Entergy

Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360

Robert G. Smith, P.E.
Site Vice President

October 25, 2012

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

SUBJECT: 90-Day Response to NRC Bulletin 2012-01, Design Vulnerability in Electric Power System
Pilgrim Nuclear Power Station
Docket No. 50-293
License No. DPR-35

REFERENCE: 1. NRC letter to Entergy, "Bulletin 2012-01 Design Vulnerability in Electric Power System", dated July 27, 2012 (1.12.048)

LETTER NUMBER 2.12.071

Dear Sir or Madam:

On July 27, 2012, the NRC issued Bulletin 2012-01 (Reference 1), requesting that each licensee submit a written response in accordance with 10 CFR 50.54(f) within 90 days of the Bulletin to provide requested information. This letter provides Entergy's 90-day response to Reference 1 for Pilgrim Nuclear Power Station (PNPS) in the attachment.

There are no new commitments contained in this submittal. Should you have any questions concerning the content of this letter, please contact Mr. Joseph R. Lynch at (508) 830-8403.

IE76
NRR

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

Sincerely,

Robert G. Smith
Site Vice President

RGS/mew

Attachment: 1. PNPS 90-Day Response to NRC Bulletin 2012-01

cc: Mr. William M. Dean
Regional Administrator, Region 1
U. S. Nuclear Regulatory Commission
2100 Renaissance Boulevard, Suite 100
King of Prussia, PA 19406-1415

Mr. Richard V. Guzman
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
MS O-8C2A
Washington, DC 20555

NRC Senior Resident Inspector
Pilgrim Nuclear Power Station

Attachment 1 to

PNPS Letter 2.12.071

PNPS 90-Day Response to NRC Bulletin 2012-01

(10 Pages)

PNPS 90-Day Response to NRC Bulletin 2012-01

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
- Figure 1 - Simplified One-Line Diagram
- Tables
  - Table 1 – Engineered Safeguards Feature (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 Normally Energized Major Loads
  - Table 4 - Offsite Power Transformers Winding and Grounding Configurations
  - Table 5 - Protective Devices

System Description

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

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

See Figure 1 for the simplified one-line diagram.

During normal operation, the main generator provides power through the isolated phase bus (ISO-Phase) at 24kV to both the Generator Step-Up Transformer (GSU) and the Unit Auxiliary Transformer (UAT). The generator voltage is stepped up through the GSU transformer to 345kV and power flows into the ring bus in the switchyard to the New England power grid over the two 345kV transmission lines connected to the ring bus. The main generator voltage is reduced through the UAT to 4160V, and the power flows to the station loads including the 4160V ESF buses A5 and A6 and the 480V ESF buses.

The ESF buses are not normally connected to the preferred offsite power source Start-Up Transformer (SUT) or secondary offsite power source the Shut-Down Transformer (SDT).

The 345kV from the ring bus provides offsite power via the SUT to 4.16kV ESF buses A5 and A6 following a SCRAM via the fast transfer scheme from the UAT.

The 23kV from Manomet substation provides secondary offsite power via the SDT to ESF buses A5 and A6 in the event of loss of the SUT and loss of one (1) or both Emergency Diesel Generators (EDGs).

See Table 2 for ESF bus power sources during normal power operation

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

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.

During normal (at power) operation the ESF buses are powered from the UAT and not by 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.

According to the Updated Final Safety Analysis Report (UFSAR), Section 8.1, the UAT supplies power to ESF buses during normal power operation. During unit startup and shutdown the SUT provides power to the ESF buses or whenever the UAT becomes unavailable.

Additionally the SDT provides a secondary offsite power source to the ESF buses in the event that the SUT is unavailable due to a loss of offsite 345kV supply or failure of the SUT and a failure of the Emergency Diesel Generators (EDG) to supply the ESF bus.

PNPS was designed prior to the issuance of the General Design Criteria. The SUT and SDT are the General Design Criterion (GDC) 17 credited offsite power sources.

The following at power (normal operating condition) configurations are confirmed to be consistent with current licensing basis:

> The ESF buses are normally powered from UAT during normal operating condition. During Startup or if the UAT becomes unavailable, the ESF buses are allowed to be powered from SUT.

The original Final Safety Analysis Report (FSAR) was reviewed and the offsite power source alignment to the ESF buses has not changed since the original plant licensing.

System Protection

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

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

Existing protective circuitry for the SUT 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 or high impedance ground fault is beyond the approved design and licensing basis of the plant.

Existing protective circuitry for the SDT is designed to separate the ESF buses from a connected offsite source in the event of a voltage unbalance, in 30 seconds, by negative sequence relays; unless the trip is bypassed by operator manual action. The negative sequence relays will also alarm at the control room instantaneously.

The credited offsite power sources for PNPS are the SUT and the SDT, which are fed from two separate offsite sources thus maintaining independence. Therefore, a single open phase condition does not affect both offsite sources.

The electrical analyses for the offsite sources have been reviewed with regard to high impedance grounds. The effects of a high impedance ground have been found to be inconclusive without detailed studies.

> ***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 such as a loss of voltage or a degraded voltage, but the devices were not designed to detect a single phase open circuit condition. See Table 5 for undervoltage protective devices and the basis for the device setpoint(s).

Existing electrical protective devices are also sufficiently sensitive to detect a ground fault. Table 5 lists ground 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.

The ESF buses A5 and A6 are not normally powered by the off site power sources (345kV system via the Startup transformer or the 23kV system via the Shutdown transformer). As explained in item 2 (System Description), buses A5 and A6 are supplied from the Unit Auxiliary Transformer (UAT) which is connected to the 24kV ISO-Phase bus at the output of the main generator. Operator tour (See eSOMS Rounds undertaken in accordance with PNPS Procedure 2.1.16) requires operations personnel in their twice daily tour to verify that all insulators, phase leads and bus bars in the 345kV switchyard (primary side of the SUT) are intact. Once the loss of phase is detected either by operations personnel or by other means, a three day LCO would be declared in accordance with technical specifications until the SUT power source is restored.

Post-insulators installed in the 345kV switchyard are primarily installed vertically so the loads are primarily compressive (wind loading applies a bending moment). Rigid post insulator failures are typically in locations where they are mounted cantilevered or under hung applications wherein bending moments and tensile stresses are constant loads. Based on walk down of the 345kV switchyard, there are only three places where cantilevered post insulators are used: 1) the Line 342 terminal structure; 2) the Line 355 terminal structure; 3) both sides of ACB-104 supporting the rigid bus connecting it to the Line 342 and GSU bus sections.

Per Preventive Maintenance Basis Document (PMBD) #284, a thermography infra-red (IR) survey of the switchyard insulators is performed quarterly. Additionally, corona surveys are performed every 6 months. Adequate detection is provided by the twice-daily tours to verify no loss of phase has occurred, the quarterly IR survey, and the corona survey.

PNPS Procedure 8.C.22, "Startup Transformer and 345kV Switchyard Surveillance" performs a weekly surveillance to verify that all three phase potentials to the SUT are available.

Also, the existing PMs are adequate to identify missing, broken, or other insulator problems in all applications. These four-year PMs are performed in accordance with PNPS Procedure 3.M.3-71, "Inspection and Maintenance of 345kV Disconnects, Insulators, and Miscellaneous Switchyard Components".

The 23kV source for the SDT from Manomet Substation is connected via the F-15 circuit switcher. The F-15 circuit switcher has a potential for insulator failure similar to the occurrence at Byron Station. The PNPS operator tour has been revised to perform visual inspection for any sign of insulator, lead or bus bar failure.

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?

Neither the SUT nor the SDT are normally connected to the ESF buses. At normal power, an open phase on the high side of the SUT or SDT will have no effect on the ESF buses since they are supplied by the UAT.

When ESF buses are aligned with either the SUT or SDT, the ESF Bus Degraded Voltage Relays will annunciate at the control room, if any of the three phases is degraded due to an open phase. The 4.16kV relays are set at approximately 95% of 4.16kV.

There is a weekly surveillance to check the voltages on all three phases of ESF buses A5 and A6 (PNPS Procedure 8.C.18, "4.16kV/480V Switchgear Surveillance").

Consequences

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

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

At PNPS, the existing installed degraded voltage relays that monitor the SUT were not designed to detect a single phase open circuit condition. Existing loss of voltage and degraded voltage relays may respond depending on load and possible grounds. In general, there will be no plant response in the event of a single-phase open circuit on a credited off-site power source (PNPS is powered via UAT in normal operation) because there is insufficient current to detect a single-phase open circuit for this configuration. Therefore, the actions as specified in section 2.b have been established to detect any open phase condition for the SUT.

The plant response for a loaded power source with or without a high impedance ground cannot be evaluated without specifying the amount of loading and the specific loads along with the detailed SUT and SDT model.

The SDT is monitored by the negative sequence and loss of voltage relays which may not respond to a single-phase open circuit condition under no-load. Therefore, the actions as specified in section 2.b have been established to detect any open phase condition for the SDT.

For a loaded SDT with an open phase condition, although this source has not been evaluated for such specific condition, the SDT source is equipped with negative sequence protection (voltage unbalance protection) which is designed to separate the ESF buses from the degraded offsite power source.

> ***1.c. If the design does not detect and automatically respond to a single-phase open circuit condition or high impedance ground fault condition on a credited offsite power circuit or another power sources, describe the consequences of such an event and the plant response.***

A high impedance ground will have no immediate effect on plant operation as ESF buses are fed from the UAT during normal power operation. If the ground is sufficiently large to affect plant operation, protective relaying will isolate the ground automatically.

In the case of a single-phase open circuit condition the following statements are concluded:

1. PNPS did not credit in the Current Licensing Basis (CLB) that the Class 1E protection scheme (for the engineered safeguard feature (ESF) buses) was designed to detect and automatically respond to a single-phase open circuit condition on the credited off-site power source as described in the UFSAR and Technical Specifications.
2. Since PNPS did not credit the ESF bus protection scheme as being capable of detecting and automatically responding to a single phase open circuit condition, an open phase fault was not included in the design criteria for either the loss of voltage relay scheme, the degraded voltage relay (DVR) scheme or secondary level undervoltage protection scheme. Since open phase detection was not credited in the PNPS design or licensing basis, no design basis calculations or design documents exist that consider this condition.
3. Without formalized engineering calculations or engineering evaluations, the electrical consequences of such an open phase event or high impedance ground fault event (including plant response), can only be evaluated in generic terms based on current available industry guidance and Operating Experience from the Byron event. The difficulty in applying these industry documents to the PNPS specific response is that these are generic assessments and cannot be formally credited as a basis for an accurate response. The primary reason is that detailed plant specific models would need to be developed (e.g., transformer magnetic circuit models, electric distribution models, motor models) including positive, negative, and zero sequence impedances (voltage and currents), and the models would need to be compiled and analyzed for the PNPS specific Class 1E electric distribution system.

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.

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 concurrent with certain design basis accidents. 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 (open phase) have been performed.

At PNPS during normal power operation, the ESF buses would not be adversely affected by an open circuit as they are not aligned to an offsite power source (ESF buses fed from UAT). If an open circuit on the offsite source were to occur during plant startup or shutdown, or during some other plant condition that caused the ESF buses to align to the offsite source (SUT), then redundant ESF buses would be aligned to a common offsite source and both buses may be adversely affected.

The offsite power source SUT is fed via the switchyard 345kV ring bus. Therefore, the SUT is normally energized via Line 355 and Line 342. Consequently, loss of a line or a degraded line will not adversely affect the SUT operation, as the other line will be available as designed.

Based on section 2.b of this response, potential for an insulator failure similar to Byron Station could be either at Line 342 terminal structure, at Line 355 terminal structure, or at ACB 104 rigid bus support connection.

When the ESF buses are connected to the SUT following a SCRAM, an ACB 104 insulator failure will not adversely affect the operation of the SUT as ACB 104 will be tripped open due to the SCRAM, and both Line 342 and Line 355 will be available. Similarly, a single insulator failure (open phase) either at Line 342 or at Line 355 will not adversely affect the operation of the SUT as the other line will be available. ESF buses may be adversely affected if both line insulators fail (open phase condition) or a single line insulator fails with one of the line being out of service.

At the PNPS switchyard, the voltage is monitored at various locations of the switchyard via 3000:1 ratio potential transformers. Both 342 and 355 Lines are monitored as well as the primary side of the SUT. In the event of an open phase, the voltage monitoring relays, which monitor all three phases, are designed to alarm at the control room to prompt operators to perform necessary action. The alarm response procedures are currently being revised to add "an open phase condition" to the list of possible causes.

The 4.16kV ESF buses are constantly monitored for degraded voltage conditions. The degraded voltage relays are connected between phases A-B and B-C. These relays are set approximately at 95% of the 4.16kV and provide an alarm-only function only when any of the phases is degraded below 95% of nominal voltage. When the ESF buses are aligned to the SUT or to the SDT, if an open phase condition at the high side of the SUT or the SDT were to occur, the degraded voltage relays are designed to pick-up to alarm in the control room; although without formalized engineering calculations or evaluations, it cannot be guaranteed that the alarm will occur. PNPS Procedure 2.4.144, "Degraded Voltage" provides necessary guidance to the control room operator to take corrective actions under this situation.

Operator eSOMS rounds have been updated as described in section 2.b to enhance operator rounds observations to identify potential open phase conditions in the 345kV switchyard and at the 23kV circuit switcher.

If both ESF buses are aligned to offsite power source from the SDT (following a loss of SUT and both EDGs), the negative sequence relays are designed to trip the SDT source after a 30 seconds delay, on a voltage unbalance situation, unless the trip is bypassed manually by operator action and will alarm instantaneously.

Consistent with the current station design, protective circuitry will protect from a ground fault condition with all three phases intact. See Table 5 for a summary of the protective devices mentioned, their setpoints and their operational basis.

Figure 1 - Simplified One-Line Diagram

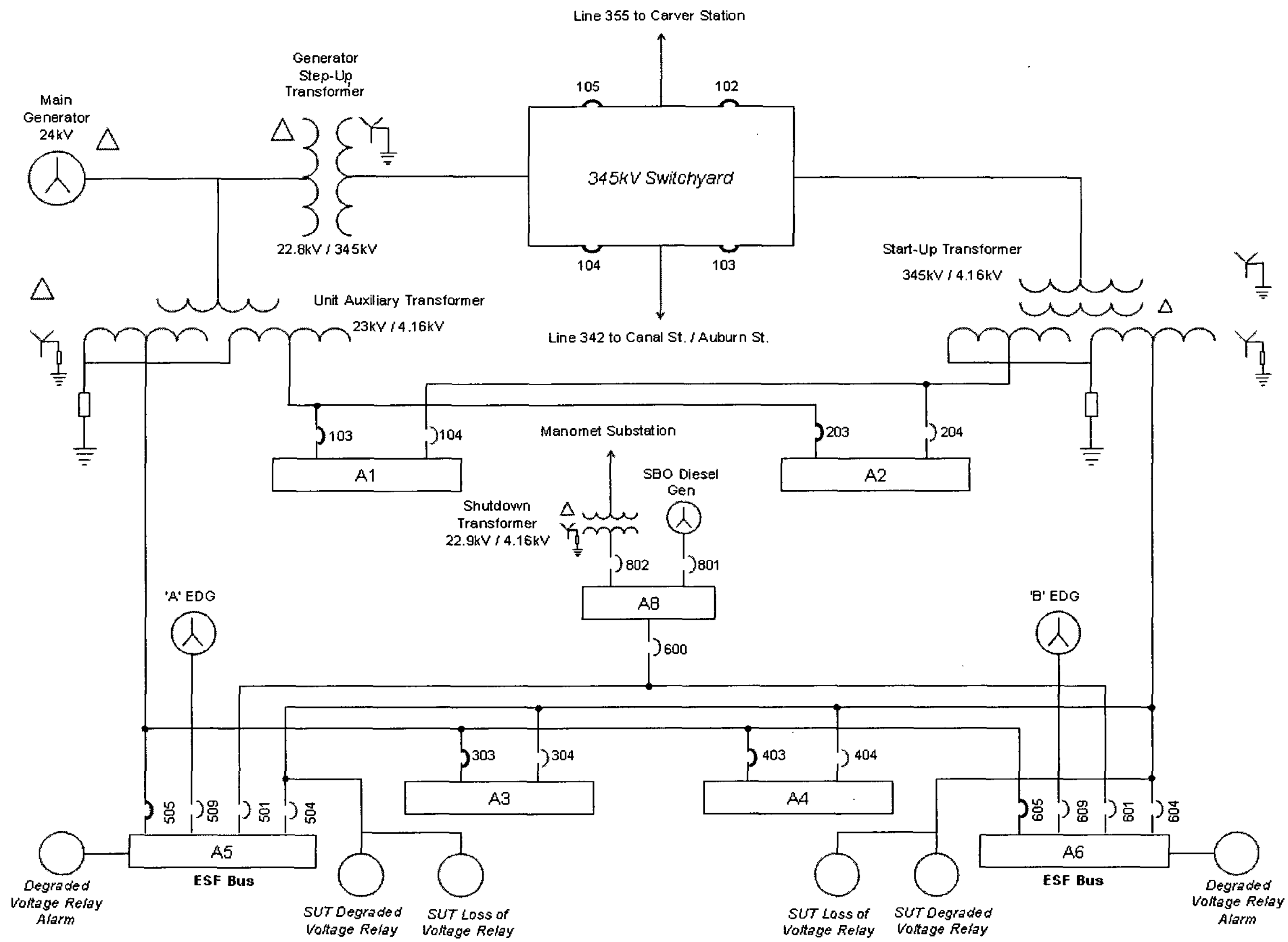

Table 1 – Engineered Safeguards Features (ESF) Buses Continuously Powered From Offsite Power Source(s)

Description of ESF Bus Power Source	ESF Bus Name (normal operating condition).	Original licensing basis configuration (Y/N)
N/A	N/A	N/A
Not applicable to Pilgrim Station		

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 Auxiliary Transformer (UAT) (X3)	4.16kv buses A5 and A6	Y

Table 3 - ESF Buses Normally Energized Major Loads

ESF Bus	Load	Voltage Level	Rating (HP)
N/A	N/A	N/A	N/A
Not applicable to Pilgrim Station			

Table 4 - Offsite Power Transformers Winding and Grounding Configurations

Transformer	Winding Configuration	MVA Size (AO/FA/FA)	Voltage Rating (Primary/Secondary)	Grounding Configuration
Start-up Transformer (SUT) (X4)	Wye / Wye / Wye with buried Delta	20/26.6/33.3	345/4.16kV	HV Solid Ground / LV Resistance Ground. (4 ohms, 600A)
Shut Down Transformer (SDT) (X13)	Delta / Wye	5.0 (AO only)	22.9/4.16kV	LV Resistance Ground (4.03 ohms, 600A).

Table 5 - Protective Devices

Protection Zone	Protective Device	UV Logic	Setpoint (Nominal)	Basis for Setpoint
SUT to ESF buses A5 & A6	Degraded Voltage Relays	1 out of 2 taken twice	3871 V (92.5%) for 10 seconds	To detect and trip the degraded offsite power source when the SUT secondary voltage drops below the setpoint.
SUT to ESF buses A5 / A6	Loss of Voltage Relays	2 out of 2	3185-3325 V (77%)	To detect and trip the faulted offsite power source on a loss of SUT secondary voltage.
4.16kV ESF Buses A5 / A6	Degraded Voltage Relays	1 out of 2	3951.5 V (95%) for 10 seconds	To detect and alarm when the voltage on the degraded ESF buses drops below the setpoint.
SDT to ESF buses A5 / A6	Loss of Voltage Relays	2 out of 2	3185-3325 V (77%)	To detect and alarm/trip the faulted offsite power source on a loss of SDT secondary voltage.
SUT (HV)	Ground Protection Relay	1 out of 1	6000 Amps	To detect and trip the offsite power source from the SUT on a ground fault.
SUT (LV)	Ground Protection Relay	1 out of 1	40 Amps	To detect and trip the offsite power source from the SUT on a ground fault.
SDT (LV)	Ground Protection Relay	1 out of 1	20 Amps	To detect and trip the offsite power source from the SDT on a ground fault.
SDT (LV) to ESF buses A5 & A6	Ground Protection Relays	1 out of 1	400 Amps @ 0.6 seconds	To detect and trip the ESF buses on a ground fault, and separate them from the SDT.
SDT to ESF buses A5 & A6	Negative Sequence Relays (Voltage Unbalance)	2 out of 2	525 V 30sec Time Delay	To detect a voltage unbalance (Negative Sequence) and trip/alarm the SDT power source from the ESF buses.
Line 342/355	Loss of Voltage Relays	1 out of 3 (1 per phase)	120000 V_{AC}	To detect and alarm on undervoltage from Line 342 or Line 355.
SUT (HV)	Loss of Voltage Relays	1 out of 3 (1 per phase)	120000 V_{AC}	To detect and alarm on undervoltage from the high voltage side of the SUT.