the 230 kV side (high voltage side) of the SUTs. However, any ground fault on the high voltage side should be easily detected by the differential relays installed either in the switchyard or on both ends of the SUT circuits, due to the various differential relay protection zones provided. Due to the bolted ground on the neutral of the primary (230-kV) SUT winding, the threshold for detection/protection by the differential relay protection should be easily met.

Due to design differences between Byron Unit 2 and St. Lucie Units 1 and 2, a high-impedance fault of the 230-kV Switchyard circuit, which interconnected the Switchyard to the offsite circuit transformers (SUT at St. Lucie), are not expected. Specifically, the configuration of the Byron overhead tower adjacent to the revenue tower helped restrain the severed conductor section from solidly contacting ground or other grounded equipment.

Review of Plant 4.16-kV and 6.9-kV Auxiliary System High-Impedance Ground Fault:

The effect of a high impedance ground has been analyzed to be of no consequence to the auxiliary power distribution system at St. Lucie. The grounding resistors are sized so as to prevent high current conditions that could cause damage the installed equipment. As such, the high-impedance-grounded auxiliary system restricts fault current of a single phase to low levels, which do not adversely impact equipment operation. Therefore, ESF equipment would not be expected to be exposed to any significant voltage imbalance, should a phase short to ground. The high impedance ground detection schemes on the secondary side of the SUTs (6.9kV system and the 4.16kV system) provide an "**alarm only**" condition when there is a single phase to ground fault on the secondary side of the SUTs. However, administrative controls are in place to address any alarm conditions detected by these ground detection relays. In addition, during Unit start-up or shutdown, the ESF buses at St Lucie Units 1 and 2 are fed by two independent offsite power sources via two independent WYE Connected SUTs.

Ground detection relays are installed across the grounding resistors on the secondary of the SUT distribution transformers such that a fraction of a single phase to ground fault on the 230kV (primary or high) side of the SUTs are detected via the secondary terminals of the distribution transformers connected to the neutral windings of these SUTs.

For ground detection system design for the 4.16kV and 6.9kV SUTs, IEEE Standards (IEEE Std. 242-1975) recommends a ground detection sensitivity setting of 5% to 10% of the maximum continuous voltage rating of the ground detection logic in order to achieve proper detection of high impedance ground faults to ensure that all connected ESF motors are protected. The secondary side of the startup transformer is capable of withstanding a ground fault voltage that is equal to 138.57 volts (that is, 240V/1.732) and the corresponding 10% value is 13.86 volts.

The installed relay at St. Lucie is a 12IAV51D relay with a maximum continuous voltage rating of 199 volts and a minimum adjustable sensitivity range setting of 8% (16 volts). This sensitivity value is acceptable, though slightly higher than the required minimum of 13.86 volts, because the 16 volts value is the best that can be achieved by this type of relay for ground detection at the time of installation. This relay is also equipped with a third harmonic protection filter capacitor in its circuit design. In addition, the relay's rated voltage of 199 volts can withstand the maximum ground fault voltage (138.57 volts) of the grounding transformers on the secondary windings of the SUTs. The detailed parameters of the distribution transformer, grounding resistor, and ground detection relay are presented in the Table 5B. As noted in the Table, the installed relays are set such as to provide adequate sensitivity for a ground fault on the offsite section of the SUTs. Due to the sensitivity of these relays, a fault just slightly above the ground fault relay setpoint will have no negative impact on the auxiliary power system.

The review of the ground detection scheme determines that the installed ground resistors will prevent the passage of a high impedance ground fault that may otherwise cause an unbalanced voltage condition sufficient to adversely affect energized equipment. Such a fault will also be easily picked up by the relays.

Note that the SUTs at St. Lucie are only used for backup during power operation, and are only required for design basis events and during Unit outages. During outages, the overall auxiliary loads are very small since majority of large BOP loads are out of service.

Preliminary studies performed by industry peers such as Basler, Southern Nuclear (via EPRI), EXELON (via Sergent and Lundy) and TVA on open phase conditions, indicate that for a WYE-WYE transformer on no-load, an open phase condition on the high side can not be detected on the secondary side of the transformers. Also, for a very lightly loaded transformer, according to open phase studies performed by industry peers, the chances of any meaningful detection of an open phase condition on the primary can not be easily established. At St. Lucie, we have two independent trains of offsite power through independent backup SUTs, and line/train separation; therefore, the possibility of a single failure affecting both trains is not credible.

During normal plant operation (modes 1, 2 and 3) the Engineered Safety Feature (ESF) buses, 4.16 kV 1A3/1B3 buses (Unit 1) and 2A3/2B3 buses (Unit 2), are powered from the UATs for each train. An open phase on the Main Power Transformer (MPT) 230kV side would have no direct effect on the ESF bus voltages. Since the UAT is tied directly to the generator terminals, they will continue to receive three phase voltage on their primary sides for as long as the generator remains online. If the generator trips on negative sequence due to the open MPT phase, the ESF buses (4.16 kV 1A3/1B3 and 2A3/2B3 buses) and the upstream balance of plant (BOP) buses 4.16 kV 1A2/1B2 and 6.9 kV 1A1/1B1 (unit 1) or 4.16 kV 2A2/2B2 and 6.9 kV 2A1/2B1 (unit 2) will automatically transfer to their alternate source (SUT). Therefore, an open phase on the MPT high side while the plant is in normal operation is not of concern.

An open phase on the UAT primary side while the Isophase, generator and main power transformer connections remain intact is not credible, due to the Isophase bus connection arrangement, which makes it highly unlikely that a phase would open without also shorting to ground and tripping the generator.

During normal plant operation (modes 1, 2 or 3) an open single-phase on the SUT primary has no effect on safety bus voltage, since the ESF buses are powered from the UAT.

***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 phase open circuit condition. See Table 5A for undervoltage protective devices. Table 5B lists ground protection/alarms on the ESF buses. The basis for the device setpoint(s) are presented above.

***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.***

Operating procedure 0-NOP-99.02 "Watchstation General Inspection Guidelines" is the operating procedure delineating expectations for the accomplishment of operator rounds, while touring through the plant. 0-NOP-99.02 includes a check of the electrical power transformers for abnormal alarms on the alarm panel (See Table 5C).

The Operations Procedure 0-NOP-99.02 has been revised to include the following inspection to the Operator shift inspections of the electrical power transformers;

***"For each Startup Transformer, visually verify, from the west roadway, that all three 240 kV lines are physically continuous from the Switchyard bay breakers to the Startup Transformer connections."***

This revised procedure requirement is consistent and more conservative than the existing Technical Specification Surveillance 4.8.1.1.1 for each Unit's offsite power circuit verification, which states:

*"Each of the above required* independent *circuits between the offsite transmission network and the onsite Class 1E distribution system shall be:*

*a. Determined OPERABLE at once per 7 days by verifying correct breaker alignments, indicated power availability ..."*

***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 Unit 1 and 2 procedures do not verify the voltages on all three phases of the ESF buses. The Unit 1 Standing Orders, Night Order #OPS-119 (effective February 8, 2012), requires that the "C-A" phase of the ESF 4.16 KV buses 1A3 and 1B3 be monitored, whenever the ESF buses are electrically aligned to receive power via the SUTs. The "A" and "C" phases are the two phases, which are not monitored (sensed) by the Unit 1 Technical Specification LV and DV relays. This Operations Night Order remains active, but is in the process of conversion to permanent plant procedures. Unit 2 has no similar action, based on the "2-out-of-3" logic used in its Technical Specification LV and DV relay schemes, as discussed above. However, as noted earlier under normal "At-Power" operation the SUTs are not connected to the ESF buses. Therefore if there was a SUT high side line loss, the ESF bus voltages would not be affected. The periodic visual inspections of the Switchyard to SUT lines, as discussed in 0-NOP-99.02 above, would provide reasonable assurance that a loss of a single phase of the Switchyard to SUT circuit would be detected.

## 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.***

At St. Lucie, there are two separate design configurations that affect the consequences. First, are the ESF buses loaded on the SUTs or are the SUTs unloaded? Second, are the two safety trains of ESF buses fed from the same transformer or are the feeds to the two safety trains independent all the way out to and including the switchyard connections? As stated above, each safety train of the Units at ST. LUCIE is fed from its own dedicated transformer with separation all the way into and in the switchyard, so that a transformer failure dropped line or fallen pole can only affect one safety train.

Consequences of Loss of a Single Phase on a SUT Circuit, with the SUTs Unloaded:

The Installed relays were not designed to detect single phase open circuit conditions. In general, there will be no plant response for an unloaded SUT (e.g., ESF buses normally aligned to unit auxiliary transformer) power source in the event of a single-phase open circuit on a credited off-site power circuit.

If a line was dropped when a Unit is operating "At-Power" there would not be an affect on the ESF buses and the operator rounds should find the detached line (if grounded there would also be indication) within a shift of the failure.

St. Lucie Unit 1 and 2 Technical Specifications (TS) provides the following Limiting Condition for Operation TS 3.8.1.1. and Action Statement gives a clear requirement delineating corrective actions, if an AC source or open phase is found:

- (TS 3.8.1.1) requires at "a minimum, the following A.C, electrical sources shall be operable: a) Two physically independent circuits between the offsite transmission network and the onsite Class 1E distribution system."
- Action Statement "a) With one offsite circuit of 3.8.1.1.a inoperable ... determine the OPERABILITY of the remaining A.C. source by performing Surveillance Requirements 4.8.1.1.1.a within 1 hour and at least once per 8 hours thereafter. Restore the offsite circuit to OPERABILITY status within 72 hours or be in at least HOT STANDBY within the next 6 hours and COLD SHUTDOWN within the following 30 hours."

Therefore, once a failed line is found, the associated SUT would be declared out-of-service and the Unit would be in a 72 hour Technical Specification action statement. The other line would be surveilled to validate that it is operable. The SUT connections would be repaired and the SUT would be returned to service.

Consequences of Loss of a Single Phase on a SUT Circuit, with the SUTs Loaded :

Assuming the operators had failed to see a dropped line and/or indication, during their periodic walkdowns, then the Unit could be brought down with one train on a transformer unable to provide full loading. Existing loss of voltage (LV) and degraded voltage (DV) relays on the associated train may respond depending on load and possible grounds, as discussed above for the Units 1 and 2 Technical Specification LV and DV relaying. The plant response for the loaded SUT condition has not been calculated without specifying the amount of loading (controlled shut down, Unit Trip, or Unit trip with SIAS) and the specific loads involved. If there is sufficient load, the voltage will be dragged down on the affected phase(s), as discussed for LV and DV relay schemes for Units 1 and 2 above, and the LV and or DV relays would initiate load shedding and start the EDG for the associated train, as well as transfer that train's loads to the EDG.

If a line is dropped (with or without a high impedance fault) with an unloaded transformer, there is NOT an immediate challenge to nuclear safety by creating a Unit trip; and there is time to detect and address a dropped line or high impedance ground fault before there is any affect on the operating ESF buses. Based on the use of independent Safety trains through the SUTs, overhead lines, and switchyard, a single failure will always leave one train fully functional to the preferred power source.

***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.***

Unit 1 UFSAR section 8.3.1.1.3 (4.16 kV System) states, "The neutrals of both the 4.16 KV and 6.9 KV systems are grounded through grounding transformers and current limiting resistors which enable the systems to operate safely, if a ground fault should occur, until the ground is located and eliminated." Operators performing 0-NOP-99.02 "Watchstation General Inspection Guidelines" in periodic walkdowns should detect the issue before the transformer is actually needed to supply power to the auxiliary power system. Once an abnormal configuration or failure is detected the transformer will be declared out of service and the appropriate action statement will be entered and the transformer issue will be addressed. As the SUTs are not loaded, there would be no affect on the ESF buses that are loaded on the UATs through the Isophase bus from the main generator.

Also, Unit 2 UFSAR section 8.3.1.1.2 (Ground Fault Protection) states, "High resistance grounding is used on the 4.16 kV and 480V systems so that ground fault currents are sufficiently low such that tripping of the affected breaker is not required. Ground faults are detected and alarmed locally or in the control room." Operators performing 0-NOP-99.02 "Watchstation General Inspection Guidelines" in periodic walkdowns should detect the issue before the transformer is actually needed to supply power to the auxiliary power system. Once an abnormal configuration or failure is detected the transformer will be declared out of service and the appropriate action statement will be entered and the transformer issue will be addressed. As the SUTs are not loaded, there would be no affect on the ESF buses that are loaded on the UATs through the Isophase bus from the main generator.

**Impacts on Containment Penetration:**

Unit 2 UFSAR, section 8.3.1.2.2 states, "The low voltage and medium voltage power systems (i.e., nominal 480V ac, 4.16 kV ac, 6.9 kV ac) are high impedance grounded (i.e., connected to station ground through an impedance value aimed to limit line-to-ground faults to less than approximately 10-15 amperes). When an electrical short circuit fault occurs, the predominant fault mode is typically a single line to ground fault as documented in IEEE Standard 500-1977, "IEEE Guide to the Collection and Presentation of Electrical, Electronic and Sensing Component Reliability Data for Nuclear-Power Generating Stations." A high impedance grounding system limited ground fault current would not result in unacceptable degradation of the penetration assembly (e.g., the additional ground current of 10-15 amperes to the 50 amperes full load current of the 4000V CEDM cooling fan motors, has no impact on the penetration which has a 500 ampere continuous current capability). This allows continued system load operation under single line-to-ground fault which for Class 1E circuits provides a margin above the single failure criterion to promote continuity of service. The failure rates for copper conductor power cable reported in Chapter 10 of IEEE Std 500 (listing 10.1.1.1 Power) would indicate that there may be no multiphase shorts for power cables in containment over the licensed plant life."

The above UFSAR statements imply that a high impedance ground will have no immediate effect on plant operation.

1. St. Lucie Units 1 and 2 did not credit in the Current Licensing Basis (CLB) that the Class 1E protection scheme (for the emergency safeguard feature (ESF) buses) was designed to detect and automatically respond to a single-phase open circuit condition on the credited off-site power source as described in the UFSAR and Technical Specifications.

   The offsite power circuits at the St. Lucie Units 1 and 2 consist of two independent circuits from the switchyard bay through the SUT to the ESF 4.16 KV bus.

   At St. Lucie Units 1 and 2, the safety-related equipment are NOT exposed to a degraded unbalanced voltage condition, if a loss of phase event were to occur on its GDC-17 power circuits (i.e. SUTs), as the safety-related Class 1E 4 kV Buses normally receive power from the Unit Auxiliary Transformers.

   Under normal "At-Power" operating mode the power to the ESF busses is from the generator via the Auxiliary Transformers, which are entirely protected with individual phase enclosed buswork. The St. Lucie SUTs only provide back-up power from the Switchyard, (i.e. when the Unit is tripped, shutdown, or undergoing UAT circuit breaker maintenance); which are abnormal plant electrical alignments. The St. Lucie SUTs are credited to satisfy maintaining the availability of the GDC-17 offsite power circuits.

   At St. Lucie Units 1 and 2, the SUT offsite power circuits maintain full Train independence, using independent Train "A" and Train "B" SUTs (4 SUTs for 2 Units), which use independent Train "A" and "B" circuits, which tie into separate Bays (Bays 2 and 4 respectively) in the Switchyard maintaining separation from the 4KV ESF busses all the way through including the switchyard. Therefore, a single failure event could not impact both Safety-Related "A" and "B" Trains. This independent configuration alignment can be seen as shown in the Simplified One-Line Diagram and documented in the UFSAR excerpts (Table 5). This independence feature significantly reduces the potential impact to the Class 1E equipment, as only 1 Train could be impacted, if this event were postulated to occur.

   St. Lucie Units 1 and 2 Technical Specifications (TS) provides the following Limiting Condition for Operation TS 3.8.1.1. and Action Statement gives a clear requirement delineating required corrective actions should an AC source or open phase is found:

- (TS 3.8.1.1) requires at "a minimum, the following A.C, electrical sources shall be operable: a) Two physically independent circuits between the offsite transmission network and the onsite Class 1E distribution system."
- Action Statement "a) With one offsite circuit of 3.8.1.1.a inoperable ... determine the OPERABILITY of the remaining A.C. source by performing Surveillance Requirements 4.8.1.1.1.a within 1 hour and at least once per 8 hours thereafter. Restore the offsite circuit to OPERABILITY status within 72 hours or be in at least HOT STANDBY within the next 6 hours and COLD SHUTDOWN within the following 30 hours."

Therefore, since only one train could be impacted at any single event and with the walkdowns performed every shift under the 0-NOP-99.02 "Watchstation General Inspection Guidelines" with repairs performed in a timely manner and in accordance with the TS Action Statement as specified in the Technical Specifications; then there will always be at least one safety train fully capable to perform in accordance with its intended current Licensing Basis / Design Function.

Since St. Lucie Units 1 and 2 did not credit the ESF bus protection scheme as being capable of detecting and automatically responding to a single phase open circuit condition, an open phase fault was not included in the design criteria for either the loss of voltage, the degraded voltage relay (DVR) scheme or secondary level undervoltage protection system (SLUPS) design criteria. Since open phase detection was not credited in the St. Lucie Units 1 and 2 design or licensing basis, no design basis calculations or design documents exist that previously considered this condition.

2. Without formalized engineering calculations or engineering evaluations, the electrical consequences of such an open phase event (including plant response), can only be evaluated to the extent of what has already been published by EPRI and Basler, which is a generic overview. The difficulty in applying these documents to the St. Lucie Units 1 and 2 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 St. Lucie Units 1 and 2 specific Class 1E electric distribution system (EDS)).

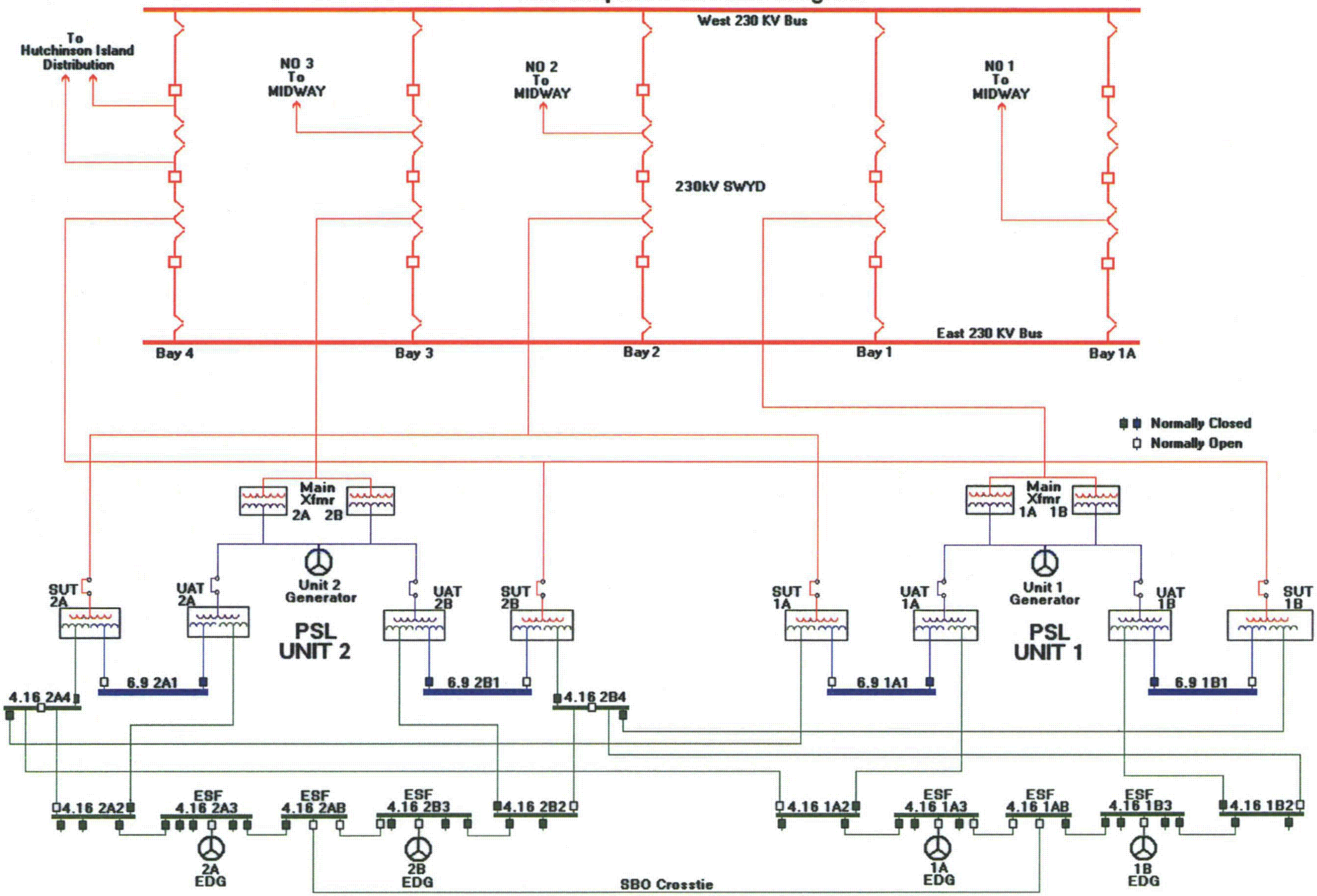
***2.e. If a common or single offsite circuit is used to supply redundant ESF buses, explain why a failure, such as a single-phase open circuit or high impedance ground fault condition, would not adversely affect redundant ESF buses.***

Not applicable since St. Lucie Units 1 and 2 do not use a common or single offsite circuit to supply redundant ESF buses. At St. Lucie Units 1 and 2, the SUT offsite power circuits maintain full Train independence, using independent Train "A" and Train "B" SUTs (4 SUTs for 2 Units), which use independent Train "A" and "B" circuits, that tie into separate Bays (Bays 2 and 4 respectively) in the Switchyard maintaining separation from the 4KV ESF busses all the way through including the switchyard. Therefore, a single failure event could not impact both Safety-Related "A" and "B" Trains. This independent configuration alignment can be seen as shown in the Simplified One-Line Diagram and documented in the UFSAR excerpts (Table 6).

**References**

1. Updated Final Safety Analysis Report 1 Rev. 24; Ch 8 "Electrical Power"
2. Updated Final Safety Analysis Report 2 Rev. 20; Ch 8 "Electrical Power"
3. Preliminary Safety Analysis Report 1 Rev. 5; Ch 8 "Electrical Power"
4. Unit 1 Technical Specifications Rev. 213; Section 3.8.1.1 "Limiting Condition for Operation"
5. Unit 2 Technical Specifications Rev. 163: Section 3.8.1.1 "Limiting Condition for Operation"
6. Calculation EC-195 Rev.0 "St. Lucie Unit 1 Grounding Calculation"
7. Calculation EC-196 Rev.0 "St. Lucie Unit 2 Grounding Calculation"
8. Calculation EC-204 Rev.0 "St. Lucie Switchyard Station Grounding Calculations"
9. ANSI/IEEE Std. 242-1975 Chapter 9, page 192 "IEEE Recommended Practice Protection and Coordination of Industrial and Commercial Power Systems"
10. PCM 197-290D Rev.0, "Unit 2 Design Equivalent Engineering Package associated with replacement of Westinghouse SV Ground Detection Relays on SUTs"
11. Plant Drawing 8770-G-272 Rev. 30; "Unit 1 Main One-Line Wiring Diagram"
12. Plant Drawing 2998-G-272 Rev. 24; "Unit 2 Main One-Line Wiring Diagram"
13. Plant Drawing 2998-G-272A Rev. 12; "Unit 2 Combined Main and Auxiliary One-Line Diagram"
14. Plant Drawing 8770-B-327 shts 901, 903, 1020, and 1022 "Unit 1 Control Wiring Diagrams"
15. Plant Drawing 2998-B-327 shts 901, 903, 1020, and 1022 "Unit 2 Control Wiring Diagrams"
16. Plant Drawing 8770-A-452 shts 24, 25A, 45A, 46A, 57, 58, 59, 65, 66, 67, 115, 116 "Unit 1 Relay Setting Sheets"
17. Plant Drawing 2998-A-452 shts 25A, 45A, 110, 110A, 110B, 111, 111A, 111B "Unit 2 Relay Setting Sheets"

## PSL Simplified One-Line Diagram



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) |
|---|---|---|
| UAT 1A | 4.16 KV SWGR 1A3 | Y |
| UAT 1B | 4.16 KV SWGR 1B3 and 4.16 KV SWGR 1AB | Y |
| UAT 2A | 4.16 KV SWGR 2A3 and 4.16 KV SWGR 1AB | Y |
| UAT 2B | 4.16 KV SWGR 2B3 | Y |

**Table 3 - ESF Buses Normally Energized Major Loads**

| ESF Bus | Load | Voltage Level | Rating (HP) |
|---|---|---|---|
| 4.16 KV SWGR 1A3 | 1A Intake Cooling Water Pump | 4160 V | 600 |
| 4.16 KV SWGR 1A3 | 1A Containment Spray Pump **(Note 1)** | 4160 V | 500 |
| 4.16 KV SWGR 1A3 | 1A Component Cooling Water Pump | 4160 V | 450 |
| 4.16 KV SWGR 1A3 | 1A High Pressure Safety Injection Pump **(Note 1)** | 4160 V | 400 |
| 4.16 KV SWGR 1A3 | 1A Low Pressure Safety Injection Pump **(Note 1)** | 4160 V | 400 |
| 4.16 KV SWGR 1A3 | 1A Auxiliary Feedwater Pump **(Note 1)** | 4160 V | 350 |
| 4.16 KV SWGR 1B3 | 1B Intake Cooling Water Pump | 4160 V | 600 |
| 4.16 KV SWGR 1B3 | 1B Containment Spray Pump **(Note 1)** | 4160 V | 500 |
| 4.16 KV SWGR 1B3 | 1B Component Cooling Water Pump | 4160 V | 450 |
| 4.16 KV SWGR 1B3 | 1B High Pressure Safety Injection Pump **(Note 1)** | 4160 V | 400 |
| 4.16 KV SWGR 1B3 | 1B Low Pressure Safety Injection Pump **(Note 1)** | 4160 V | 400 |
| 4.16 KV SWGR 1B3 | 1B Auxiliary Feedwater Pump **(Note 1)** | 4160 V | 350 |
| 4.16 KV SWGR 1AB | 1C Intake Cooling Water Pump | 4160 V | 600 |
| 4.16 KV SWGR 1AB | 1C Component Cooling Water Pump | 4160 V | 450 |
| 4.16 KV SWGR 2A3 | 2A Intake Cooling Water Pump | 4160 V | 600 |
| 4.16 KV SWGR 2A3 | 2A Containment Spray Pump **(Note 1)** | 4160 V | 500 |
| 4.16 KV SWGR 2A3 | 2A Component Cooling Water Pump | 4160 V | 450 |
| 4.16 KV SWGR 2A3 | 2A High Pressure Safety Injection Pump **(Note 1)** | 4160 V | 400 |

| ESF Bus | Load | Voltage Level | Rating (HP) |
|---|---|---|---|
| 4.16 KV SWGR 2A3 | 2A Low Pressure Safety Injection Pump **(Note 1)** | 4160 V | 400 |
| 4.16 KV SWGR 2A3 | 2HVE-21A CEDM Cooling Fan | 4160 V | 400 |
| 4.16 KV SWGR 2A3 | 2A Auxiliary Feedwater Pump **(Note 1)** | 4160 V | 350 |
| 4.16 KV SWGR 2B3 | 2B Intake Cooling Water Pump | 4160 V | 600 |
| 4.16 KV SWGR 2B3 | 2B Containment Spray Pump **(Note 1)** | 4160 V | 500 |
| 4.16 KV SWGR 2B3 | 2B Component Cooling Water Pump | 4160 V | 450 |
| 4.16 KV SWGR 2B3 | 2B High Pressure Safety Injection Pump **(Note 1)** | 4160 V | 400 |
| 4.16 KV SWGR 2B3 | 2B Low Pressure Safety Injection Pump **(Note 1)** | 4160 V | 400 |
| 4.16 KV SWGR 2B3 | 2HVE-21B CEDM Cooling Fan | 4160 V | 400 |
| 4.16 KV SWGR 2B3 | 2B Auxiliary Feedwater Pump **(Note 1)** | 4160 V | 350 |
| 4.16 KV SWGR 2AB | 2C Intake Cooling Water Pump | 4160 V | 600 |
| 4.16 KV SWGR 2AB | 2C Component Cooling Water Pump | 4160 V | 450 |

NOTE 1: Equipment aligned to receive power from associated switchgear but not normally running.

**Table 4 - Offsite Power Transformers**

| Transformer | Winding Configuration | MVA Size (OA/FA/FOA 55C/FOA ) | Voltage Rating (Primary H / Secondary: X and Y) | Grounding Configuration |
|---|---|---|---|---|
| *e.g. Start-up Transformer 242* | *Wye-Wye-Wye (3 Leg)* | | | *Neutral Grounded* |
| Start-Up Transformer SUT 1A | *Wye-Wye-Wye (3 Leg)* | 21/28/35/39.2 MVA<br>12.6/16.8/21/23.6 MVA<br>8.4/11.2/14/15.7 MVA | H: 218.5/**224.25**/230.0/235.75/241.0 KV<br>X: 6.9 KV<br>Y: 4.16 KV | Neutral Grounded<br>XFMR 37.5KVA .885Ω<br>XFMR 25KVA 1.6Ω |
| Start-Up Transformer SUT 1B | *Wye-Wye-Wye (3 Leg)* | 21/28/35/39.2 MVA<br>12.6/16.8/21/23.52 MVA<br>8.4/11.2/14/15.68 MVA | H: 218.5/**224.25**/230.0/235.75/241.5 KV<br>X: 6.9 KV<br>Y: 4.16 KV | Neutral Grounded<br>XFMR 37.5KVA .885Ω<br>XFMR 25KVA 1.6Ω |
| Start-Up Transformer SUT 2A | *Wye-Wye-Wye (3 Leg)* | 21/28/35/39.2 MVA<br>12.6/16.8/21/23.6 MVA<br>8.4/11.2/14/15.7 MVA | H: 218.5/**224.25**/230.0/235.75/241.0 KV<br>X: 6.9 KV<br>Y: 4.16 KV | Neutral Grounded<br>XFMR 37.5KVA .885Ω<br>XFMR 25KVA 1.6Ω |
| Start-Up Transformer SUT 2B | *Wye-Wye-Wye (3 Leg)* | 21/28/35/39.2 MVA<br>12.6/16.8/21/23.52 MVA<br>8.4/11.2/14/15.68 MVA | H: 218.5/**224.25**/230.0/235.75/241.5 KV<br>X: 6.9 KV<br>Y: 4.16 KV | Neutral Grounded<br>XFMR 37.5KVA .885Ω<br>XFMR 25KVA 1.6Ω |

**Table 5A - Protective Devices**

| Protection Zone | Protective Device | UV Logic | Relay Setpoint (Nominal) | Basis for Setpoint |
|---|---|---|---|---|
| *Unit 1 4 KV ESF Bus (1A3/1B3)* | *Loss of Voltage Relay* | *2 of 2* | *3118.5V (75% of 4160V)* | *To actuate upon loss of ESF Bus voltage condition* |
| *Unit 2 4 KV ESF Bus (2A3/2B3)* | *Loss of Voltage Relay* | *2 of 3* | *3297.0V (79.3% of 4160V)* | *To actuate upon loss of ESF Bus voltage condition* |
| *Unit 2 480V ESF Bus (2A2/2B2)* | *Loss of Voltage Relay* | *2 of 3* | *363.6V (75.8% of 480V)* | *To actuate upon loss of ESF Bus voltage condition* |
| *Unit 2 480V ESF Bus (2A5/2B5)* | *Loss of Voltage Relay* | *2 of 3* | *363.6V (75.8% of 480V)* | *To actuate upon loss of ESF Bus voltage condition* |
| *Unit 1 4 KV ESF Bus (1A3/1B3)* | *Degraded Grid* | *2 of 2* | *3916.5V (94.1% of 4160V)* | *To actuate upon Degraded ESF Bus voltage condition* |
| *Unit 2 480V ESF Bus (2A2/2B2)* | *Degraded Grid* | *2 of 3* | *434.8V (90.6% of 480V)* | *To actuate upon Degraded ESF Bus voltage condition* |
| *Unit 2 480V ESF Bus (2A5/2B5)* | *Degraded Grid* | *2 of 3* | *440.0V (91.7% of 480V)* | *To actuate upon Degraded ESF Bus voltage condition* |
| *Unit 1 480V ESF Bus (1A2/1B2)* | *Degraded + SIAS* | *2 of 2* | *418.8V (87.3% of 480V)* | *To actuate upon bus Degraded Voltage + SIAS Event* |
| *Unit 2 4 KV ESF Bus (2A3/2B3)* | *Degraded + SIAS* | *2 of 3* | *3881.5V (93.3% of 4160V)* | *To actuate upon bus Degraded Voltage + SIAS Event* |

**Table 5B – Ground Protective Devices**

| Component Parameters | | Startup Transformer 1A/1B | | Startup Transformer 2A/2B | |
|---|---|---|---|---|---|
| Component | Parameter | SEC (6.9 kV) | SEC (4.16 kV) | SEC(6.9 kV) | SEC (4.16 kV) |
| Total System Capacitance | Value (micro farad) | 0.71 µF | 1.29 µF | 0.740 µF | 1.20 µF |
| Distribution Transformer | Voltage Ratio | 240V/7200V | 240V/4160V | 240V/7200V | 240V/4160V |
| | KVA Rating | 37.5kVA | 25kVA | 37.5kVA | 25kVA |
| Primary Fault Currents | Capacitive Component | 3.20 Amps | 3.50 Amps | 3.33 Amps | 3.26 Amps |
| | Resistive Component | 4.96 Amps | 4.95 Amps | 4.96 Amps | 4.95 Amps |
| | Total Ground Fault Current (Primary) | 5.90 Amps | 6.06 Amps | 5.97 Amps | 5.93 Amps |
| Grounding Resistor | Power Rating | 20 kW | 12 kW | 20 kW | 12 kW |
| | Resistance | 0.885 ohms | 1.6 ohms | 0.885 ohms | 1.6 ohms |
| | Max Sec. Current across Grounding Resistor | 150.3 Amps | 85.3 Amps | 150 Amps | 85.4 Amps |
| | Max. Voltage across Grounding Resistor | 133Vac | 136.5 Vac | 133Vac | 137Vac |
| **Relay Setting** | Max Relay Operating Voltage | 199Vac | 199Vac | 199Vac | 199Vac |
| | Tap (Volts) | 16 Vac | 16 Vac | 16 Vac | 16 Vac |
| | Approx. Dial | 1 | 1 | 1 | 1 |
| | TD - 8xTAP (sec.) | 0.60 | 0.60 | 0.60 | 0.60 |

**Table 5C – Ground Fault Annunciator Windows**

| Equipment | | Ground Detection Relay | Annunciator | Window | CWD/Ref |
|---|---|---|---|---|---|
| SUT 1A | 6.9 kV SWGR | 64/STA-1 | B | B-31 | RTGB 101 /901/1020 |
| | 4.16 kV SWGR | 64/STA-2 | B | B-32 | RTGB 101 /901/1020 |
| SUT 1B | 6.9 kV SWGR | 64/STB-1 | A | A-31 | RTGB 101 /903/1022 |
| | 4.16 kV SWGR | 64/STB-2 | A | A-32 | RTGB 101 /903/1022 |
| SUT 2A | 6.9 kV SWGR | 64/STA-1 | B | B-31 | RTGB 201 /901/1020 |
| | 4.16 kV SWGR | 64/STA-2 | B | B-32 | RTGB 201 /901/1020 |
| SUT 2B | 6.9 kV SWGR | 64/STB-1 | A | A-31 | RTGB 201 /903/1022 |
| | 4.16 kV SWGR | 64/STB-2 | A | A-32 | RTGB 201 /903/1022 |

**Table 6A – Unit 1 Current Licensing Basis**

| UFSAR | Unit 1<br>Description |
|---|---|
| 8.1.1 | ...The Transmission network can provide power to the plant for operation of the plant onsite auxiliary power system during start-up or for plant operation, shutdown or accident conditions. |
| 8.1.2.1 | The offsite transmission system is designed to provide reliable facilities to accept the electrical output of the plant and to provide offsite power for supplying the plant auxiliary power system for station startup, shutdown, or at any time that auxiliary power is unavailable from the unit auxiliary transformers. The system meets the requirements of AEC GDC 17 and Safety Guide 32. |
| 8.2.1.2 | A five bay 230KV (nominal) switchyard provided switching for main generator output, each on the two SUTs and the three outgoing transmission lines. ..<br><br>The east pull-off tower Bay No.2 serves SUTs 1A and 2A located in the Unit 1 transformer yard. Both transformers 1A and 2A are connected to a single overhead line from the switchyard. The 1B and 2B SUTs are located in the Unit No 2 transformer yard and are served from the east pull-pull-off tower Bay No 4 as is done for 1A and 2A startup transformer. Either set of transformers, 1A and 2A or 1B and 2B, can be supplied from any on of the transmission lines. |
| 8.2.1.3 | Each startup transformer (SUT), 1A and 1B, is rated 21/28/35/39.2 MVA ..., double secondary winding, 230 – 6.9 – 4.16 KV. The SUT 1A 6.9 KV secondary is rated 12.6/16.8/21.0/23.6 MVA and 4.16 KV secondary is rated 8.4/11.2/14.0/15.7 MVA, OA/FA/FOA ... The SUT 1B 6.9 KV secondary is rated 8.4/11.2/14.0/15.7 MVA and 4.16 KV is rated 8.4/11.2/14.0/15.68 MVA, OA/FA/FOA...<br><br>The SUTs are sized to accommodate the auxiliary loads of the unit under any operating or accident condition. |
| 8.2.2.2.d.5 | Physical independence of power for the SUTs is achieved by separating their switchyard 230 KV connections in two different bays. Each bay consists of separate circuit breakers and associated equipment to connect the SUTs with two main 230 KV buses. Two spatially separated over-head lines are used to supply power to the SUTs (one line for SUTs 1A and 2A in the Unit 1 Transformer yard, and online for SUTs 1B and 2B in the Unit 2 Transformer yard). |
| 8.3.1.1.1 | The normal source of auxiliary ac power for plant start-up or shutdown is from the incoming off-site transmission lines through the plant switchyard and SUTs. The SUTs step down the 230 KV incoming line voltage to 6.9 KV for auxiliary system use. During normal plant operations, ac power is provided from the main generator through the unit auxiliary transformers. The UATs step down the main generator output voltage from 22kV to 6.9 KV and 4.16 KV.<br><br>Normal transfer of 6.9 KV or 4.16 KV auxiliary buses between the unit auxiliary and SUTs will be initiated by the operator from the control room; emergency transfer from the auxiliary transformer |

| Unit 1 | |
| --- | --- |
| **UFSAR** | **Description** |
| | to the start-up transformer will be initiated automatically by protective relay action. |

**Table 6B – Unit 2 Current Licensing Basis**

| | **Unit 2** |
|---|---|
| **UFSAR** | **Description** |
| 8.2.1.2 | A five bay 230KV (nominal) switchyard provides switching capability for two generator ouputs, four SUTs, three outgoing transmission lines, and one distribution substation.<br><br>The east pull-off tower in bay 2 supplies power via a single overhead line to SUTs 1A and 2A, located in the St.Lucie Unit 1 transformer yard. The east pull-off tower in Bay 4 supplies power via 3 single overhead line, to SUTs 1B and 2B located in the St.Lucie Unit 2 transformer yard. Either set of SUTs can be fed from any one of the incoming transmission lines. |
| 8.2.1.5 | Each Startup Transformer (SUT) 2A and 2B, is rated 21/28/35/39,2 MVA: SUT 2A – oil air/forced air/forced oil and air... (OA/FA/FOA). SUB 2B oil air/forced oil and air/forced oil and air... (OA/FOA/FOA), double secondary winding, 230 – 6.9 – 4.16KV. The SUT 2A 6.9 KV secondary is rated 12.6/16.8/21.0/23.6 MVA and 4.16 KV secondary is rated 8.4/11.2/14.0/15.7 MVA, OA/FA/FOA... The SUT 2B 6.9 KV secondary is rate 12.6/16.8/21.0/23.52 MVA and 4.16 KV secondary is rated 8.4/11.2/14.0/15.68 MVA, OA/FOA /FOA..<br><br>The SUTs do not perform a safety function and are not safety-related. During normal plant operation each of the two SUTs is in standby and is available to provide offsite (Preferred) power. The transformers are sized to accommodate the auxiliary loads of the unit under any operating conditions, including orderly shutdown and cooldown, or the mitigation of design basis accident (DBA) loads. |
| 8.2.1.6 | The 6.9 kV and 4.16 kV switchgear, located in the Turbine Building switchgear rooms receive power from the unit auxiliary or startup transformer and distribute power to non-safety related loads and the Onsite Power System. |
| 8.2.2.1.3 | A single breaker failure to trip does not result in loss of both lines to the SUTs, because there are always at least two breakers in series between the two lines. |
| 8.2.2.1.6.e | Physical independence of power for SUTs is achieved by separating their switchyard 230kV connection in two different bays. Each bay consists of separate circuit breakers and associated equipment to connect the SUTs with two main 230KV busses. Two spatially separated over-head lines are used to supply power to the SUTs (one line for SUTs 1A and 2A in Unit 1 transformer yard, and one line for SUTs 1B and 2B in the Unit 2 transformer yard). |
| 8.2.2.2.a | Two physically independent circuits are provided for offsite power. Although in the same right of way, the two startup transformer lines are spaced sufficiently far apart, such that a falling tower cannot involve the other over-head line. |
| 8.2.2.2.b | All circuits are normally energized so that either is available immediately to provide sufficient power to assure that fuel design and reactor coolant pressure design limits are not exceeded, assuming loss |

| Unit 2 | |
|---|---|
| **UFSAR** | **Description** |
| | of all onsite power. |
| 8.2.2.2.c | The transformers associated with Offsite Power System... They are located sufficiently apart so as to prevent any damage that may occur in one transformer from occurring in the other. |
| 8.2.2.2.d | The two Startup transformer lines connected are electrically separated by at least two circuit breakers in series, at the switchyard. Two breakers would have to fail to trip in order for a fault in one line to involve the other. |
| 8.2.2.2 | Each transmission line may be tested for operability and functional performance independently of each other. The lines are physically independent.<br><br>Transfer of power between the startup and the UATs is provided by in-plant equipment (not at the switchyard) and may be initiated by the plant operator at any time the unit is on line.<br><br>The "fast dead bus" power transfer from the unit auxiliary transformer to the startup transformer (only a one way transfer) as described in Subsections 8.3.1.1.1 and 8.3.1.1.2... |
| 8.3.1.1.1 | The preferred source of auxiliary ac power for plant startup and shutdown is from the incoming offsite transmission lines, through the plant switchyard and SUTs. The SUTs step down the 230 kV line voltage to 6.9 kV and 4.16kV for auxiliary system use.<br><br>During plant operation, ac power is provided from the main generator through the unit auxiliary transformers.<br><br>... Power is also distributed from the two 4.16 kV buses 2A2 and 2B2 to the safety related 4.16 kV buses 2A3 and 2B3, which supply all safety related loads ...<br><br>Transfer of the 6.9 kV or 4.16 kV auxiliary buses between the unit auxiliary and SUTs is initiated by the operator from the control room. Routine bus transfers used on startup and shutdown of a unit are "Live bus" transfers, i.e., the incoming source feeder circuit breakers are momentarily paralleled with the running source feeder breakers. This results in transfer without power interruption.<br><br>Bus transfers, initiated automatically by protective relaying action, are "fast-dead" bus transfers. |

**Table 6C – Unit 1 Original Licensing Basis**

| **Unit 1** | |
|---|---|
| **UFSAR** | **Description** |
| 8.2.1.2.d | . . . Each star-up transformer is connected through motor operated disconnect switches to a separate main bus. |
| 8.2.2.2 | Unit 1 is provided with two half-capacity auxiliary transformers and two half-capacity SUTs with the later fed via separate overhead 240 KV ties from the switchyard.<br><br>Each auxiliary transformer is directly connected to the main generator 22 KV isolated phase bus with disconnectable taps, and is provided with a double secondary to supply 6.9 KV and 4.16 KV power for the Unit under normal operating conditions. . .<br><br>The two half-capacity SUTs provide SUTs provide start-up power and full capacity reserve auxiliary service from the 240 KV switchyard in the event of auxiliary transformer nonavailability. During availability of the 240 KV system, the SUTs provide the preferred source for normal and emergency shutdown requirements and safeguards loads.<br><br>Each unit auxiliary transformer powers one 6.9 KV bus, 4160 KV normal bus and one 4.16 KV redundant emergency bus. Alternatively, these buses are powered by a start-up transformer. |
| 8.2.2.4 | During normal operation the UATs will supply the normal and emergency 4.16 KV buses through sectionalizing tie breakers.<br><br>Normal transfer of the 6.9 KV and 4.16 KV auxiliary buses between the Unit auxiliary and standby sources will be initiated by the operators from the control room; emergency transfer from the auxiliary transformer to the start-up transformer will be initiated automatically by protective relay action.<br><br>Normal bus transfers used on start-up or shutdown of a Unit will be "Live bus" transfers, . . .Emergency bus transfers, initiated automatically by protective relay action, will be "Fast-Dead" bus transfers. |