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U. S. Nuclear Regulatory Commission
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Washington, DC 20555-0001

SUSQUEHANNA STEAM ELECTRIC STATION
90-DAY RESPONSE TO NRC BULLETIN 2012-01
PLA-6919

Docket No. 50-387
and 50-388

Reference: NRC Bulletin 2012-01: "Design Vulnerability in Electric Power System," dated July 27, 2012.

The Nuclear Regulatory Commission (NRC) issued Bulletin 2012-01, "Design Vulnerability in Electric Power System," dated July 27, 2012, to request each licensee to provide a comprehensive verification of 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). Addressees are required to provide a written response to the NRC in accordance with 10 CFR 50.54(f).

In Bulletin 2012-01, the NRC requested each licensee to submit a written response within 90 days of the date of the Bulletin, which was provided in the reference above.

The attachment to this letter forwards the PPL response, within 90 days of the date of the Bulletin, which addresses the requested information.

This response is submitted in accordance with 10 CFR 50.54(f).

There are no new regulatory commitments contained in this letter.

If you have questions regarding this letter please contact Mr. Duane L. Filchner at (610) 774-7819.

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

Executed on 10/24/12

Sincerely,

J. M. Helsel

Enclosure: 90-Day Response to Bulletin 2012-01

Copy: NRC Region I
Mr. P. W. Finney, NRC Sr. Resident Inspector
Mr. J. A. Whited, NRC Project Manager
Mr. L. J. Winker, PA DEP/BRP

ENCLOSURE TO PLA-6919

90-DAY RESPONSE TO BULLETIN 2012-01

The following PPL response to NRC Bulletin 2012-01 has been prepared consistent with the template developed by an NEI focus group for use in responding to the NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System."

For clarity, responses to the individual items in the Bulletin are grouped according to the following overview.

- SYSTEM DESCRIPTION – ITEMS 2., 1.d, 2.a, and 2.c
- SYSTEM PROTECTION – ITEMS 1., 1.a, 2.b, and 2.d
- CONSEQUENCES – ITEMS 1.b, 1.c, and 2.e
- ATTACHMENTS

  Attachment 1: SSES Simplified One-Line Diagram

  Attachment 2: Tables

  Table 1: 4.16kV ESF Buses Continuously Powered from Offsite Power Source(s)
  Table 2: 4.16kV ESF Buses Major Loads
  Table 3: Offsite Power Transformers
  Table 4: Protective Devices

SYSTEM DESCRIPTION – ITEMS 2., 1.d, 2.a, and 2.c

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).***

At PPL Susquehanna, (SSES) offsite electrical power sources are supplied by two independent sources via startup transformers T10 and T20 and are shared by both units. One source is supplied from the Susquehanna T10 230kV Switchyard located to the east of the plant. The Susquehanna T10 230kV Switchyard is supplied by two 230 kV transmission lines, the Mountain-Susquehanna T10 and Montour-Susquehanna T10 lines. Several lines feed the Montour Switchyard and Mountain Substation thereby offering a multitude of possible supplies for the Susquehanna startup transformer T10.

The second offsite power source is supplied at 230 kV from the yard tie circuit between the Susquehanna 500 kV and 230 kV Switchyards south of the plant. (FSAR 8.2.1.1)

The startup transformers T10 and T20 convert the 230kV Offsite power to 13.8kV power for use by the auxiliary plant equipment. Startup transformers T10 and T20 supply startup Bus 10 and 20 respectively and each startup bus can supply both units via the startup tie bus.

The startup buses supply 13.8 kV power to the Engineered Safeguard System (ESS) Buses, Auxiliary Buses 11(12) A/B (during plant startup and shutdown conditions), Makeup Water Auxiliary Equipment, and Auxiliary Boilers.

During at power (normal operating condition), the auxiliary buses 11(12) are powered by the Main Generators. The Unit 1 Main Generator supplies 24 kV power to Unit Auxiliary Transformer T-11, where power is reduced to 13.8 kV to power Auxiliary Buses 11A and 11B. The Unit 2 Main Generator supplies Auxiliary Buses 12A and 12B through Unit Auxiliary Transformer T-12, where power is reduced to 13.8 kV to power Auxiliary Buses 12A and 12B.

The 13.8 kV Distribution System is a Non-Class 1E System, but provides a preferred and an alternate source of AC electric power via ESS transformers to all safety-related loads through the Class 1E 4.16 kV Distribution System. The Class 1E AC System distributes power at 4.16kV, 480 V and 208/120 V to the loads. Each of the Class 1E 4.16kV Engineered Safeguard System (ESS) buses is normally powered via one of the two 13.8kV Offsite power sources.

Each unit has four 4.16kV ESS Buses, identified as ESS bus 1A (2A), 1B (2B), 1C (2C), and 1D (2D). These ESS Buses are divisionalized. Division 1 is comprised of ESS buses A and C, and Division 2 is comprised of buses B and D.

Each 4.16kV ESS bus is normally supplied by the preferred power source. If the preferred power source is not available at the 4.16kV bus, automatic transfer is made to the alternate power source. If both preferred and alternate power feeders become de-energized, the safety related loads on each bus are picked up automatically by the Class 1E standby diesel generator assigned to that bus. The station has four diesel generators shared between the two units. Each DG can be connected to its respective 4kV bus in each unit i.e. DG "A" can be connected to Unit 1 4.16kV Bus 1A and Unit 2 4.16kV Bus 2A. Additionally, a spare fifth diesel generator (E-diesel) with sufficient loading capacity is provided and can be manually aligned as a replacement for any one of the other four diesel generators.

The Class 1E AC system is divided into four load group channels per generating unit (load group channel A, B, C, and D). Each load group has its own distribution system and power supplies. All class 1E AC loads are divided among the four load group so that any combination of three out of four load groups has the capability of supplying the minimum required safety loads to safely shutdown the unit and maintain it in safe shutdown condition. (FSAR Sections 8.3.1.3 and 8.3.1.3.3)

See Attachment 1: SSES Simplified One-Line Diagram for plant ESF buses lineup with preferred and alternate offsite power sources as well as the standby diesel generators.

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

See Attachment 2 - Table 3, for offsite power transformer winding and grounding configurations.

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

During at power (normal operating condition) configurations, each 4.16kV ESF bus is powered by offsite power sources via ESS transformers (13.8kV-4.16kV). The startup buses also supply power to the intake structure transformers and associated loads which are non-Class 1E.

See Attachment 2 - Table 1 for ESF bus power sources
See Attachment 2 – Table 2 for ESF bus major loads connected 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 plant preferred and alternate offsite power for the engineered safety systems is provided from two independent offsite sources. The following at power (normal operating condition) configurations have been confirmed to be consistent with the current licensing basis.
(FSAR 8.3.1.3.1 and 8.3.1.3.3):

- A 230kV line from the Susquehanna T10 230 switching station feeds start-up transformer No.10 (T10). T10 provides normal and alternate offsite power source to both units' ESF buses (1A, 1C, 2A, 2C) and (1B, 1D, 2B, 2D), respectively. The Susquehanna T10 230 kV switchyard is supplied by two 230kV transmission lines, the Mountain-Susquehanna T10 and Montour-Susquehanna T10 lines.

- A 230 kV tap from the 500-230kV tie line feeds the start-up transformer No. 20 (T20). T 20 provides normal and alternate offsite power source to ESF buses (1B, 1D, 2B, 2D) and (1A, 1C, 2A, 2C) respectively. The second offsite power supply is supplied by multiple sources throughout the bulk power grid system through the 230kV and 500kV lines emanating from the Susquehanna 230kV and 500kV switchyards.

See Attachment 2 - Table 1 for the offsite power source alignment to the ESF buses. No configuration changes have been made from the original plant licensing.

SYSTEM PROTECTION – ITEMS 1., 1.a, 2.b, and 2.d

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

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

Consistent with the current licensing basis and GDC 17, existing protective circuitry will separate the ESF buses from a connected failed offsite source due to a short circuit condition, loss of voltage or a sustained balanced degraded grid voltage. The relay systems were not specifically designed to detect a single phase open circuit of a three phase system. Detection of a single-phase open circuit condition is beyond the approved design and licensing basis of the plant.

SSES offsite power is supplied by two independent sources, via Startup Transformers T10 and T20, shared by both Unit 1 and Unit 2. The Class 1E power system for each unit consists of four independent load group channels, channels A, B, C, and D. Each load group has its own distribution buses and loads. Minimum ESF loads required to shutdown the unit safely and maintain it in a safe shutdown condition are met by any three out of four load group channels. In addition, two divisionalized load groups are established for those ESF loads which require one out of two load groups to meet the design basis requirements. Division 1 is comprised of ESS buses A and C, and Division 2 is comprised of buses B and D. As such, under normal lineup conditions, a single phase open circuit event on one offsite power source will cause a potential loss to only one division of the distribution system for each unit. The other division, fed from the other Startup transformer would see no adverse conditions (i.e., an open phase event in the T10 230kV switchyard would potentially affect T-10 along with associated preferred power source to division 1 load group channels A and C, while T-20 and the division 2 load groups it provides preferred power would see no adverse conditions).

The 4.16kV Class 1E undervoltage detection and backup bus transfer on loss of offsite power or sustained degraded voltage on the bus are provided by (1) incoming feeder undervoltage relay-device 27AI, (2) bus undervoltage relay-device (27A), and (3) degraded voltage protection relay devices 27B1, 27B2, 27B3, and 27B4. Degraded voltage relays (DVRs) 27B1 and 27B2 make up one level of SSES multiple levels of undervoltage relays used to detect degraded power supply voltage. These relays operate on a two-out-of two logic scheme and are intended to detect sustained degraded voltage at 4.16kV buses and initiate bus transfer. Although the DVR scheme was not designed for detection and automatic response of unbalanced open phase conditions on a credited offsite power circuit and the analytical model is still under development as a long term solution, engineering judgment suggests that under some postulated single-phase open circuit conditions, the ESF bus voltage could drop below the dropout value of these relays. However due to startup transformer light loading during normal operation and the automatic operation of its Load Tap Changer (LTC), the 4.16kV ESF bus voltage is anticipated to recover above the DVR reset value within the 5 minute non-accident time delay in effect during normal operation. Therefore, the existing SSES DVR protection scheme for 4.16kV ESF buses can not ensure its ability to detect and automatically respond to all postulated single-phase open circuit conditions on a credited offsite power circuit.

The SSES electrical offsite circuit protection schemes have been surveyed with regard to high impedance ground fault detection. Currently there is no protection scheme installed explicitly to detect and automatically respond to high impedance ground fault conditions in the offsite transmission system or in the onsite Class 1E 4.16kV system. A plant specific analysis of high impedance fault conditions has not been developed to determine the effects on safety related ESF equipment.

At SSES the startup transformer yards are physically separated from each other. On the primary side, the incoming 230 kV line is connected to the startup transformers using aluminum conductor steel reinforced (ACSR) bare conductors. On the secondary side (13.8kV), insulated cables are run in underground conduits between the startup transformers and the turbine building, where a transition to a non-segregated bus duct is made to establish the tie to the 13.8kV startup buses. As such, based on routings and enclosures on the low voltage side of the startup transformer, a postulated scenario in which a phase primary conductor will make unwanted electrical contact with a surface restricting the flow of fault current to a level below that reliably detectable by existing overcurrent devices is unlikely. Primary protection of the T10 Tap 230kV line is provided by a microprocessor based phase and ground distance scheme with inherent ground overcurrent backup systems and fault location capabilities. Backup protection of this circuit is provided by a microprocessor based phase distance and directional ground overcurrent schemes with fault locating capabilities. Both primary and backup schemes are continuously self-monitored and alarm to the Alarm Management System (AMS) at the Susquehanna T10 230kV Switchyard. Line relay protection for the 230kV Yard Tie circuit is provided by fully independent primary and backup relay systems. The primary protection system is a microprocessor-based line differential scheme, and the backup protection system is a microprocessor-based permissive overreaching transfer trip scheme with inherent two-zone phase-distance and directional ground-overcurrent protection in the event of channel failure. Both primary and backup systems and their associated communication channels are continuously self-monitoring for maximum reliability. Review of the aforementioned line protection relay settings and offsite circuit configuration has been performed. High impedance ground fault current magnitudes, generally considered to vary anywhere from zero to less than 100 A, are not expected to reach the required pick-up value for relay actuation. Normal system unbalances limit the sensitivity of existing ground protection and, existing line protection devices are not expected to reliably detect fault impedance greater than approximately 100 ohms.

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 designed to detect a single phase open circuit condition.

Electrical protection of startup buses, in the event of abnormal operation, is provided for high differential current, bus overcurrent, ground faults. These protective devices actuate lockout relays (primary and/or backup) that operate to maintain isolation on the occurrence of abnormal conditions. The startup buses are also protected against bus undervoltage conditions.

See Attachment 2 Table 4 for 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 SSES are powered by two independent offsite power sources designated as preferred and alternate power supplies.

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 off-normal operating procedures, specifically require verification of the voltages on all three phases of the ESF buses.

CONSEQUENCES – ITEMS 1.b, 1.c, and 2.e

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

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

Installed relays were not designed to detect single phase open circuit conditions. Existing loss of voltage and degraded voltage relays may respond, depending on load and possible grounds. In general, there will be no plant response for an unloaded (e.g., ESF buses normally aligned to unit auxiliary transformer) power source in the event of a single-phase open circuit on a credited off-site power circuit, because there is insufficient current to detect a single-phase open circuit for this configuration. SSES 4.16kV ESF buses are aligned to their respective offsite power transformers which are lightly loaded during normal operation. Light load conditions on the startup transformer are expected to minimally affect phase voltage levels under single-phase open circuit conditions. Therefore, existing voltage monitoring devices are unlikely to detect such conditions.

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

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.

SSES 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 FSAR and Technical Specifications (FSAR 8.3.1.3.6; TS Bases 3.8.1).

Two independent offsite power sources are supplied to the Susquehanna plant via startup transformers T10 and T20 shared by both units. One source is supplied from the Susquehanna T10 230kV switchyard to the startup transformer T10, and the second offsite power source is supplied at 230kV from the yard tie circuit to startup transformer T20. The second offsite power supply is furnished by multiple sources throughout the bulk power grid system through the 230kV and 500kV lines emanating from the Susquehanna 230kV and 500kV switchyards. Offsite power (preferred and alternate) is then supplied to 4.16kV ESF buses by ESS transformers connected to startup buses (See Attachment 1: SSES Simplified One-Line Diagram).

Since SSES did not credit the ESF bus protection scheme as being capable of detecting and automatically responding to a single phase open condition, an open single-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 design criteria. As such, open phase detection was not credited in the SSES design or licensing basis, no design basis calculations or design documents exist that previously considered this condition.

Without formalized engineering calculations or engineering evaluations, the electrical consequences of such an open phase event (including plant response), can only be evaluated to the extent of what has already been published by EPRI report 1025772 [1] and Basler technical report [2]; which is a generic overview. The difficulty in applying these documents to the SSES 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 analytical models are still under development as a long term solution (e.g., transformer magnetic circuit models, electric distribution models, motor models; including positive, negative, and zero sequence impedances (voltage and currents)), and they will need to be compiled and analyzed for the SSES specific Class 1E electric distribution system (EDS).

During normal plant operation, startup transformers T10 and T20 are lightly loaded and circuit breakers to Safety Related loads fed off 4.16kV ESF buses are typically opened. Major running loads such as the Turbine Building and Reactor Building Chillers and the CRD pumps are Non- Class 1E loads. A single phase open circuit condition on one offsite power source would have minor immediate impact during normal plant operation. SSES Class 1E power system for each unit consists of four independent load group channels. Minimum ESF loads required to safely shutdown the unit and maintain it in safe shutdown conditions are met by any three out of four load group channels. In addition, two divisionalized load groups are established for those ESF loads, which require one out of two load groups to meet the design basis requirements. An open single-phase condition on one offsite power source will potentially affect only one load group division. The other division fed from the other startup transformer would not see adverse conditions. Each startup transformer rating provides the necessary capacity to accommodate required loads on all eight ESF buses for both units (See Attachment 1 and/or Attachment 2 Table 1 for reference).

Following the Byron event, SSES reviewed it's susceptibility to a potential single-phase open circuit condition. The following interim compensatory measures to evaluate the extent of applicability were performed:

- An initial walkdown of Susquehanna switchyards (T10, 230kV and 500kV) was completed by PPL Electric Utilities (PPL EU) to identify the type and mounting configuration of insulators currently installed within these switchyards. Walkdowns were completed on equipment available for visual inspection, and manufacturer documentation was reviewed for installed insulators. Currently, no Ohio Brass insulators have been identified and only one (1) underhung configuration in the 500kV switchyard was found.

- For equipment where a visual identification could not be performed, PPL EU shall perform an inspection of the remaining insulators/equipment within all three Susquehanna switchyards during upcoming outages for verification of no installed Ohio Brass insulators. An action to track and document PPL EU findings was created in the station's corrective action program (CAP).

- A visual inspection of the lines and insulators for identification of abnormalities was added to PPL EU weekly walkdown of the three Susquehanna switchyards. Per the switchyard interface agreement, any abnormalities will be reported to the PPL Susquehanna Control Room and Station Engineering.

To support Operators in promptly diagnosing and responding to a single-phase open circuit condition on offsite power supplies to Class 1E ESF buses, the following actions have been established in Operational Decision-Making (ODM) Implementation Plan 1578080:

A possible single phase open circuit condition on either offsite power source may be detected through one or more of the following:

- Receipt of a "4kV Bus Lo Volt / Prot Ckt Trouble Alarm." This is a common alarm received through the actuation of one of two DVRs (27B1 or 27B2) designed to detect a 4kV bus undervoltage condition.

- Various unexplained trips and/or overloads of 4kV and/or 480V motors during starts / accelerations.

Upon receipt of any of the above conditions, the following actions shall be taken:

- Identify affected 4kV buses and associated switchgear (0A103 or 0A104).

- Dispatch Operator(s) to check phase voltages and currents for unbalances on the affected bus(es). Voltage unbalances at the associated 13.8kV switchgear ≥ 400V (~3%) shall require immediate notification to PPL EU and Electrical Maintenance to conduct a walkdown and inspection of the offsite distribution system for a possible open phase condition.

- Operations shall evaluate the offsite circuit for operability.

SSES representatives continue to actively participate in various industry discussions that have taken place since the occurrence of the Byron event. These exchange platforms encompass, but are not limited to, a two day workshop hosted by INPO and weekly teleconferences facilitated by NEI. These ongoing discussions are intended to enhance the industry understanding of plant responses to a high impedance fault or single phase open circuit phenomenon on offsite power sources and allow information sharing of analysis findings and design technical challenges.

At this time, the industry does not have a proven reliable solution to automatically detect all postulated single-phase open circuit conditions of the offsite power source. SSES will continue its involvement in ongoing discussions with industry representatives to evaluate responses and long-term corrective actions pertaining to an open single-phase event on one offsite power source.

The following actions have been entered in the plant corrective action program to track long-term corrective actions to potentially provide automatic protection from single-phase open circuit conditions on offsite power supplies to Class 1E ESF buses:

- AR# 1580827 - Perform studies and plant EDS computer modeling to analyze system and component response to an open single phase condition.

- AR# 1580828 - Based on the plant EDS computer modeling (AR/EWR 1580827) results, determine if a protective relay scheme could be installed to detect a single-phase open circuit condition and if the subject scheme would be an automatic trip or alarm function.

- AR# 1580829 - If warranted by the results from items 1 and 2 above, develop and implement a protective relaying scheme capable of detecting open single phase conditions for Susquehanna's offsite power sources T10 and T20.

> ***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 SSES does not use a common or single offsite circuit to supply redundant ESF busses.

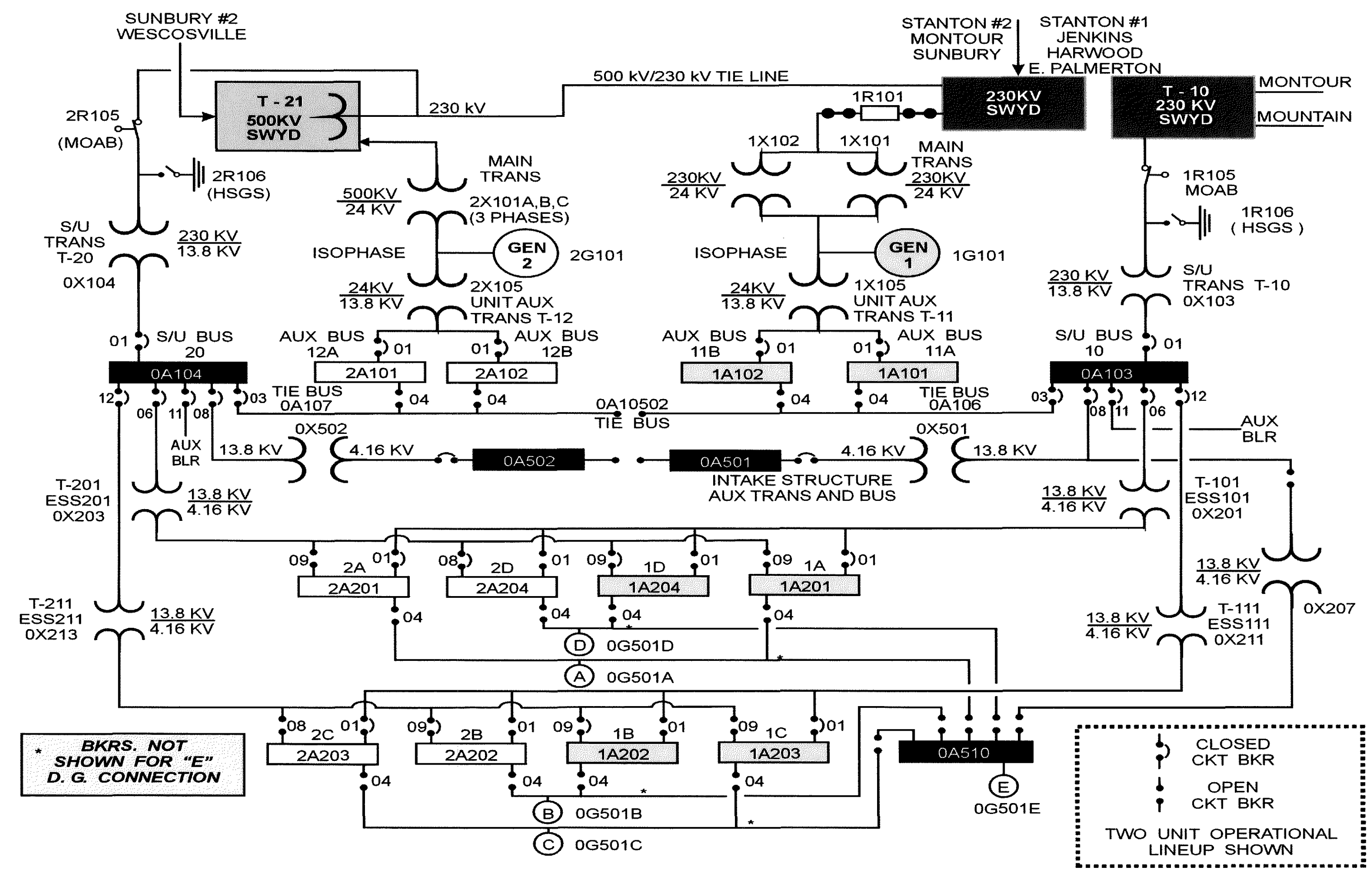
REFERENCES

[1] "Analysis of Station Auxiliary Transformer Response to Open Phase Conditions," EPRI Report 1025772, June 2012

[2] "A Practical Guide for Detecting Single-Phasing on a Three-Phase Power System," Basler Electric Corporation Technical Paper, October 2002

[3] "Automatic Reactor Scram Resulting from a Design Vulnerability in the 4.16-kV Bus Undervoltage Protection Scheme," INPO IER L2 12-14, February 2012.

Attachment 1: SSES Simplified One-Line Diagram



Attachment 2: Tables

Table 1: 4.16kV ESF Buses Continuously Powered from Offsite Power Source(s)

Description of Offsite Power Source Configuration	ESF buses connected to offsite power (Normal operating condition).		Original licensing basis configuration (Y/N)
T10 (Via ESS Transformer T-101)	4kV Bus 1A (Norm)	4kV Bus 1D (Alt)	Y
	4kV Bus 2A (Norm)	4kV Bus 2D (Alt)	
T10 (Via ESS Transformer T-111)	4kV Bus 1B (Alt)	4kV Bus 1C (Norm)	Y
	4kV Bus 2B (Alt)	4kV Bus 2C (Nom)	
T20 (Via ESS Transformer T-201)	4kV Bus 1A (Alt)	4kV Bus 1D (Norm)	Y
	4kV Bus 2A (Alt)	4kV Bus 2D (Norm)	
T20 (Via ESS Transformer T-211)	4kV Bus1B (Norm)	4kV Bus 1C (Alt)	Y
	4kV Bus 2B (Norm)	4kV Bus 2C (Alt)	

NOTE:
During normal operation, Startup Buses 10 and 20 supply power to ESS Transformers. Each transformer in turn supplies power to the 4.16 kV ESS buses.
Norm: Normal offsite supply to ESF bus.
Alt: Alternate offsite supply to ESF bus.

Table 2: 4.16kV ESF Buses Major Loads

Unit 1 ESF Bus	Load	Voltage Level	Rating (HP)
ESF Bus 1A (1A201)	RHR PUMP 1A	4 kV	2000
	CORE SPRAY 1A	4 kV	700
	ESW Pump A	4 kV	450
	CRD Pump 1A (Non-Class 1E)	4 kV	300
	Rx Bldg Chiller 1A (Non-Class 1E)	4 kV	904
	Turbine Bldg Chiller 1A (Non-Class 1E)	4 kV	1080
	Load Center Transformer (1X210)	4.16 - 0.48kV	1000kVA
ESFBus 1B (1A202)	RHR PUMP 1B	4 kV	2000
	CORE SPRAY 1B	4 kV	700
	ESW Pump B	4 kV	450
	Main Cond Mech Vac Pump (Non-Class 1E)	4 kV	300
	Rx Bldg Chiller 1B (Non-Class 1E)	4 kV	904
	Turbine Bldg Chiller 1B (Non-Class 1E)	4 kV	1080
	Load Center Transformer (1X220)	4.16 - 0.48kV	1000kVA
ESF Bus 1C (1A203)	RHR PUMP 1C	4 kV	2000
	CORE SPRAY 1C	4 kV	700
	ESW Pump C	4 kV	450
	Cont Strc Chiller A	4 kV	351
	RHRSW Pump 1A	4 kV	600
	Load Center Transformer (1X230)	4.16 - 0.48kV	1000kVA
ESF Bus 1D (1A204)	RHR PUMP 1D	4 kV	2000
	CORE SPRAY 1D	4 kV	700
	ESW Pump D	4 kV	450
	CRD Pump 1B(Non-Class 1E)	4 kV	300
	Cont Strc Chiller B	4 kV	351
	RHRSW Pump 1B	4 kV	600

Unit 1 ESF Bus	Load	Voltage Level	Rating (HP)
	Load Center Transformer (1X240)	4.16 - 0.48kV	1000kVA
Unit 2 ESF Bus (title)	**Load**	**Voltage Level**	**Rating (HP)**
ESF Bus 2A (2A201)	RHR PUMP 2A	4 kV	2000
	CORE SPRAY 2A	4 kV	700
	CRD Pump 2A (Non-Class 1E)	4 kV	300
	RHRSW Pump 2A	4 kV	600
	Turbine Bldg Chiller 2A (Non-Class 1E)	4 kV	1080
	Load Center Transformer (2X210)	4.16 - 0.48kV	750kVA
ESF Bus 2B (2A202)	RHR PUMP 2B	4 kV	2000
	CORE SPRAY 2B	4 kV	700
	Rx Bldg Chiller 2B (Non-Class 1E)	4 kV	904
	RHRSW Pump 2B	4 kV	600
	Load Center Transformer (2X220)	4.16 - 0.48kV	750kVA
ESF Bus 2C (2A203)	RHR PUMP 2C	4 kV	2000
	CORE SPRAY 2C	4 kV	700
	Rx Bldg Chiller 2A (Non-Class 1E)	4 kV	904
	Main Cond Mech Vac Pump (Non-Class 1E)	4 kV	300
	Load Center Transformer (2X230)	4.16 - 0.48kV	750kVA
ESF Bus 2D (2A204)	RHR PUMP 2D	4 kV	2000
	CORE SPRAY 2D	4 kV	700
	CRD Pump 2B (Non-Class 1E)	4 kV	300
	Turbine Bldg Chiller 2B (Non-Class 1E)	4 kV	1080
	Load Center Transformer (2X240)	4.16 - 0.48kV	1000kVA

Table 3: Offsite Power Transformers

Transformer	Winding Configuration	MVA Size	Voltage Rating (Primary/Secondary)	Grounding Configuration
Start-up Transformer T10	3 Winding (3 legged core) Grounded Wye – Wye – Buried stabilizing tertiary	45/60/75 (AO/FA/FA)	225kV GRD Y/ 13.8kV Y	High side – Neutral bolt grounded Sec Side – Neutral grounded via resistance
Start-up Transformer T20	3 Winding (3 legged core) Grounded Wye – Wye – Buried Delta stabilizing tertiary	45/60/75 (ONAN/ONAF/ONAF)	225kV GRD Y/ 13.8kV Y	High side – Neutral bolt grounded Sec Side – Neutral grounded via resistance

Table 4: Protective Devices

Protection Zone	Protective Device	UV Logic	Setpoint (Nominal)	Basis for Setpoint
13.8kV switchgear Bus	27AI (Initiates tripping of incoming breaker)	2 of 2	66% of rated 120V TD = 30 Cycle	Two independent single phase relays are used to monitor the A-B and B-C phase voltages. The incoming breaker is tripped on coincident logic of the two undervoltage relays at 74V with a 30 cycle time delay.
13.8kV switchgear Bus	27A1 (Provides permissive for closing the tie breaker)		91% of rated TD = 15 Sec.	Two single phase relays are provided to monitoring the availability of the alternate offsite power supply at the 13.8kV level and provide a coincidence logic for closing of the tie breaker with a 15 Sec. time delay
13.8kV switchgear Bus	27A2 (Initiates the bus transfer)		22% of rated	Three phase instantaneous set to drop out at 22% of rated voltage. Bus transfer is completed by the closing of the tie breaker (Permissive by device 27A1)
4.16kV ESF switchgear bus	27AI Provides permissive to close the preferred power incoming breaker		96.5% of rated bus voltage TD = 1 Sec	Two single phase relays used to monitor the availability of the offsite power supply at the 4.16kV Class 1E level
4.16kV ESF switchgear bus	27A Initiates bus transfer		20% of rated bus voltage TD = 10 Cycles	Three phase relay used to initiate 4.16kV bus transfer with TD by tripping of the preferred incoming feeder breaker. The transfer is completed if the alternate power supply to this bus is available (permissive by device 27AI). In case the alternative offsite power source is not available, the standby diesel generator is initiated to start with a 0.5 second delay.
4.16kV ESF switchgear bus	27B1 & 27B2 Initiates bus transfer and undervoltage alarm	2 of 2	93% rated bus voltage TD= 10 Sec & 5 min	If a degraded voltage condition occurs on the 4.16kV Class 1E bus with no LOCA signal present which is below the setting of relays, an alarm (coincident logic) will be initiated after 10 seconds. These relays will initiate the bus transfer after 5 minute time delay. The 10 second time delay is provided to preclude spurious alarms and trips for motor start transients. The 5 minute timer is provided so that Operators can initiate corrective actions during non-LOCA conditions.
4.16kV ESF switchgear bus	27B3 & 27B4 Initiates bus transfer on LOCA condition	2 of 2	65% TD = 3 Sec.	Relays trip the offsite power breakers (coincident logic) after time delay when the bus voltage falls below setpoint. Settings are based on coordination with overcurrent relays to prevent false trips due to transient voltage dips from fault currents.
Startup Transformer	87A1N Ground differential overcurrent		240 PA TD = 0.249 Sec	Trip the startup transformer T10 lockout relays on ground differential current exceeding relay setpoint.