

October 25, 2012

PG&E Letter DCL-12-104

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

10 CFR 50.54(f)

Docket No. 50-275, OL-DPR-80  
Docket No. 50-323, OL-DPR-82  
Diablo Canyon Units 1 and 2  
Ninety-Day Response to NRC Bulletin 2012-01: "Design Vulnerability In Electric Power System"

On July 27, 2012, the NRC issued Bulletin 2012-01, "Design Vulnerability In Electric Power System" (Bulletin). The Bulletin requires that Pacific Gas & Electric Company (PG&E) submit written responses within 90 days of the date of the Bulletin.

The Bulletin was issued to:

- (1) Notify the addressees that the NRC staff is requesting information about the facilities' electric power system designs, in light of the recent operating experience that involved the loss of one of the three phases of the offsite power circuit (single-phase open circuit condition) at Byron Station, Unit 2, to determine if further regulatory action is warranted.
- (2) Require that the addressees comprehensively verify their compliance with the regulatory requirements of General Design Criterion (GDC) 17, "Electric Power Systems," in Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR 50 or the applicable principal design criteria in the updated Final Safety Analysis Report; and the design criteria for protection systems under 10 CFR 50.55a(h)(2) and 10 CFR 50.55a(h)(3).
- (3) Require that addressees respond to the NRC in writing, in accordance with 10 CFR 50.54(f).

The enclosure provides PG&E's 90-day response to the Bulletin.

PG&E is making a regulatory commitment (as defined by NEI 99-04) in this letter. The commitment is contained in Attachment 3 of the Enclosure to this letter. If you have questions regarding these responses, please contact Mr. Tom Baldwin at (805) 545-4720.



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

Executed on October 25, 2012.

Sincerely,

A handwritten signature in blue ink that reads "Barry S. Allen".

Barry S. Allen  
*Site Vice President*

dngd/4955/50501409

Enclosure

cc Diablo Distribution

cc/enc: Elmo E. Collins, NRC Region IV

Laura H. Micewski, Acting NRC Senior Resident Inspector

Joseph M. Sebrosky, NRR Project Manager

**Pacific Gas & Electric Company (PG&E) 90-Day Response to  
NRC Bulletin 2012-01  
Design Vulnerability in Electric Power System**

**Diablo Canyon Power Plant (DCPP) Units 1 and 2 Response**

For clarity the bulletin requested actions have been grouped together into topical sections. This approach follows the Nuclear Energy Institute template presented to the NRC in an industry meeting on August 21, 2012.

**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 1 - Simplified One-Line Diagram
- Attachment 2 - Tables
  - Table 1 - Engineered Safety 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 Major Loads
  - Table 4 - Offsite Power Transformers
  - Table 5 - Protective Devices

**System Description:**

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

**NRC Question 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).*

**PG&E Response 2:**

See Attachment 1 of this enclosure for a simplified one-line diagram for DCPD.

DCPD is interconnected to the PG&E's electric grid system via a 230 kV and a 500 kV switchyard. These switchyards are physically and electrically separated and independent of each other. The 230 kV system provides one source of offsite power for startup and standby power, and is immediately available. The 500 kV system provides for transmission of the plant's power output. The 500 kV connection also provides a delayed access source of offsite power after the main generator is disconnected.

During normal (at power) operation the three 4.16 kV vital buses for each DCPD unit are powered from the Main Generator 25 kV output via one of the two Unit Auxiliary Transformers. Each unit at DCPD has a 25 kV/12 kV Unit Auxiliary Transformer and a 25 kV/4.16 kV Unit Auxiliary Transformer. The 25 kV/12 kV Unit Auxiliary Transformer feeds large nonvital motor loads critical to plant availability, which are the reactor coolant pumps and circulating water pumps. The 25 kV/4.16 kV Unit Auxiliary Transformer supplies ESF loads via the three DCPD 4.16 kV Vital Buses and non-ESF loads via two additional 4.16kV Nonvital Buses. The main generator is isolated from its unit auxiliary transformers and 500 kV Switchyard Breakers by a motor operated disconnect.

A single tie-line from the 230 kV Switchyard supplies the 230 kV/12 kV Startup Transformer for each unit. The 12 kV system in each unit supplies an additional 12 kV/4.16 kV Startup Transformer. During normal (at power) operation the 230 kV distribution system only feeds ancillary buildings and facilities (nonpower block). Large nonvital motor loads at the 12 kV level, and both vital ESF and nonvital loads at the 4.16 kV level and lower can auto transfer to this immediately available offsite power source.

NRC Question 1.d:

*Describe the offsite power transformer (e.g., startup, reserve, station auxiliary) winding and grounding configurations.*

PG&E Response 1.d:

See Attachment 2 of this enclosure, Table 4 for offsite power transformers winding and grounding configuration.

NRC Question 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.*

PG&E Response 2.a:

During normal plant operations (at power), the three vital buses feeding ESF loads at DCPD are not powered by offsite power. The vital buses are normally powered from the main generators via the 25 kV/4.16 kV Unit Auxiliary Transformers. The 230 kV/12 kV Startup Transformers powered from the immediately available offsite source only supply ancillary buildings and facilities (nonpower block).

See Attachment 2 of this enclosure, Tables 1 and 2 for ESF bus power sources.

See Attachment 2 of this enclosure, Table 3 for ESF bus major loads energized during normal (at power) operations, including their ratings.

NRC Question 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.*

PG&E Response 2.c:

The licensing basis for the offsite power system was reviewed, including the Updated Final Safety Analysis Report (UFSAR) Revision 0, dated September 21, 1984, and the living UFSAR to determine the current and historical licensing basis. Based on this review it was determined that the normal (at power) operating configuration of the vital buses, powered from the main generator via the 25 kV/4.16 kV Unit Auxiliary Transformer, is consistent with the current licensing basis. There have also been no changes to the offsite power source alignment from original plant licensing.

**System Protection:**

Items 1, 1.a, 2.b, and 2.d requested information concerning existing electrical distribution system protection and are addressed in this section.

**NRC Question 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.*

**PG&E Response 1:**

Consistent with the current design and licensing basis, including General Design Criteria (GDC) 17-1971, existing Class 1E electrical protection will separate the vital 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 a single open phase of a three phase system. The original plant design was submitted, reviewed, and approved by the NRC as meeting the DCCP-specified design and licensing bases. Therefore, PG&E considers the detection of a single-open phase condition is beyond the approved design and licensing basis of the plant.

During normal (at power) operations the 4.16 kV vital buses are powered from the unit main generator via the units' 25 kV/4.16 kV Unit Auxiliary Transformer. A single open phase on the 500 kV feed to the unit main bank transformer would be detected by the generator negative sequence relaying and cleared by the 500 kV switchyard breakers. The vital buses would then be automatically transferred to the 230 kV offsite power source.

PG&E has performed a preliminary study of the 230 kV offsite power system and the 230 kV/12 kV Startup Transformers under a single open phase condition using the electrical transmission system analysis software "Aspen One-Liner." Results of the studies indicate that under lightly loaded conditions, there would be less unbalance between phases on the secondary of the startup transformers than under heavily loaded conditions, such as after a unit trip. Without an accompanying ground fault, the voltage imbalance between phases under either loading condition would not be of a magnitude to be detectable by existing plant electrical protection or vital bus Class 1E undervoltage protection.

PG&E has also performed a preliminary study of a sustained single phase high impedance ground fault (not an open phase) on the 230 kV feeder to the startup

transformer, such that the fault current was below the setpoint of protective relaying. Under these conditions, a high impedance fault to ground on one phase may be considered as an additional load on that one phase. Due to the high impedance of the ground fault, this additional load would be insignificant with respect to the capacity of the grid. The evaluation results showed that the voltage imbalance between phases would be within the PG&E Transmission and Distribution standard for voltage unbalance.

The secondary side of the 230 kV/12 kV Startup Transformer uses a high resistance zigzag grounding transformer to establish a delta neutral. This high resistance grounding scheme functions to minimize ground current and reduce arcing damage from postulated ground faults. Due to the lack of damaging ground fault current, the existing relays are set to alarm only on a ground fault. With a high impedance ground fault, current would be further reduced with less potential for voltage imbalance on the electrical distribution system.

NRC Question 1.a:

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

PG&E Response 1.a:

Consistent with the design and licensing basis, Class 1E undervoltage relaying on the vital buses protect the ESF loads from a failed offsite power source due to a loss of voltage or a balanced degraded grid voltage. The Class 1E undervoltage relays were not designed to detect a single open phase circuit condition.

All three vital buses for each DCP unit have first level (loss of voltage) and second level (sustained degraded voltage) Class 1E undervoltage relay protection. The first level undervoltage relay setpoints are designed to detect low and loss of voltage conditions on the 4.16 kV vital buses. After a sufficient time delay, they initiate the transfer of vital buses to the startup transformer. The diesel generators (DGs) are automatically started on sustained bus undervoltage. If the automatic transfer to the startup transformer is unsuccessful, the first level undervoltage protection relays will shed the vital bus loads and initiate the transfer of vital buses to the DGs.

The second level undervoltage relays detect bus voltage approaching the 3785V limit (approximately 91 percent of bus voltage). The 3785V setting is based on ensuring a minimum of 90 percent voltage at the motor load terminals. Two separate time delays are provided for DG starting and loading, once the second level undervoltage is detected. The DGs are started after a maximum delay of

10 seconds. The 4160V motors are shed after a maximum delay of 20 seconds in preparation for DG loading.

See Attachment 2 of this enclosure, Table 5, for undervoltage protective devices and the basis for the device setpoint(s).

Attachment 2 of this enclosure, Table 5, also lists ground protection/alarms on the ESF buses and the basis for the device setpoint(s).

NRC Question 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.*

PG&E Response 2.b:

Operator round sheets have been revised to include daily inspections of the 230 kV tie-line from the switchyard to the 230 kV/12 kV Startup Transformer. These inspections confirm the integrity of the overhead lines including the terminations at the startup transformers. The daily inspection frequency was selected because it is within the 72-hour TS 3.8.1 Limiting Condition for Operation (LCO) for offsite power.

NRC Question 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?*

PG&E Response 2.d:

At DCPD the vital buses are normally fed from the main generator. Therefore, routine verification of voltages on all three phases would not provide any useful information concerning a potential open phase condition from offsite power. Because the bus is normally lightly loaded, a routine verification of the voltages on the 12 kV Startup Bus would also not provide any information concerning a potential open phase condition.

To address off-normal conditions, the annunciator response procedure for a 12 kV Bus Voltage Unbalanced Alarm will be revised to require Operations to confirm the alarm by checking the startup 12 kV and 4 kV supply for imbalanced voltages via 3-phase analog voltage indication available in the control room. If



the alarm is confirmed (and the bus is powered via the startup offsite power circuit), 12 kV motors will be manually stopped, as necessary, to reduce the startup transformer load and thus the resulting voltage imbalance.

**Consequences:**

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

NRC Question 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.*

PG&E Response 1.b:

During normal (at power) operations with both the vital and nonvital buses aligned to the unit auxiliary transformers, the 230 kV/12 kV Startup Transformers powered from the immediately available offsite source normally only supply ancillary buildings and facilities (nonpower block). There would be no plant response to a single open phase condition on the primary of the startup transformers during normal (at power) operations under these conditions.

NRC Question 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.*

PG&E Response 1.c:

The DCPD design does not postulate a single open phase without a ground fault at the input to the credited offsite power sources. DCPDs' two qualified offsite power sources (or circuits) refer to the circuits from the first inter-tie switchyard breaker (230 kV and 500 kV) via the 230 kV/12 kV and 500 kV/25 kV Transformers to the Class 1E vital buses for each unit. Design calculations or system analyses were not performed to assess the electrical consequences of a single open phase condition. A single open phase condition was also not considered in the Class 1E undervoltage relay protection calculation basis.

The vulnerability of an unidentified single open phase condition occurring at DCPD has been reduced with the addition of daily operator rounds inspections. However, further detailed plant electrical analysis would be required to determine

the specific electrical consequences of a single open phase condition on the 230 kV feeder to the primary of the startup transformers.

A sustained single phase high impedance ground fault (with no open phase) on the 230 kV feeder to the startup transformer, such that ground fault current is below the setpoint of protective relaying was evaluated by PG&E in a preliminary study. The imbalance on the feeder to the startup transformer from a high impedance ground fault is not expected to impact plant operations. The conclusion of the study showed that the magnitude of voltage imbalance was within the PG&E Transmission and Distribution standard for voltage unbalance.

NRC Question 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.*

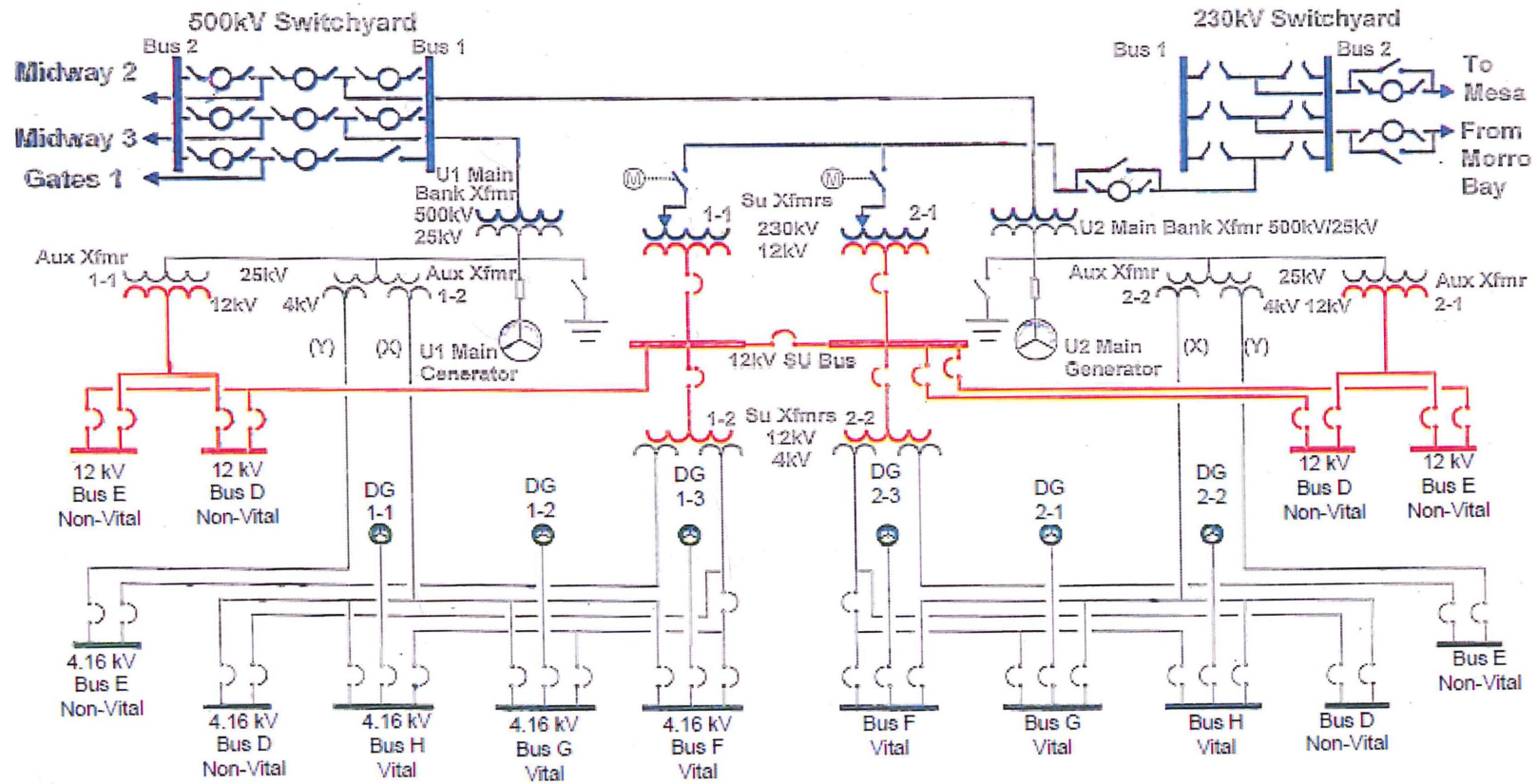
PG&E Response 2.e:

At DCP, the ESF loads are grouped between three 4.16 kV vital buses such that the functions required during a design basis event are provided regardless of any single failure in the Class 1E electrical system. Any two of the three vital buses are adequate to serve the minimum required ESF loads of a unit after a design basis event. At DCP, all three 4.16 kV Vital Buses are fed by a single startup transformer circuit post unit trip, hence all three vital buses could be subjected to a postulated single open phase condition to the primary of the startup transformer.

Consistent with the DCP design and licensing basis, the vital buses are protected from a failed offsite power source due to a loss of voltage or balanced degraded grid voltage. The Class 1E undervoltage protection for the vital buses was not designed to detect a single open phase condition. No design basis analysis or calculation has been performed to evaluate the affect of a single open phase on the vital buses. A detailed analysis (e.g., transformer magnetic circuit models, electric distribution models, motor models; including positive, negative, and zero sequence impedances) of the DCP electrical distribution system would need to be performed to completely understand the consequences of this new scenario.

The consequence of a high impedance ground fault (no open phase) was discussed in response to Question 1.c.

## DCPP Simplified One Line Diagram



**Attachment 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*

\* To be consistent with the NEI template, this table is included in the response. However, it is not applicable due to the fact that the DCPD vital buses are normally fed from the main generator.

**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)
<b>Unit 1</b>		
Unit Auxiliary Transformer 12 (Main Generator)	4.16 kV bus H	Y
	4.16 kV bus G	Y
	4.16 kV bus F	Y
<b>Unit 2</b>		
Unit Auxiliary Transformer 22 (Main Generator)	4.16 kV bus H	Y
	4.16 kV bus G	Y
	4.16 kV bus F	Y

**Table 3 - ESF Buses Normally Energized Major Loads**

<b>ESF Buses F,G,H</b>	<b>Load</b>	<b>Voltage Level</b>	<b>Rating</b>
4 kV Bus F/G/H	Component Cooling Water Pump (One Pump per Bus, Two Operating)	4 kV	400 HP
4 kV Bus F/G	Auxiliary Salt Water Pump (One Pump per Bus, One Operating)	4 kV	400 HP
4 kV Bus F/G/H	480V Load Center Transformer (One per Bus, Three Operating)	4 kV	1333 KVA
4 kV Bus G	Charging Pump *	4 kV	600 HP

\* DCPD has three charging pumps per unit. Only two charging pumps perform ECCS safety-related functions and are deenergized during normal power plant operations. One charging pump (non-ECCS) as listed above in Table 3 is normally energized during normal plant operations (at power).

**Table 4 - Offsite Power Transformers**

Transformer	Winding Configuration	MVA Size (AO/FA/FA)	Voltage Rating (Primary/Secondary)	Grounding Configuration
<b>Unit 1</b>				
Startup Transformer 11	Wye - Delta	45/60/75 MVA	230 kV/12 kV	Solid neutral grounded - Primary Zigzag resistance grounded - Secondary
Startup Transformer 12	Delta - Wye - Wye	24/32/40 MVA	12 kV/4.16 kV/4.16 kV	Resistance grounded neutral - Secondary
Main Bank Transformer	Wye - Delta	1320/1478 MVA	525 kV/25 kV	Solid grounded neutral - Primary Resistance grounded through generator neutral - Secondary
Unit Auxiliary Transformer 11*	Delta - Delta	33.75/45/56.25 MVA	25 kV/12 kV	Zigzag resistance grounded - Secondary
Unit Auxiliary Transformer 12	Delta - Wye - Wye	24/32/40 MVA	25 kV/4.16 kV	Resistance grounded neutral - Secondary
<b>Unit 2</b>				
Startup Transformer 21	Wye - Delta	45/60/75 MVA	230 kV/12 kV	Solid neutral grounded - Primary. Zigzag resistance grounded - Secondary
Startup Transformer 22	Delta - Wye - Wye	24/32/40 MVA	12 kV/4.16 kV/4.16 kV	Resistance grounded neutral - Secondary
Main Bank Transformer	Wye - Delta	1320/1478 MVA	525 kV/25 kV	Solid grounded neutral - Primary Resistance grounded through generator neutral - Secondary
Unit Auxiliary Transformer 21*	Delta - Delta	33.75/45/56.25 MVA	25 kV/12 kV	Zigzag resistance grounded -Secondary
Unit Auxiliary Transformer 22	Delta - Wye - Wye	24/32/40 MVA	25 kV/4.16 kV	Resistance grounded neutral - Secondary

\* Not part of either General Design Criteria 17 offsite power circuit.

**Table 5 - Protective Devices**

Protection Zone	Protective Device	UV Logic	Setpoint	Basis for Setpoint
4.16 kV vital Bus H	Loss of Voltage Relay*	2 of 2	$\geq 0$ V and $\leq 4.0$ Sec $\geq 2583$ V and $\leq 5.88$ Sec $\geq 3430$ V (instantaneous)	Provides protection for ESF components under low and loss of voltage conditions
	Degraded Voltage Relay	2 of 2	$\geq 3785$ V and $\leq 20$ Sec	Provides protection for ESF components under sustained balanced degraded grid voltage conditions
	Ground Protection	None	None	Offsite power circuit feeders are high resistance grounded, (alarm only at 2 amps of ground current).
4.16 kV vital Bus G	Loss of Voltage Relay*	2 of 2	$\geq 0$ V and $\leq 4.0$ Sec $\geq 2583$ V and $\leq 5.88$ Sec $\geq 3430$ V (instantaneous)	Provides protection for ESF components under low and loss of voltage conditions.
	Degraded Voltage Relay	2 of 2	$\geq 3785$ V and $\leq 20$ Sec	Provides protection for ESF components under sustained balanced degraded grid voltage conditions
	Ground Protection	None	None	Offsite power circuit feeders are high resistance grounded, (alarm only at 2 amps of ground current).
4.16 kV vital Bus F	Loss of Voltage Relay*	2 of 2	$\geq 0$ V and $\leq 4.0$ Sec $\geq 2583$ V and $\leq 5.88$ Sec $\geq 3430$ V (instantaneous)	Provides protection for ESF components under low and loss of voltage conditions.
	Degraded Voltage Relay	2 of 2	$\geq 3785$ V and $\leq 20$ Sec	Provides protection for ESF components under sustained balanced degraded grid voltage conditions.
	Ground Protection	None	None	Offsite power circuit feeders are high resistance grounded, (alarm only at 2 amps of ground current).
Startup Xfmr 11(21)	Overcurrent Relay	None	In accordance with PG&E Transmission Standards	Provides overcurrent protection for startup transformer (offsite power source).
	Differential Relay	None	In accordance with PG&E Transmission Standards	Provides internal fault protection for startup transformer (offsite power source).
230 kV Tie-Line from Switchyard	Differential Relay	None	In accordance with PG&E Transmission Standards	Provides overcurrent and ground fault protection for 230 kV feeder to startup transformer.
Main Generator	Generator Negative Sequence Relay	None	In accordance with PG&E Transmission Standards	Provide protection from an unbalanced load on main generator.

\* Loss of voltage setpoints shown in this table are based on a Prompt Operability Assessment associated with a 2010 NRC Component Design Basis Inspection (CDBI) noncited violation.

### **List of Regulatory Commitments**

#### **Commitment 1**

To address off-normal conditions, the annunciator response procedure for a 12 kV Bus Voltage Unbalanced Alarm will be revised to require Operations to confirm the alarm by checking the startup 12 kV and 4 kV supply for imbalanced voltages via 3-phase analog voltage indication available in the control room.