FENOC

FirstEnergy Nuclear Operating Company

Perry Nuclear Power Plant
10 Center Road
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Perry, Ohio 44081

October 23, 2012
L-12-359

10 CFR 50.54(f)

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

SUBJECT:
Perry Nuclear Power Plant
Docket No. 50-440, License No. NPF-58
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 Perry Nuclear Power Plant, 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 23, 2012.

Sincerely,

Harlan D. Hanson, Jr.
Director, Performance Improvement

Attachment: Response to NRC Bulletin 2012-01 for Perry Nuclear Power Plant

cc: NRC Region III Administrator
NRC Resident Inspector
NRC Project Manager

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

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 Safety Analysis Report (USAR) Figure 8.3-1.

The Perry Nuclear Power Plant (PNPP) powers the Engineered Safety Feature (ESF) Buses (EH11, EH12, and EH13) through either the Unit 1 Startup Transformer (100-PY-B) and Interbus Transformer LH-1-A, or through the Unit 2 Startup Transformer (200-PY-B) and Interbus Transformer LH-2-A. The ESF buses are powered from the 345 kV switchyard (offsite supply) through one of these paths when at power (normal operating condition).

> ***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.

> ***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:

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

- Table 1 lists the ESF buses continuously powered from offsite power sources.
- Table 2, "ESF Buses Not Continuously Powered From Offsite Power Source(s)," is not applicable for PNPP.
- Table 3 lists ESF bus major loads that are energized when at power (normal operating condition), 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.

Response:

PNPP Technical Specification 3.8.1, "AC Sources-Operating," requires two qualified circuits between the offsite transmission network and the onsite Class 1E alternating current (AC) electric power distribution system. Clarification regarding what constitutes a qualified offsite circuit is provided in PNPP Technical Specification Bases 3.8.1. The Bases state that circuits between the switchyard and the 13.8 kV buses (L10 and L20) may utilize appropriate paths involving two startup transformers, and are considered immediate access circuits. PNPP USAR section 8.2.1.2.2 further clarifies the offsite sources as the interfaces between the transmission station and the Class 1E power system, consisting of 345 kV transmission circuits, disconnect switches, startup transformers, circuits in cable tray and underground duct banks, interbus transformers, and 5 and 15 kV switchgear.

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

1. Unit 1 Circuit 1 - Power to the ESF buses via 345 kV switchyard (Unit 1 Startup Transformer 100-PY-B)
2. Unit 1 Circuit 2 - Power to the ESF buses via 345 kV switchyard (Unit 2 Startup Transformer 200-PY-B)

Table 1, "ESF Buses Continuously Powered From Offsite Power Source(s)," identifies that both of the above-listed sources were part of the original plant licensing basis.

<u>System Protection</u>

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, existing 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. The relay systems were not specifically designed to detect an open single phase of a three phase system. Detection of a single open phase condition was not required for licensing of the plant.

Although the degraded voltage protection scheme at PNPP was not designed to detect and automatically respond to a single-phase open circuit condition on a credited offsite power circuit, preliminary investigation has indicated that the degraded or loss of voltage relays would likely respond to this condition and automatically isolate the offsite supply and start the emergency diesel generator for the affected division(s). During normal at-power plant operation the emergency buses (1E buses) are powered from either the Unit 1 or Unit 2 Startup Transformer. An open phase on either of the qualified offsite supplies will cause a loss of voltage or a degraded voltage at the 1E buses due to the line impedance and normally running load. The voltage drop is anticipated to be sufficient to cause the ESF bus degraded voltage relays (DVRs) or loss of voltage relays (LVRs) to operate, and isolate the offsite supplies, although no specific calculations have been performed to confirm this engineering judgment. Both the DVRs and LVRs monitor voltage on all three phases (A-B, B-C, C-A), and a single degraded phase voltage would trip the offsite supply.

The electrical analyses for offsite circuits have been reviewed with regard to high impedance grounds. The transformers used at PNPP to supply ESF buses with offsite power when the plant is at power (100-PY-B, 200-PY-B, LH-1-A, and LH-2-A) have time overcurrent ground fault (51NT) relays. Additionally, when shutdown and utilizing a backfeed source through the main and auxiliary transformers (1-PY-T and 110-PY-B), the auxiliary transformer has a 51NT time overcurrent ground fault relay. When a ground fault is sensed by any of these 51NT relays, the associated transformer is isolated. This would produce a loss of voltage on the respective ESF bus and would initiate a start of the emergency diesel generator for the affected division(s).

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 specifically designed to detect a single-phase open circuit condition. There is no quantitative analysis to show that these protection schemes will detect an open phase condition; however, based on PNPP's specific offsite supply design, it is anticipated that these schemes are sufficiently sensitive to detect and respond to an open phase condition. Table 5 lists the undervoltage protective devices and the basis for the device setpoint(s).

Existing electrical protective devices are sufficiently sensitive to detect a ground fault. Table 5 lists ground protection for the qualified offsite supplies 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.

Response:

Not applicable to PNPP; the ESF buses at PNPP are normally 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?

Response:

The current plant operating procedures specifically call for verification of the voltages on all three phases of the ESF buses when the plant is at power (normal operating condition).

Two PNPP procedures implement Technical Specifications (TS) surveillance requirements (SRs) 3.8.1.1 and 3.8.7.1 to verify electric power availability. Both have a seven day Frequency. Since the ESF buses are supplied from offsite power when the plant is at power, although one procedure is entitled "Off-Site Power Availability Verification" and the other is entitled "On-Site Power Distribution System Verification," both procedures are actually verifying offsite power availability. The first (Off-Site Power) procedure uses a single-phase voltage check to determine if a bus is energized or not energized; however, the second (On-Site Power) procedure does measure voltage on all three phases at each of the three ESF buses. Since the checks are done at the ESF bus level, it verifies availability of the entire offsite supply leading to the ESF bus. Therefore, although responses to other NRC requests for information note that installed PNPP electrical equipment was not specifically designed to detect and respond to a single-phase open circuit condition, the weekly checks will identify such a condition.

<u>Consequences</u>

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:

Since there are no unloaded ESF buses at PNPP, it is not possible to describe differences in electrical consequences of loaded versus unloaded power supplies.

With respect to single-phase open circuit conditions, the installed relays were not specifically designed to detect such conditions. The existing loss of voltage and degraded voltage relays may respond, depending on load and possible grounds. The plant response for a loaded power source cannot be calculated without specifying the amount of loading and the specific loads involved.

With respect to a high impedance ground condition, the offsite circuits (normal and backfeed) at PNPP have time overcurrent ground fault (51NT) relays for the transformers. As described in response to item 1 above, when a ground fault is sensed by any of these 51NT relays, the associated transformer is isolated. This would produce a loss of voltage on the respective ESF bus and would initiate a start of the emergency diesel generator for the affected division(s).

> ***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*** [sic], ***describe the consequences of such an event and the plant response.***

Response:

With respect to single-phase open circuit conditions, the PNPP Class 1E protection scheme for the ESF buses did not credit the ability to detect and automatically respond to a single-phase open circuit condition. Since the ESF bus protection scheme was not credited 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 or the degraded voltage relay (DVR) schemes. Since open phase detection was not credited in the PNPP design or licensing basis, no design basis calculations or design documents exist that previously considered this condition. Although formal engineering calculations or evaluations are not available, 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. Detailed plant specific models would need to be developed (including 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 PNPP-specific Class 1E electric distribution system. As noted above, weekly checks at the ESF buses would detect a single-phase open circuit condition.

With respect to a high impedance ground condition, such a condition would have no immediate effect on plant operation. If the ground is sufficiently large to affect plant operation, protective relaying will isolate the ground automatically as described above.

> ***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:

Typically, the ESF buses are split between the two qualified offsite sources. Occasionally, they are all supplied from a single source. Consistent with the current licensing basis and GDC 17, protective circuitry will separate the ESF buses from a failed offsite source due to a loss of voltage or a sustained balanced degraded grid voltage. The relay systems were not specifically designed to detect an open single phase of a three phase system. Detection of a single-open phase circuit is beyond the approved design and licensing basis of the plant. No calculations for this scenario have been done. As noted above, weekly checks at the ESF buses would detect a single-phase open circuit condition.

With respect to a high impedance ground condition, the current plant protective circuitry will protect from a ground fault condition with all three phases intact.

Figure 1: Simplified One-Line Diagram

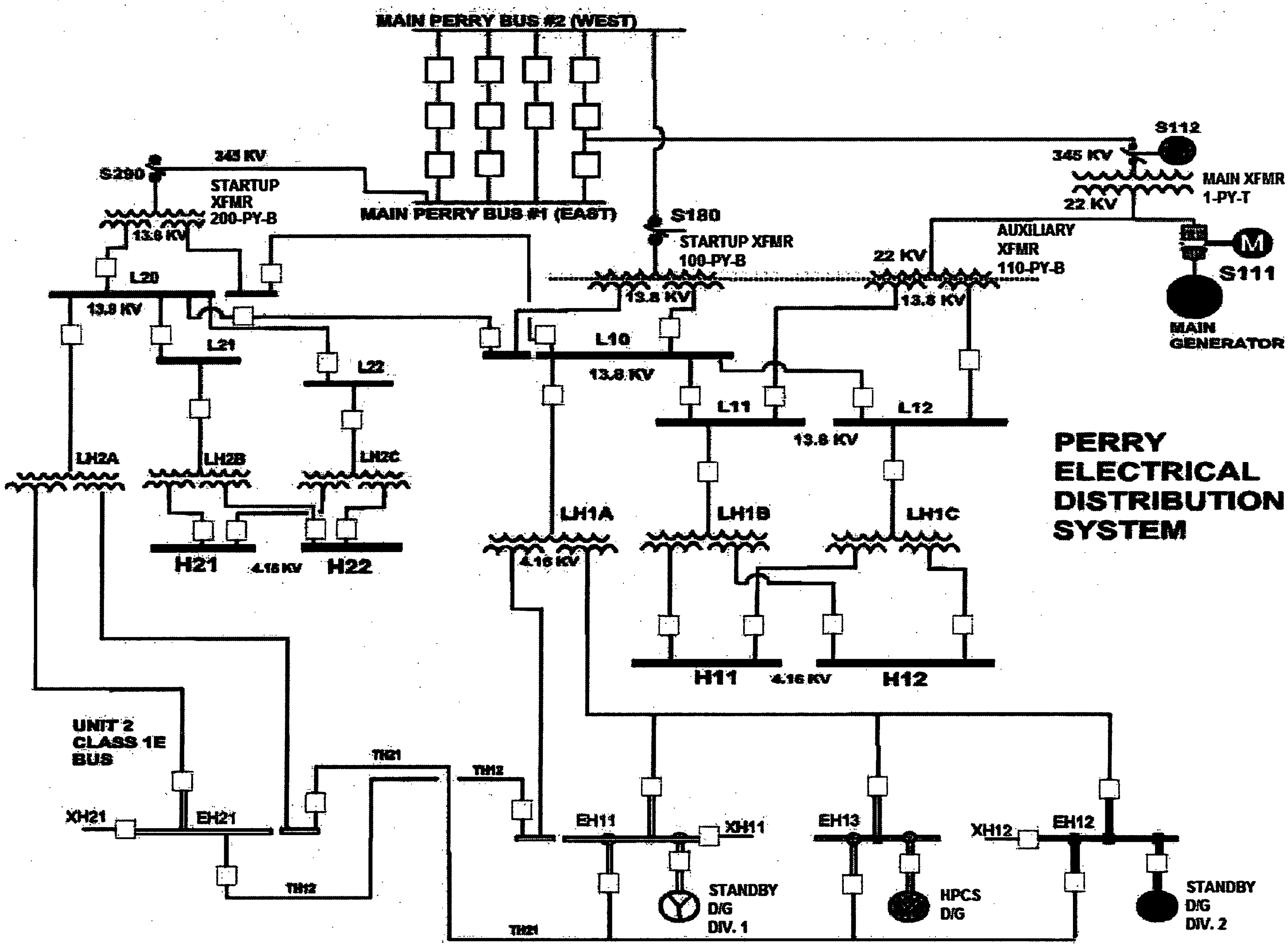

Table 1 - ESF Buses Continuously Powered From Offsite Power Source(s)

Description of ESF Bus Power Source	ESF Bus Name (normal operating condition)	Original licensing basis configuration (Y/N)
Unit 1 Startup Transformer (100-PY-B)	Bus EH11 and/or Bus EH12 and/or Bus EH13 (4.16 kV)	Y
Unit 2 Startup Transformer (200-PY-B)	Bus EH11 and/or Bus EH12 and/or Bus EH13 (4.16 kV)	Y

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

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

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

ESF Bus	Load	Voltage Level	Rating
EH11 / EH12	(1) Control Complex Chiller	4160 VAC*	580 kW †
EF1B08 / EF1D08	(1) Off-Gas Building Vent Fan	480 VAC	40 HP ‡
EF1A / EF1C	(1) Fuel Pool Cooling and Circulating Pump	480 VAC	200 HP
EF1A / EF1C	(1) Motor Control Center (MCC) Switchgear and Battery Rooms Supply Fan	480 VAC	100 HP
EF1B / EF1D / EF2D	(1) Control Complex Chilled Water Pump	480 VAC	100 HP
EF1B09 / EF1D09	(1) MCC Switchgear and Battery Rooms Recirculation Fan	480 VAC	100 HP
EF1B09 / EF1D09	(1) Control Room HVAC§ Supply Fan	480 VAC	60 HP
EF1B09 / EF1D09	(1) Control Room HVAC Return Fan	480 VAC	60 HP
EF1B09 / EF1D09 / EF2D11	(1) Fuel Handling Building Exhaust Fan	480 VAC	40 HP
XH11(Fed from EH11) / XH12 (Fed from EH12)	(1) Control Rod Drive Pump	4160 VAC	400 HP
XH11(Fed from EH11) / XH12 (Fed from EH12)	(1) Nuclear Closed Cooling Pump	4160 VAC	700 HP
XH12	(1) Service Water Pump B	4160 VAC	1000 HP

* VAC = Volts AC

† kW = Kilowatts

‡ HP = Horsepower

§ HVAC = Heating, Ventilation, and Air Conditioning

Table 4 - Offsite Power Transformers

Transformer	Winding Configuration	MVA** Size (Cooling††)	Voltage Rating (Primary/Secondary)	Grounding Configuration
Unit 1 Startup Transformer 100-PY-B	Wye-Wye	72.8 / 72.8 MVA (OA/FA/FA)	345 kV / 13.8 kV‡‡	Neutral Grounded
Unit 2 Startup Transformer 200-PY-B	Wye-Wye-Wye	90/65/65 MVA (FOA/FOA)	345 kV / 13.8 kV	Neutral Grounded
Unit 1 Main Transformer 1-PY-T (Backfeed Configuration Only)	Delta – Wye	415 / 415 MVA (FOA)	22 kV / 345 kV	Neutral Grounded
Unit 1 Auxiliary Transformer (Backfeed Configuration Only)	Delta-Wye-Wye	64/40/40 MVA (OA/FA/FA)	22 kV / 13.8 kV	Neutral Grounded

Table 5 - Protective Devices

Protection Zone	Protective Device	UV Logic	Setpoint (Nominal)	Basis for Setpoint
4.16 kV ESF Bus (EH11/EH12/EH13)	Loss of Voltage Relay	1 of 3 (twice)	3000 V§§ (72.12% of 4160 V)	To actuate upon complete loss of ESF Bus voltage condition. The following were considered for the basis of 72.12 percent (%) of 4160 V setpoint: motors are rated to start at 75% or above rated voltage; and motors can deliver rated full load torque at 70% of rated voltage for 5 minutes. Technical Specification Basis: The Bus Undervoltage Allowable Values are low enough to prevent inadvertent power supply transfer, but high enough to ensure power is available to the required equipment. The Time Delay Allowable Values are long enough to provide time for the offsite power supply to recover to normal voltages, but short enough to ensure that power is available to the required equipment.

** MVA = Megavolt Amperes

††OA/FA/FOA = Oil Air / Forced Air / Forced Oil Air

‡‡ kV = kilovolts

§§ V = Volts

Protection Zone	Protective Device	UV Logic	Setpoint (Nominal)	Basis for Setpoint
4.16 kV ESF Bus (EH11/EH12/EH13)	Degraded Grid	1 of 3 (twice)	3800 V (<91.3% of 4160 V)	To actuate on degraded voltage to prevent damage to the motors that could disable the emergency core cooling system (ECCS) function. The degraded voltage relays (DVRs) are arranged in a one-out-of-three taken twice logic scheme that initiates two separate time-delays, a "limited time delay" (TDR 2-1) and a "long time delay" (TDR 2-2). In the event that the 4.16 kV emergency bus remains below the DVR trip setpoint, the timers trip the offsite power source breakers and initiate the necessary logic to start and connect the diesel generator associated with that bus. The TDR 2-1 timer provides sufficient delay time to prevent initiation of the logic during the short duration voltage dips expected to occur during the automatic load sequencing associated with a loss of coolant accident (LOCA). The TDR 2-2 timer provides delay time to allow operator response to a degraded voltage condition during non-LOCA events, while maintaining sufficient protection to plant safety equipment that may be running. <u>Technical Specification Basis:</u> A reduced voltage condition on a 4.16 kV emergency bus indicates that while offsite power may not be completely lost to the respective emergency bus, power may be insufficient for starting large motors without risking damage to the motors that could disable the ECCS function. The Bus Undervoltage Allowable Values are low enough to prevent inadvertent power supply transfer, but high enough to ensure that sufficient power is available to the required equipment. The Time Delay Allowable Values are long enough to provide time for the offsite power supply to recover to normal voltages, but short enough to ensure that sufficient power is available to the required equipment.

Protection Zone	Protective Device	UV Logic	Setpoint (Nominal)	Basis for Setpoint
Transformers LH-1-A, LH-2-A	Ground Fault Protection	N/A	300 A[***] @10PU[†††], 2.5 A Tap	Detect a ground fault condition and isolate the affected transformer downstream lines.
Transformers 100-PY-B, 200-PY-B	Ground Fault Protection	N/A	320 A @10PU, 4 A Tap	Detect a ground fault condition and isolate the affected transformer upstream and downstream lines.
Transformer 110-PY-B	Ground Fault Protection	N/A	300 A @10PU, 2.5 A Tap	Detect a ground fault condition and isolate the affected transformer upstream and downstream lines.

[***] A = Amperes

[†††] PU = Pickup