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OCT 25 2012

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LR-N12-0324

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

Hope Creek Generating Station
Renewed Facility Operating License No. NPF-57
NRC Docket No. 50-354

Subject: 90-Day Response to NRC Bulletin 2012-01: Design Vulnerability In Electric Power System

References:

1. NRC Bulletin 2012-01: Design Vulnerability in Electric Power Systems, dated July 27, 2012

On July 27, 2012, the Nuclear Regulatory Commission (NRC) issued Reference 1 to all power reactor licensees and holders of combined licenses for nuclear power reactors. Reference 1 requires that each licensee must provide a response to the requested actions within 90 days of the date of this bulletin. Attachments 1, 2, and 3 provide the responses to the requested actions. This response follows the Nuclear Energy Institute (NEI) template issued on September 5, 2012.

This letter contains no new regulatory commitments.

Should you have any questions concerning the content of this letter, please contact Brian Thomas at 856-339-2022.

IE76
NRR

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

Executed on OCT 25 2012.
(Date)

Sincerely,

John F. Perry
Site Vice President
Hope Creek Generating Station

Attachments (3):
Attachment 1 – Response to Bulletin Required Actions
Attachment 2 – Simplified One-Line of Offsite Power Connection to ESF Buses
Attachment 3 – Tables

cc: W. Dean, Regional Administrator - NRC Region I
J. Hughey, Project Manager - USNRC
NRC Senior Resident Inspector – Hope Creek
P. Mulligan, Manager IV, NJBNE
Commitment Coordinator – Hope Creek
PSEG Commitment Coordinator – Corporate

Hope Creek 2012-01 Bulletin Response

Overview:

- System Description - Items 2., 1.d, 2.a, 2.c
- System Protection - 1., 1.a, 2.b, 2.d
- Consequences - 1.b, 1.c, 2.e
- Attachment 2 - Simplified One-Line Diagram
- Attachment 3 - Tables
    - Table 1 - ESF Buses Continuously Powered From Offsite Power Source(s)
    - Table 2 - ESF Buses Not Continuously Powered From Offsite Power Source(s)
    - Table 3 - ESF Buses Major Loads
    - Table 4 - Offsite Power Transformers
    - Table 5 - Protective Devices

System Description

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

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

See Attachment 2, for a simplified one-line diagram.

Three independent 500kV offsite power sources supply the Hope Creek 500kV switchyard as described in section 8.2 of the Updated Final Safety Analysis Report (UFSAR). Offsite power for Hope Creek is fed through the 500kV switchyard via the 13.8kV switchyard ring bus. There are two physically independent connections from the 500kV switchyard to the 13.8kV ring bus. Each connection supplies power to the 13.8kV ring bus through two 500/13.8kV station power transformers (SPTs). The 13kV system provides continuously connected offsite power to two (2) station service transformers (SSTs) (AX501, BX501). SST AX501 provides normal offsite power to 4.16kV Class 1E buses 10A401 and 10A403, and alternate offsite power to 4.16kV Class 1E buses 10A402 and 10A404. The BX501 SST provides normal offsite power to 4.16kV Class 1E buses 10A402 and 10A404 and alternate offsite power to the 4.16kV Class 1E buses 10A401 and 10A403.

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

See Attachment 3, Table 4 for offsite power transformer winding and grounding configurations.

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

For at power (normal operating condition) configurations, ESF buses are powered by offsite sources.

See Attachment 3, Tables 1 and 2 for ESF bus power sources
See Attachment 3, 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 following at power (normal operating condition) configurations have been confirmed to be consistent with the current licensing basis:

1. Two out of four ESF buses fed from each station service transformer (Normal Operating Line-up).
2. Three out of four ESF buses fed from a single station service transformer and the remaining ESF bus fed from the other station service transformer (lineup during relay / EDG testing).

See Attachment 3 Table 1 for any changes in the offsite power source alignment to the ESF buses from the original plant licensing.

Hope Creek is licensed to 10 CFR 50 Appendix A General Design Criterion 17 (GDC 17) with respect to electrical design configuration and maintaining connection to the preferred offsite power source.

The GDC 17 redundant offsite power sources are as described in UFSAR section 8.2 and include the normal and alternate load paths from the termination of the 500kV offsite power sources at the 500kV switchyard to the infeed breakers at each 4.16kV Class 1E Bus.

Hope Creek is a four (4) Channel electrical plant which supports two (2) safety related mechanical divisions. Any combination of three out of four electrical load groups has the capability to supply the minimum required safety loads to safely shut down the unit and mitigate the consequences of an accident.

The GDC 17 offsite power system as described in the Hope Creek UFSAR consists of the following components:

500kV Arrangements

1.) 500kV switching station aligned in a breaker-and-a-half ring bus configuration with all tie breakers normally closed.

2.) Three (3) 500kV transmission sources connect the Hope Creek 500kV switching station to adjacent Bulk Electric switching stations located at New Freedom (5023 Line), Red Lion (5015 Line) and Salem (5037 Line).

3.) Two (2) 500kV/14.4kV SPTs (T1 and T4) feed the 13kV isolated ring bus that supplies Class 1E and non-Class 1E buses via two (2) SST AX501 and BX501. The SPTs are connected to the 500kV ring bus via solid bus work. The connection from the 13kV bus to SSTs is cable run underground in duct banks. There are two fully redundant SPTs (T2 and

T3) which can be manually switched in service to supply offsite power from the 500kV ring bus to the 13kV system.

Class 1E and non-Class 1E Bus Arrangement

4.) Two (2) 13.8/4.16kV SSTs normally fed as follows:
   a. AX501 (From Bus Section 7 and SPT T4),
   b. BX501 (From Bus Section 2 and SPT T1)

5.) Four (4) Class 1E buses and two (2) non-Class 1E buses are normally fed as follows with the ability to automatically transfer between redundant GDC 17 offsite sources upon actuation of the first level or second level undervoltage protection:
   a. Class 1E A Channel 10A401 (from AX501)
   b. Class 1E B Channel 10A402 (from BX501)
   c. Class 1E C Channel 10A403 (from AX501)
   d. Class 1E D Channel 10A404 (from BX501)
   e. Non-Class 1E 10A101 (from AX501)
   f. Non-Class 1E 10A102 (from BX501)

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

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

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

Consistent with the current licensing basis and GDC 17, existing protective circuitry is designed to separate the ESF buses from a connected offsite source due to a loss of voltage or a sustained, balanced degraded grid voltage. The protective relay systems were not specifically designed to detect an open single phase of a three phase system. Detection of a single-open phase condition is beyond the approved design and licensing basis of the plant. The station is not currently analyzed for high impedance grounds on the offsite power system and the impact to downstream plant equipment.

At Hope Creek, offsite power is supplied through two out of four 500kV / 13.8kV station power transformers (two redundant transformers per offsite power source). The station power transformers are wye-g/delta connected transformers that feed the 13kV / 4.16kV station service transformers. The station service transformers are delta/wye-g connected transformers that ultimately provide the two independent sources of offsite power to the four 4.16kV Class 1E buses. Both sources of offsite power are in-service during normal operation, with two out of four Class 1E buses connected to each offsite source. Therefore, loss of a single offsite source results in two out of four Class 1E buses transferring to the alternate offsite power source, and the remaining two Class 1E buses remain unaffected.

The 4.16kV Class 1E buses contain an undervoltage and degraded voltage protection scheme. Each 4.16kV Class 1E bus is normally energized by the normal power supply. If the normal power supply is not available at the 4.16 kV Class 1E bus due to transformer or transformer feeder protective relay actuation, automatic fast transfer to the alternate source takes place. If the normal power supply is lost due to degraded grid conditions (i.e., 4.16kV Class 1E bus voltage less than 92 percent of rated volts for greater than 20 seconds) or a loss of voltage (i.e., bus voltage less than 70 percent), a slow or dead bus transfer to the alternate source takes place. If both the normal and the alternate power sources are unavailable, the loads on each bus are picked up automatically by the emergency diesel generator.

Although the protection scheme at Hope Creek was not 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, preliminary review has shown that the 4.16kV emergency bus undervoltage (degraded voltage) relay protection will respond to this condition in some instances by automatically transferring power to an alternate supply if the open occurs on the 13.8kV or 4.16kV bus section.

<u>500kV Switchyard - Open Phase Protection</u>

An open circuit condition in the 500kV system will result in a minimal unbalanced 13kV or 4kV offsite power source, due to the wye-g to delta configuration of the 500kV / 13.8kV SPTs. Therefore an open phase in the 500kV system would not be detected or result in an isolation of offsite power at the 4.16kV Class 1E buses.

<u>13.8kV Switchyard - Open Phase Protection</u>

The 13.8kV yard is delta connected, ungrounded system. Only differential relay protection schemes are used for bus protection, and there is no undervoltage protection provided. Therefore, an open phase condition in the 13.8kV switchyard will not be automatically isolated at the 13.8kV level, and will affect the 4.16kV offsite power source through the station service transformer. Although no detailed engineering study is available at this time, preliminary engineering review shows that the degraded voltage relays are likely to actuate, transferring the ESF buses to an alternate power supply after a 20 second time delay.

4.16kV System - Open Phase Protection

The 4.16kV system is made up of non-segregated metal enclosed bus (MEB). Degraded voltage protection is used at each infeed breaker to the 4.16kV Class 1E buses. For each offsite power source, two degraded voltage relays are used: one relay to monitor A-B phase voltage, and one relay to monitor B-C phase voltage. Voltage is measured on the primary side of each 4.16kV bus infeed beaker. Both A-B and B-C degraded voltage relays are required to actuate in order to initiate a bus transfer on degraded voltage (2 out of 2 logic).

If an open phase condition were to occur on the B phase, both degraded voltage relays would actuate, initiating an automatic bus transfer to the alternate offsite power source. If an open circuit on either A or C phase were to occur, only one out of two degraded voltage relays would actuate, keeping the 4.16kV Class 1E bus connected to the degraded offsite source.

However, this single phase condition, though highly unlikely based on the MEB construction, will be apparent to Operations due to actuation and alarming of one half of the degraded voltage relay logic, negative sequence alarm, and subsequent impact to running motor loads.

High Impedance Faults: The Hope Creek 500kV switchyard is designed with a 500kV breaker-and-a-half ring bus configuration with three offsite transmission sources normally terminated at the ring bus. Solid buswork is run from the ring bus to the 500kV/13.8kV SPTs in the GDC17 load path. The station is not currently analyzed for high impedance grounds on the offsite power system and the impact to downstream plant equipment, however the following design features exist which minimize the likelihood or impact of a postulated high impedance ground:

1. Based on the ring bus configuration, high impedance grounds on a single phase of an incoming transmission line would not result in discontinuity of voltage on the impacted phase due to voltage support provided by the other two lines and station generator when online connected to the bus.
2. The bus work from the 500kV ring bus to the low side of the 500kV/13.8kV SPTs is outfitted with high speed differential relaying which rapidly clears faults upon operation.
3. The 500kV switchyard is operated under a vegetation management program to ensure all original design clearances from bus work to ground are maintained in the current switchyard configuration.

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. See Attachment 3, Table 5 for undervoltage 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 Class 1E buses at Hope Creek Generating Station are powered by offsite power sources.

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

The current plant operating procedures, including operating procedures for off-normal alignments, specifically call for verification of the voltages on all three phases of the Class 1E buses.

Consequences

Items 1.b, 1.c, 2.e request information regarding the 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. The configuration of Hope Creek is such that the transformers supplying the Class 1E buses are continuously loaded and will not be unloaded. 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.

Hope Creek Generating Station did not credit in the Current Licensing Basis (CLB) that the Class 1E protection scheme was designed to detect and automatically respond to a single-phase open circuit condition or high impedance ground fault condition on the credited off-site power source.

The offsite power circuits at the Hope Creek Generating Station consist of two independent circuits from termination of the 500kV offsite power sources at the 500kV ring bus up to the infeed breakers at each 4.16kV Class 1E Bus.

Since the Hope Creek Generating Station did not credit the Class 1E design for the detection and automatic response to a loss of a single phase event, an open phase fault was not included in the design criteria for the degraded voltage relay (DVR) scheme or loss of voltage design criteria. Since open phase detection was not credited in the Hope Creek Generating Station design or licensing basis, no design basis calculations or design documents exist that previously analyzed 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 in industry literature and references. The difficulty in applying these documents to Hope Creek Generating Station specific response is that these are generic assessments which do not take into account voltage limits, bus loading, and distribution system configuration. A full analysis requires detailed plant specific models 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 analyzed for Hope Creek Generating Station specific Class 1E electric distribution system.

<u>500kV Switchyard</u>

Preliminary reviews illustrate that an open circuit condition in the 500kV system will not impact the 13kV and 4kV offsite power sources. Although open phase does not impact plant loads, it is not possible to detect with existing current and voltage instrumentation. Walkdowns and visual inspection of open phase connections is the only viable method of detection. Currently, operators perform daily rounds in the Hope Creek Switchyard, to identify degraded conditions.

<u>13kV Switchyard / 4.16kV System</u>

An open circuit in the 13kV switchyard will most likely result in an automatic isolation the 4.16kV Class 1E bus. It was also determined that an open phase on the 4.16kV metal enclosed bus will not initiate an automatic isolation of the 4.16kV Class 1E bus. In either case, annunciation of an open phase condition is available to Operations in the main control room. If one out of two degraded voltage relays actuates on a single phase open circuit for each bus offsite power source, a Control Room Integrated Display System (CRIDS) point will alarm in the control room.

During an open phase condition, negative sequence voltage will develop on the 4.16kV Class 1E bus. The 4.16kV Class 1E bus voltage is monitored by a negative phase sequence relay (47 device) which brings in a CRIDS alarm in the main control room.

The negative sequence relay is a type CVQ relay, which will alarm on negative sequence voltages greater than 5% line to neutral voltage. Per the CVQ vendor documentation, when one of three supply circuits to a motor is opened, a minimum 6% negative sequence voltage will appear on the motor side of the open circuit, even if single phasing occurred at no load. Therefore, the negative sequence relay will bring in a CRIDS alarm if a single phase open circuit event occurs in the 13.8kV system.

<u>High Impedance Ground</u>

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

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 Hope Creek Generating Station does not use a common or single offsite circuit to supply redundant Class 1E buses.

Simplified One-Line Diagram

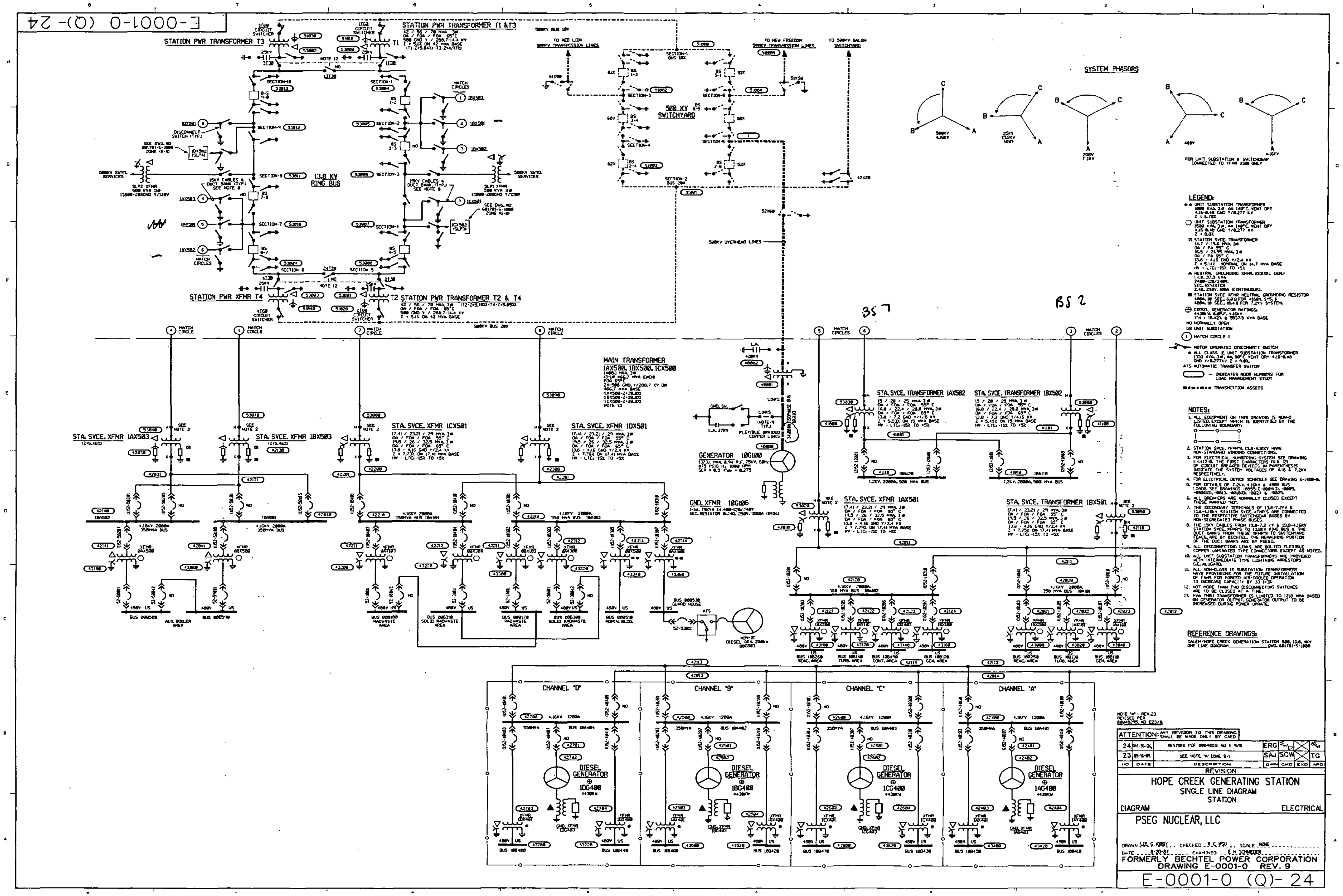

Table 1 - ESF Buses Continuously Powered From Offsite Power Source(s)

Description of ESF Bus Power Source	ESF Bus Name (normal operating condition).	Original licensing basis configuration (Y/N)
Station Service Transformer 1AX501 (Normal) Station Service Transformer 1BX501 (Alternate)	Class 1E A Channel 10A401	Y
Station Service Transformer 1AX501 (Alternate) Station Service Transformer 1BX501 (Normal)	Class 1E B Channel 10A402	Y
Station Service Transformer 1AX501 (Normal) Station Service Transformer 1BX501 (Alternate)	Class 1E C Channel 10A403	Y
Station Service Transformer 1AX501 (Alternate) Station Service Transformer 1BX501 (Normal)	Class 1E D Channel 10A404	Y
Station Service Transformer 1AX501 (Normal) Station Service Transformer 1BX501 (Alternate)	Non-Class 1E 10A101[1]	Y
Station Service Transformer 1AX501 (Alternate) Station Service Transformer 1BX501 (Normal)	Non-Class 1E 10A102[1]	Y

[1] The Non-Class 1E buses are included on the table since they are powered by the same transformers that feed the Class 1E buses.

Table 2 - ESF Buses Not Continuously Powered From Offsite Power Source(s)
Note: Table 2 is not applicable to Hope Creek Generating Station.

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

Table 3 - ESF Buses Normally Energized Major Loads

ESF Bus	Load	Voltage Level	Rating (HP)
10A401	Safety Aux Clg System Pump 'A'	4.16kV	600[1]
	1333 kVA Unit Substation Transformer 1AX401	4.16kV	1333 kVA
	1333 kVA Unit Substation Transformer 1AX400	4.16kV	1333 kVA
	Station Service Water Pump 'A'	4.16kV	800[1]
	Safety Related Panel Room Water Chiller 1AK403	4.16kV	430[2]
10A402	Safety Aux Clg System Pump 'B'	4.16kV	600[1]
	1333 kVA Unit Substation Transformer 1BX401	4.16kV	1333 kVA
	Station Service Water Pump 'B'	4.16kV	800[1]
	1333 kVA Unit Substation Transformer 1BX400	4.16kV	1333 kVA
	Safety Related Panel Room Water Chiller 1BK403	4.16kV	430[2]
10A403	Safety Aux Clg System Pump 'C'	4.16kV	600[1]
	1333 kVA Unit Substation Transformer 1CX401	4.16kV	1333 kVA
	Station Service Water Pump 'C' 1CP502	4.16kV	800[1]
	1333 kVA Unit Substation Transformer 1CX400	4.16kV	1333 kVA
	Control Room Water Chiller 'A'	4.16kV	506[3]
10A404	Safety Aux Clg System Pump 'D'	4.16kV	600[1]
	1333 kVA Unit Substation Transformer 1DX401	4.16kV	1333 kVA
	Station Service Water Pump 'D'	4.16kV	800[1]
	1333 kVA Unit Substation Transformer 1DX400	4.16kV	1333 kVA
	Control Room Water Chiller 'B'	4.16kV	506[3]
10A101[4]	1500 kVA Reactor Area Unit Substation Transformer 1AX200	4.16kV	1500 kVA
	1500 kVA Turbine Area Substation Transformer 1AX101	4.16kV	1500 kVA
	1500 kVA Generator Area Unit Substation Transformer 1AX100	4.16kV	1500 kVA
	Water Chiller 'C' 1CK111	4.16kV	1308 kW
	1500 kVA Reactor Area Unit Substation Transformer 1BX200	4.16kV	1500 kVA
10A102[4]	1500 kVA Turbine Area Substation Transformer 1BX101	4.16kV	1500 kVA
	1500 kVA Control Area Unit Substation Transformer 1DX403	4.16kV	1500 kVA
	1500 kVA Generator Area Unit Substation Transformer 1BX100	4.16kV	1500 kVA
	Primary Condensate Pump 'C' 1CP102	4.16kV	1500

[1] **Indicates 3 out of the 4 available are normally energized**

[2] **Indicates 1 out of the 2 available units is normally energized (Either the 1AK403 or 1BK403 is in service)**

[3] **Indicates 1 out of the 2 available is normally energized (Either the 1AK400 or 1BK400 is in service)**

[4] **The non-Class 1E buses are included on the table since they are powered by the same transformers that feed the ESF buses.**

Table 4 - Offsite Power Transformers

Transformer	Winding Configuration	MVA Size (AO/FA/FOA)	Voltage Rating (Primary/Secondary)	Grounding Configuration
T1, T2, T3, T4	Wye - Delta	70 MVA (FOA)	500 / 14.4kV	*500kV: Grounded Neutral 13kV: Ungrounded*
1AX501, 1BX501	Delta - Wye	32.5 MVA (FOA)	13.8 / 4.16kV	*4.16kV: Low-Impedance Grounded Neutral*

Table 5 - Protective Devices

Protection Zone	Protective Device	UV Logic	Setpoint (Nominal)	Basis for Setpoint
ESF	Under Voltage - Degraded Grid	2 out of 2	3867.5 V (92.97% of 4160V)	Hope Creek Technical Specification Table 3.3.3-2 provides both trip setpoint (> 3815 V) and allowable (≥ 3815) range for the 4.16kV 1E undervoltage relays. The range of the allowable value corresponds with the Calculation E-7.4 (Q) basis setting of 92% which is the analytical limit for the buses. The setpoint calculation SC-PB-0002, calibrates the relay at a higher setpoint than the Technical Specification to account for relay inaccuracies as well.
ESF	Under Voltage - Loss of Voltage	1 out 2 Taken Twice	2975 V (71.5% of 4160V)	Hope Creek Technical Specification Table 3.3.3-2 provides both trip setpoint (85 +/- 0.85 V or 2975 +/- 30V) and allowable (85 +/- 1.8 V or 2975 +/- 63V) ranges for the 4.16kV 1E undervoltage relays. The low range of the allowable value corresponds with the Calculation E-7.4 (Q) basis setting of 70%, and the trip is appropriately set higher than the minimum allowable value ensuring conservatism is maintained. 70% is a typical industry value based on NEMA MG-1 motors and their ability to operate for a period of time (30 sec. to 1 min) at down to 70% terminal voltage. NEMA MG-1 and this particular requirement was invoked via original motor purchase specifications G-006 (Q)/E-112(Q) used to procure safety related motors at Hope Creek.
ESF	Negative Sequence	Alarm Only	5% Negative Sequence	Alarm Only - From NEMA MG 1, "A polyphase circuit is considered to be virtually balanced if, when supplied by a balanced system of voltages, the system of currents is virtually balanced, i.e., neither the negative-sequence components nor the zero-sequence component exceeds 5% of the positive-sequence component." The basis for the 5% negative sequence sensitivity is typical with industry standards as stated above. This relay provides an alarm only and does not have any automatic actuations.
13.8kV / 4.16kV Transformer	Ground Fault	N/A	100 A	To detect 4.16kV phase-to-ground fault via high current in the neutral grounding resistor.
500kV Bus	Differential Current	N/A	25% Slope	To detect system faults within the transformer differential protection zone.