FENOC

FirstEnergy Nuclear Operating Company

October 25, 2012
L-12-361

10 CFR 50.54(f)

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT:
Beaver Valley Power Station, Unit Nos. 1 and 2
Docket No. 50-334, License No. DPR-66
Docket No. 50-412, License No. NPF-73
Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System"

On July 27, 2012, the Nuclear Regulatory Commission (NRC) staff issued Bulletin 2012-01, "Design Vulnerability in Electric Power System," requesting information on electric power system design, to determine if further regulatory action is warranted. Licensees are required to provide a written response in accordance with 10 CFR 50.54(f) within 90 days of the date of the bulletin.

FirstEnergy Nuclear Operating Company hereby provides the requested information for the Beaver Valley Power Station (BVPS), Unit Nos. 1 and 2, as an attachment.

There are no regulatory commitments contained in this submittal. If there are any questions or if additional information is required, please contact Mr. Thomas A. Lentz, Manager – Fleet Licensing, at 330-315-6810.

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

Sincerely,

Paul A. Harden, Vice President - Beaver Valley Power Station

Attachment:
Response to NRC Bulletin 2012-01 for Beaver Valley Power Station, Unit Nos. 1 and 2

cc: NRC Region I Administrator
NRC Resident Inspector
NRC Project Manager
Director, Pennsylvania Bureau of Radiation Protection, Department of Environmental Protection (BRP/DEP)
BVPS Site BRP/DEP Representative

Nuclear Regulatory Commission (NRC) Bulletin 2012-01, "Design Vulnerability in Electric Power System," requested information regarding single-phase open-circuit conditions or high impedance ground fault conditions. The NRC-requested information is identified using bolded and italicized text, followed by the FirstEnergy Nuclear Operating Company (FENOC) response. The following outline identifies the order the NRC requests are addressed in, with similar items grouped together.

Outline of Bulletin Response:

- System Description – NRC Items 2., 1.d, 2.a, 2.c
- System Protection - NRC Items 1., 1.a, 2.b, 2.d
- Consequences - NRC Items 1.b, 1.c, 2.e
- Figure 1 - Simplified One-Line Diagram
- 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 - Major ESF Bus Loads Normally Powered From Offsite Power Source(s)
  - Table 4 - Offsite Power Transformers
  - Table 5 - Protective Devices

Note: Throughout this response, the content applies to both Beaver Valley Power Station (BVPS) Unit 1 and Unit 2, unless specifically noted otherwise.

System Description

Items 2., 1.d, 2.a, and 2.c request system descriptions and are grouped 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).***

Response:

See Figure 1 for a simplified one-line diagram, which provides necessary information from Updated Final Safety Analysis Report (UFSAR) Figures 8.3-1 for each unit, along with Figure 8.4-1 for Unit 1, and Figure 8.3-3 for Unit 2.

Power to station auxiliary loads (including the engineered safety feature (ESF) buses) is available from four station service transformers. Two Unit[1] Station Service Transformers (USSTs) supply power from the main generator; two System Station Service Transformers (SSSTs) supply power from the 138 kV switchyard. The primary side of each SSST is connected through separate breakers to separate buses in the 138 kV switchyard. When at power (normal operating condition), station service power may be supplied by the main generator, the 138 kV switchyard, or a combination of both.

Each train of ESF buses receives power from a non-ESF 4.16 kV bus that is aligned to one of the four station service transformers. Although these buses are permitted to be aligned to the 138 kV switchyard via the SSSTs, this is not the normal operating configuration. When at power (normal operating condition), station auxiliary loads are typically aligned to the main generator via the USSTs.

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

Response:

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

[1] In the Unit 1 UFSAR, these are referred to simply as the Station Service Transformers.

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.

Response:

When at power (normal operating condition), ESF buses are permitted to be powered from the 138 kV switchyard via the SSSTs; however, this is not the normal alignment. ESF buses are normally aligned to the main generator via the USSTs.

Therefore, Table 1 "Essential Buses Continuously Powered From Offsite Power Source(s)" and Table 3 "Major ESF Bus Loads Normally Powered From Offsite Power Source(s)" are not applicable to BVPS. Table 2 lists the ESF buses not continuously powered from offsite power sources.

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.

Response:

The operating configurations of the ESF buses shown in Table 2 were verified to be consistent with the current licensing basis as described in the UFSAR. With respect to the normal offsite power alignment, no relevant changes have been made since the original plant licensing.

System Protection

Items 1., 1.a, 2.b, and 2.d request information regarding electrical system protection, and are grouped 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*** [sic].

Response:

Consistent with the current licensing basis and General Design Criterion (GDC) 17, the existing electrical protection system will separate the ESF buses from a connected, failed offsite source due to a loss of voltage or a sustained, balanced degraded grid voltage. The protection scheme was not specifically designed to detect a single-phase open circuit in a three phase system. Detection of a single-phase open-circuit condition was not required for licensing of the plant.

The response of the electrical protection system to a single-phase open-circuit condition (with or without a ground) depends on the electrical power alignment at the time the open phase occurs.

Normal Alignment

When at power (normal operating condition), station auxiliary power is typically supplied from the main generator through the USSTs, and the SSSTs are unloaded. In this alignment, a single-phase open-circuit condition in the offsite power supply will not be detected by the electrical protection system for the ESF buses, because the ESF buses will continue to receive stable, balanced power from the main generator.

Startup/Shutdown/Alternate Alignment

During plant startup and shutdown, station auxiliary power is typically supplied from the 138 kV switchyard via the SSSTs. This alignment may also be used when at power (normal operating condition); however, this is uncommon. When station auxiliary loads are aligned to the SSSTs, a single-phase open circuit upstream of the SSSTs may or may not be detected by the electrical protection system. The protection system response is dependent on plant conditions and the specifics of the open circuit failure; relevant details include the load on the SSST and whether the open conductor becomes grounded when the failure occurs.

Backfeed Alignment

During shutdown, station auxiliary power may be supplied from the 345 kV switchyard through the main transformer and USSTs. In this alignment, a single-phase open circuit in the 345 kV switchyard may or may not be detected by the electrical protection system. The protection system response is dependent on plant conditions and the specifics of the open circuit failure; relevant details include the load on the main transformer and whether the open conductor becomes grounded when a failure occurs.

An open phase between the main transformer and a USST is not considered to be credible due to the robustness of the accompanying isophase bus connection.

High Impedance Ground Faults (with or without an open phase)

Ground fault protection is provided for the 4.16 kV ESF buses and their associated offsite power circuits. This protection consists of relays and circuit breakers that automatically operate to isolate ground faults. Ground alarms are provided for the normally ungrounded 480 V ESF buses. The ground protection/alarm setpoints are chosen to provide sensitive ground protection/detection while maintaining appropriate protective device coordination and minimizing spurious actuation for normally expected electrical transients.

> ***1.a. The sensitivity of protective devices to detect abnormal operating conditions and the basis for the protective device setpoint(s).***

Response:

Consistent with the current licensing basis and GDC 17, existing electrical protective devices are designed 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. Table 5 lists the undervoltage protective devices and the basis for the device setpoints.

Existing electrical protective devices are designed to detect ground faults of sufficient magnitude. Table 5 lists ground protection/alarms on the ESF buses and the basis for the device setpoints.

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.

Response:

Periodic surveillances are in place to specifically monitor for a single-phase open-circuit condition in the offsite power supply. Daily walkdowns are performed to visually inspect the transmission lines and connections between the 138 kV switchyard and the system station service transformers.

Previous plant experience has demonstrated that a single-phase open-circuit on the primary side of an unloaded system station service transformer yields a small voltage imbalance on the secondary side of the transformer. Operator rounds periodically (approximately every eight hours) check for voltage imbalances on the secondary sides of the transformers. The same checks are performed immediately preceding any planned transfers to the offsite power supply. Operating procedures address actions to be taken if a voltage imbalance is detected.

There are no surveillances to specifically monitor for a high-impedance ground fault without an open phase. Ground faults of sufficient magnitude are expected to be detected by the electrical protection scheme regardless of whether the ESF buses are aligned to the offsite power source.

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?

Response:

Yes, weekly surveillance procedures call for measurement of three-phase voltages at the 4.16 kV and 480 V ESF buses. These surveillances are performed for all operating modes and electrical power alignments.

Consequences

Items 1.b, 1.c, and 2.e request information regarding the electrical consequences of an event, and are grouped 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.***

Response:

When station auxiliary loads (including ESF buses) are aligned to the main generator via the USSTs, a single-phase open circuit in the offsite power supply is not expected to be detected by the electrical protection scheme. However, because station auxiliary loads will continue to receive balanced, stable power from the main generator, the condition is not anticipated to have an immediate, adverse effect on plant operation and/or equipment. In this alignment, the open-circuit condition is expected to be detected by the periodic surveillances described in response to 2.b.

If station auxiliary loads are aligned to the offsite power supply, the electrical protection scheme may or may not detect a single-phase open-circuit condition. The response of the electrical protection scheme and the effect on plant equipment is dependent on plant conditions and the specifics of the open circuit failure; relevant details include the load on the offsite power transformer and whether the open conductor becomes grounded when the failure occurs. If the condition is not automatically detected, plant operators may be required to identify that the offsite power supply is inoperable and take manual action to separate station auxiliary loads from the degraded power source.

Regardless of the offsite power alignment, ground faults of sufficient magnitude are expected to be detected and isolated by the electrical protection scheme.

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.

Response:

The current licensing basis does not credit the electrical protection system to detect and automatically respond to a single-phase open-circuit condition in the offsite power supply. Because the electrical protection scheme is not credited to detect and automatically respond to a single-phase open-circuit condition, an open phase fault was not included in the design criteria for either the loss of voltage or degraded voltage relay schemes.

Since open-phase detection was not credited in the design or licensing basis, no design basis calculations or design documents previously considered this condition. It is possible to provide a generic assessment of the consequences of an open-phase event using information from operating experience and guidance from published literature. However, such an assessment cannot be formally credited as the basis for an accurate response, because the consequences of an open-phase event are highly dependent on the specific characteristics of each plant electrical system. An analysis that takes into account those characteristics would be necessary to develop a detailed response.

The following is provided as a high-level description of the possible consequences of an open-phase event:

In the normal alignment through the USSTs, a single-phase open circuit or a high impedance ground fault in the offsite power supply is not expected to have an immediate, adverse effect on plant operation and/or equipment, because station auxiliary loads will continue to receive balanced, stable power from the main generator. In this alignment, the open-circuit condition is expected to be detected by the periodic surveillances described in response to 2.b.

In the less common alignment where station auxiliary loads are aligned to the offsite power supply, the consequences of a single-phase open circuit or high impedance ground fault have not been fully analyzed. If the condition is not automatically detected by the electrical protection system, plant operators may be required to identify that the offsite power supply is inoperable and take manual action to separate station auxiliary loads from the degraded power source. Without detailed analysis to support an alternate conclusion, for a worst-case scenario, it is conservatively assumed that one of two ESF trains could be made inoperable.

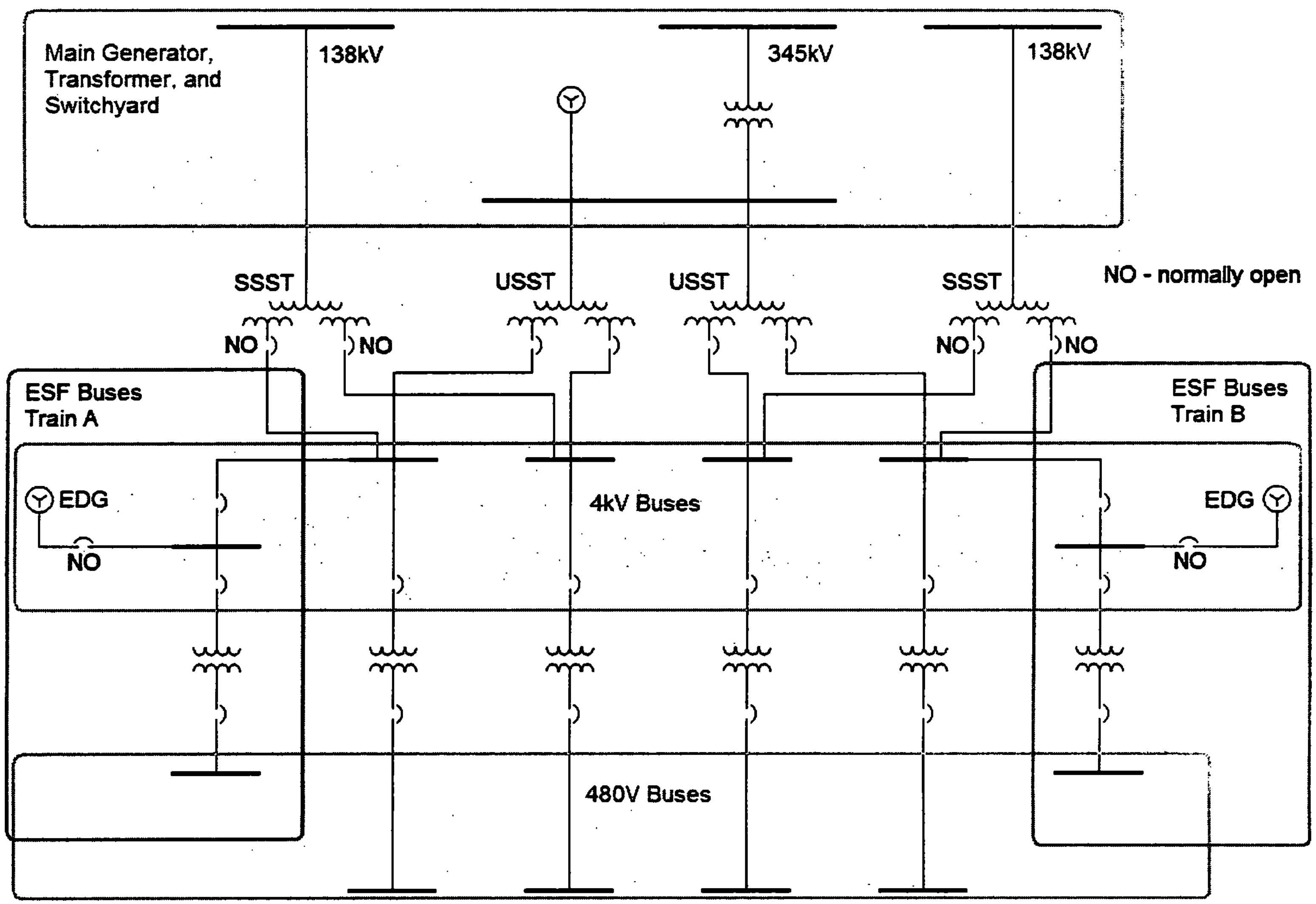
> ***2.e. If a common or single offsite circuit is used to supply redundant ESF buses, explain why a failure, such as a single-phase open circuit or high impedance ground fault condition, would not adversely affect redundant ESF buses.***

Response:

This request is not applicable. Redundant ESF buses are supplied by independent offsite power circuits.

Figure 1

Simplified One-Line Diagram – Beaver Valley Power Station Unit 1 or Unit 2



Tables

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

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

Table 2 - ESF Buses Not Continuously Powered From Offsite Power Source(s)

Description of ESF Bus Power Source	ESF Bus Name (normal operating condition)	Original licensing basis configuration (Y/N)
Unit 1		
Unit Station Service Transformer 1C (TR-1C)	4KVS-1AE, 480VUS-1-8	Y
Unit Station Service Transformer 1D (TR-1D)	4KVS-1DF, 480VUS-1-9	Y
Unit 2		
Unit Station Service Transformer 2C (TR-2C)	4KVS-2AE, 480VUS-2-8	Y
Unit Station Service Transformer 2D (TR-2D)	4KVS-2DF, 480VUS-2-9	Y

Table 3 - Major ESF Bus Loads Normally Powered From Offsite Power Source(s)

ESF Bus	Load	Voltage Level	Rating (HP)
N/A	N/A	N/A	N/A

Table 4 - Offsite Power Transformers

Transformer	Winding Configuration	MVA[†] Size (Cooling[‡])	Voltage Rating (Primary/Secondary)	Grounding Configuration
		Unit 1		
System Station Service Transformer 1A (TR-1A)	Three winding, Wye-Wye-Wye	19.2/25.6/32 MVA (OA/FOA/FOA)	138 kV[§]/4.36 kV/4.36 kV	Solidly grounded primary, resistance grounded secondary
System Station Service Transformer 1B (TR-1B)	Three winding, Wye-Wye-Wye	19.2/25.6/32 MVA (OA/FOA/FOA)	138 kV/4.36 kV/4.36 kV	Solidly grounded primary, resistance grounded secondary
Unit Station Service Transformer 1C (TR-1C)	Three winding, Delta-Wye-Wye	19.2/25.6/32 MVA (OA/FOA/FOA)	22 kV/4.36 kV/4.36 kV	Resistance grounded secondary
Unit Station Service Transformer 1D (TR-1D)	Three winding, Delta-Wye-Wye	19.2/25.6/32 MVA (OA/FOA/FOA)	22 kV/4.36 kV/4.36 kV	Resistance grounded secondary
Main Generator Step-Up Transformer (TR-MT1)	Two winding, Delta-Wye	945 MVA (FOA)	21.5 kV/345 kV	Solidly grounded secondary
		Unit 2		
System Station Service Transformer 2A (TR-2A)	Three winding, Wye-Wye-Wye	19.2/25.6/32 MVA (OA/FOA/FOA)	138 kV/4.36 kV/4.36 kV	Solidly grounded primary, resistance grounded secondary
System Station Service Transformer 2B (TR-2B)	Three winding, Wye-Wye-Wye	19.2/25.6/32 MVA (OA/FOA/FOA)	138 kV/4.36 kV/4.36 kV	Solidly grounded primary, resistance grounded secondary
Unit Station Service Transformer 2C (TR-2C)	Three winding, Delta-Wye-Wye	19.2/25.6/32 MVA (OA/FOA/FOA)	22 kV/4.36 kV/4.36 kV	Resistance grounded secondary
Unit Station Service Transformer 2D (TR-2D)	Three winding, Delta-Wye-Wye	19.2/25.6/32 MVA (OA/FOA/FOA)	22 kV/4.36 kV/4.36 kV	Resistance grounded secondary
Main Generator Step-Up Transformer (TR-MT-2)	Two winding, Delta-Wye	945 MVA (FOA)	21.5kV/345kV	Solidly grounded secondary

[†] MVA = Megavolt Ampere
[‡] OA/FA/FOA = Oil Air / Forced Air / Forced Oil Air
[§] kV = kilovolt

Table 5 - Protective Devices

Protection Zone	Protective Device	UV Logic	Setpoint (Nominal)	Basis for Setpoint
			Unit 1	
4.16 kV ESF Bus	Degraded Voltage	2 of 2	3899 V** (93.7% of 4160 V), 90 seconds	The degraded voltage relays are designed to detect sustained undervoltage conditions. The voltage setpoint is chosen to ensure that at least 90% of the rated voltage is available at motor terminals. Voltages are monitored by two single-phase relays.
4.16 kV ESF Bus	Loss of Voltage	1 of 1	3122 V (75% of 4160 V), 1 second	The loss-of-voltage relays are designed to detect significant undervoltage conditions. The voltage and time delay settings are chosen to preclude relay actuation during normally expected voltage transients (e.g. motor starts and bus transfers). A three-phase relay operates on the difference between the positive sequence and the negative sequence voltage.
480 V ESF Bus	Degraded Voltage	2 of 2	450 V (93.7% of 480 V), 90.1 seconds	The degraded voltage relays are designed to detect sustained undervoltage conditions. The voltage setpoint is chosen to ensure that at least 90% of the rated voltage is available at motor terminals. Voltages are monitored by two single-phase relays.
480 V ESF Bus	Loss of Voltage	1 of 1	360 V (75% of 480 V), 29.5 seconds	The loss-of-voltage relays detect significant undervoltage conditions. The voltage and time delay settings are chosen to preclude relay actuation during normally expected voltage transients (e.g. motor starts and bus transfers). A three-phase relay operates on the difference between the positive sequence and the negative sequence voltage.

** V = Volts

Protection Zone	Protective Device	UV Logic	Setpoint (Nominal)	Basis for Setpoint
4.16 kV ESF Bus Supply	Ground Differential	N/A	10 A[††] 0.1 seconds	The setpoint is selected to provide sensitive ground protection for the cables supplying the 4kV ESF buses. The time delay is sufficient to avoid spurious operation during normally expected electrical transients.
4.16 kV ESF Bus Supply	Ground Overcurrent	N/A	30 A 0.3 seconds	The setpoint is selected to provide sensitive ground protection for the cables supplying the 4 kV buses while coordinating with the ground protection for the ESF motors.
4.16 kV ESF Motors	Ground Overcurrent	N/A	10 A 0.1 seconds	The setpoint is selected to provide sensitive ground protection for the 4 kV ESF motors. The time delay is sufficient to avoid spurious operation during normally expected electrical transients.
480 V ESF Bus	Ground Alarm	N/A	16 V 1 second	The 480 V ESF buses are ungrounded. The alarm setpoint is chosen to be sufficiently sensitive to detect a ground fault without resulting in nuisance alarms.
Unit 2				
4.16 kV ESF Bus	Degraded Voltage	2 of 2	3888.5 V (93.5% of 4160 V), 90.1 seconds	The degraded voltage relays are designed to detect sustained undervoltage conditions. The voltage setpoint is chosen to ensure that at least 90% of the rated voltage is available at motor terminals. Voltages are monitored by two single-phase relays.
4.16 kV ESF Bus	Loss of Voltage	2 of 2	3122 V (75% of 4160 V), 1 second	The loss-of-voltage relays are designed to detect significant undervoltage conditions. The voltage and time delay settings are chosen to preclude relay actuation during normally expected voltage transients (e.g. motor starts and bus transfers). Three-phase relays operate on the difference between the positive sequence voltage and the negative sequence voltage.

[††] A = Amperes

Protection Zone	Protective Device	UV Logic	Setpoint (Nominal)	Basis for Setpoint
480 V ESF Bus	Degraded Voltage	2 of 2	448.4 V (93.4% of 480 V), 90.1 seconds	The degraded voltage relays are designed to detect sustained undervoltage conditions. The voltage setpoint is chosen to ensure that at least 90% of the rated voltage is available at motor terminals. Voltages are monitored by two single-phase relays.
480 V ESF Bus	Loss of Voltage	2 of 2	336 V (70% of 480 V), 5 seconds	The loss-of-voltage relays are designed to detect significant undervoltage conditions. The voltage and time delay settings are chosen to preclude relay actuation during normally expected voltage transients (e.g. motor starts and bus transfers). A three-phase voltage relay operates in conjunction with a single-phase voltage relay. The three-phase relay monitors the difference between the positive sequence voltage and the negative sequence voltage.
4.16 kV ESF Bus Supply	Ground Differential	N/A	254.4 A, 255.3 A	The setpoint is selected to provide sensitive ground protection for the cables supplying the 4 kV ESF buses.
4.16 kV ESF Bus Supply	Ground Overcurrent	N/A	40 A, 30 A 0.4 seconds, 0.3 seconds	The setpoint is selected to provide sensitive ground protection for the cables supplying the 4 kV buses while coordinating with the ground protection for the ESF motors.
4.16 kV ESF Motors	Ground Overcurrent	N/A	10 A 0.1 seconds	The setpoint is selected to provide sensitive ground protection for the 4 kV ESF motors. The time delay is sufficient to avoid spurious operation during normally expected electrical transients.
480 V ESF Bus	Ground Alarm	N/A	15 V 1 second	The 480 V ESF buses are ungrounded. The alarm setpoint is chosen to be sufficiently sensitive to detect a ground fault without resulting in nuisance alarms.