EPRI | ELECTRIC POWER RESEARCH INSTITUTE

# Losses of Offsite Power at U.S. Nuclear Power Plants

## Summary of Experience Through 2013

2014 TECHNICAL REPORT

# Losses of Offsite Power at U.S. Nuclear Power Plants

*Summary of Experience Through 2013*

This document does NOT meet the requirements of 10CFR50 Appendix B, 10CFR Part 21, ANSI N45.2-1977 and/or the intent of ISO-9001 (1994)

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# Product Description

This report describes losses of offsite power that occurred during 2013 at nuclear power plants operating in the United States and offers insights into the causes of such events for the 10-year period 2004–2013.

## Background

Each year, the Electric Power Research Institute (EPRI) updates a summary of experience involving losses of offsite power. This update describes relevant events that occurred during 2013 and provides an evaluation of the experience for 2004–2013.

## Objectives

The objective of this effort was to examine and document the causes of offsite power losses at U.S. nuclear plants from 2004–2013.

## Approach

Available information describing each of the events involving a partial or total loss of offsite power during 2013 was reviewed to determine the nature of the events. Each of the events that occurred from 2004–2013 was appropriately categorized and described.

## Results

During 2013, there were eight events involving losses of all offsite power at U.S. nuclear power plants. On two occasions, both units at two-unit sites experienced losses of offsite power. Therefore, these eight total losses of offsite power on a unit basis were the result of six different occurrences.

While there are unusual years such as 2010 in which there were no total losses of offsite power, there were seven such events in 2011, five in 2012, and eight in 2013. Four weather-related total losses of offsite power occurred in 2013, and there were several events in which weather contributed to partial losses of offsite power. In contrast, severe weather contributed to five of the seven total losses of offsite power in 2011.

On average, the frequency of losing all offsite power was approximately 0.038 per year per unit for the period 2004–2013. This is slightly higher than the average for the period 2003–2013 (0.033 per year). There has been an upward trend in both the frequency and duration of losses of offsite power, in part due to a higher rate of weather-related events in recent years.

## Applications, Value, and Use

This report serves as a valuable source of information for understanding the types of challenges that can lead to a loss of offsite power. This information is useful as an input to probabilistic risk assessments, for which the potential for a loss of offsite power is often an important consideration. The information in this report can be used in calculating site- and unit-specific frequencies of loss of offsite power and in characterizing the duration of such losses for evaluation of recovery potential.


## Keywords

LOOP
Loss of offsite power
Offsite power
Risk analysis
Safety analysis

# List of Acronyms

| | |
|---|---|
| **ANO** | **Arkansas Nuclear One** |
| **DC** | **direct current** |
| **ESF** | **engineered safety feature** |
| **LER** | **licensee event report** |
| **LOOP** | **loss of offsite power** |
| **OCB** | **oil circuit breaker** |
| **PCB** | **power circuit breaker** |
| **RAT** | **reserve auxiliary transformer** |
| **RCP** | **reactor coolant pump** |
| **RSST** | **reserve station service transformer** |
| **SAT** | **system auxiliary transformer** |
| **SUT** | **startup transformer** |
| **UAT** | **unit auxiliary transformer** |

# Executive Summary

This report is one in an annual series that describes events in which at least some of the supplies of offsite power were lost for nuclear power plants operating in the United States. This report extends previous summaries by capturing experiences from 2013. It also includes a rolling 10-year summary and assessment of operating experience.

The information in this report is useful in several ways, including the following:

- The summaries in this report allow interested users to identify events of particular types or those that resulted from particular causes, providing a quick reference to sources of further information.
- The information is presented in such a way that trends in event occurrences, causes, and outage durations can be tracked effectively.
- The data can be used to form generic inputs to plant-specific estimates of frequencies and durations of losses of offsite power for use in probabilistic risk assessment.

The number of events involving a loss of offsite power for 2013 was higher than the range for such occurrences over the past decade. There is a continuing upward trend in the average durations and frequency of loss of offsite power events. Some of this may be attributable to the fact that a higher fraction of such losses in recent years has been caused by severe weather or (in the case of 2011) earthquakes. Recovering offsite power following such events typically takes longer than does restoring power following an upset due to, for example, an equipment malfunction.

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# Section 1: Review and Categorization of Events

The Electric Power Research Institute (EPRI) has, for many years, tracked operating experience involving losses of offsite power at nuclear power plants in the US. This document is an update to EPRI Report 3002000697, *Losses of Offsite Power at U.S. Nuclear Power Plants – 2012*. That report provided a summary and evaluation of events for the ten-year period 2003 through 2012. This update incorporates experience for the year 2013 and event summaries for the ten-year period 2004 through 2013.

In examining the events that have occurred, EPRI employs the best information available to characterize how long all offsite power remains unavailable. This is in contrast to having an alternate source available but not used. For example, at many plants emergency diesel generators (EDGs) automatically supply safety buses when offsite power is lost. It is often possible to reenergize safety buses from offsite power in a short time. It is often the case, however, that the operators exercise appropriate caution by allowing the EDGs to continue to supply power to safety loads while dealing with plant situations that may require more immediate attention. In such instances, the operators then typically transfer back to offsite power in an orderly manner.

Each event was assigned to one of the following categories:

Ia. No offsite power available to the safety buses for 30 minutes or longer.

Ib. No offsite power available to the safety buses for up to 30 minutes.

IIa. With the unit online, the startup/shutdown sources of offsite power for the safety buses become de-energized.

During these events, the main generator remains online (connected to the offsite grid) and power for the safety buses is available from a unit auxiliary transformer.

IIb. With the unit online, the startup/shutdown sources of offsite power for the safety buses remain energized but in question. There is low or unstable grid voltage, or such a condition could result if the unit were to trip or tripped coincident with a LOCA and emergency safety feature actuation.

During these events, the main generator remains online (connected to the offsite grid) and power for the safety buses is available from a unit auxiliary transformer.

III. The unit auxiliary source of power for the safety buses becomes de-energized or unavailable, but offsite power for the safety buses remains available, or can be made available, from a startup/shutdown source.

Connection to the available source may require a fast or slow automatic transfer, or manual switching from the control room. Category III does not include events in which a loss of power from the unit auxiliary source results from a unit trip. To be assigned to Category III, the loss of power from the unit auxiliary source must be the initiating event and must precede the unit trip. A Category III event is most often associated with a failure of main electrical power hardware that makes the near-term use of the unit auxiliary source of power for the safety buses unlikely.

IV. No offsite power available during cold shutdown because of special maintenance conditions that do not occur during or immediately following power operation.

# Section 2: Summary of Occurrences for 2013

Each of the events involving at least a partial interruption of offsite power was reviewed. Where relevant, each of the events was assigned to one of the categories described above. This section provides a description of the events that occurred in calendar-year 2013, starting with those that involved a total loss of offsite power to the affected unit(s). Partial losses and those events not assigned to a specific category are also described.

## Total Losses of Offsite Power

During the year 2013, there were eight losses of all offsite power (LOOPs) at U.S. nuclear power plants (category Ia or Ib). These eight events are summarized in Table 2-1 and described further below. The number of such events in a given year has historically ranged from zero to six. Therefore, experience for 2013 is at or somewhat above the historical range. It should also be noted that each unit that experiences a LOOP is accounted for as a separate event. This is in contrast to the manner in which the events may be accounted for with respect to initiating event frequencies for probabilistic risk assessments. In several instances over the years (including in two cases for 2013), the initiating condition affected multiple units at a station. These instances have therefore been accounted for as multiple LOOP events.

### *Pilgrim: Two Related Events (February 8 and 10, 2013)*

On February 8, 2013, at 21:17, Pilgrim Nuclear Power Station (PNPS) experienced a loss of offsite power (LOOP) associated with severe winter storm Nemo, followed by a load rejection from 85% power and a reactor scram. Emergency diesel generators automatically started and powered the two safety-related buses. All other safety systems functioned as required and the plant stabilized in hot shutdown.

The PNPS is connected to the grid by two 345kV lines connected to a ring bus located within the station's 345kV switchyard. The ring bus also connects to the main transformer and the startup transformer (SUT). The ring bus design locates

the power transmission bus sections such that a failure of any one bus section will not result in the loss of the other bus section. Either of the two 345kV lines is capable of carrying full station output and supplying station loads via the SUT.

In addition to the preferred 345kV offsite power lines, PNPS has a secondary offsite power source, a 23kV line that provides power to a shutdown transformer.

*Table 2-1*
*Losses of All Offsite Power at U.S. Nuclear Plants in 2013*

| Date and Category | Plant Name | Duration (hr:min) | Summary |
|---|---|---|---|
| 2/8/2013<br>Ia | Pilgrim | 30:43 | Severe weather during storm "Nemo" caused loss of both 345kV transmission lines, resulting in a load rejection from 85% full power, scram, and LOOP. |
| 2/10/2013<br>Ia | Pilgrim | 40:00 | With the unit in cold shutdown, a flashover fault occurred during storm "Nemo" due to salt-contaminated ice bridging on a startup transformer bus insulator, resulting in a second LOOP. |
| 3/31/2013<br>Ia | Arkansas Nuclear One (ANO) Unit 1 | 150:57 | With the unit in refueling shutdown, the main generator stator was dropped due to failure of a temporary lift assembly. The impact of the heavy stator caused partial collapse of the turbine deck onto electrical buses located beneath the deck. Failure of the buses resulted in a LOOP. |
| 4/17/2013<br>Ia | LaSalle Units 1 and 2 | 8:02 | With both units at 100% power, a lightning strike on a transmission line caused a phase-to-ground fault and subsequent flashover to the switchyard DC protective system through a degraded grounding system. This resulted in opening of all oil circuit breakers (OCBs) in the switchyard, a LOOP and scram of both units. |
| 10/14/2013<br>Ia | Pilgrim | 23:02 | With the unit at 100% power and one offsite transmission line out of service for an upgrade, the second offsite transmission line failed because of an offsite pole failure. The reactor scrammed and EDGs automatically started and supplied power to the safety buses. |
| 12/4/2013<br>Ia | Comanche Peak Units 1 and 2 | 27:36 | With both units at 100% power and one offsite power - safeguards transformer out of service for modifications, the plant lost all offsite safeguards power to both units due to an incorrectly cut cable. The units remained at power with all four EDGs automatically starting and supplying power to the safeguards buses. The cable was repaired and the safeguards buses were energized with offsite power. |

In anticipation of a major winter storm impacting PNPS, the station entered into procedures for dealing with severe weather. The station risk level was elevated to yellow. On Friday, February 8, 2013, meteorological instruments at PNPS recorded sustained wind speeds between 42 and 49 miles per hour (mph) through 22:28, at which time the plant information system stopped recording weather data until the following day.

On Friday, February 8, 2013, at 20:18, the shutdown transformer was declared inoperable due to repeated offsite alarms and reports regarding power loss at the line's terminal point, an offsite substation.

At 21:02, a major fault occurred on line 342 (one of the two 345kV lines) and the line remained deenergized for the remainder of the storm. At 21:17, a fault on line 355 (the second 345kV line) occurred, resulting in the LOOP previously mentioned.

The LOOP was initiated by severe weather causing faults on both 345KV transmission lines connected to the PNPS ring bus. One of the 345kV transmission lines was restored to reenergize the SUT at 22:11. Two subsequent bus faults associated with the SUT, however, precluded energizing the safety buses from offsite power until one safety bus was reenergized at 04:00 on February 10, 2013. This was followed by energizing the second safety bus at 08:30.

At 14:01 on February 10, 2013, with the unit in cold shutdown, a second LOOP occurred. This loss was initiated by a flashover fault on one phase of the SUT bus section. The flashover fault was due to salt-contaminated ice bridging on the phase insulator. The single remaining breaker on the 345kV ring bus that had been supplying the SUT opened, resulting in a loss of power to the two safety-related buses. The associated diesel generators started and supplied power to the safety-related buses. At 06:01 on February 12, 2013, offsite power was restored to one safety-related bus through the main/unit auxiliary transformers. Offsite power was restored to all 4.16kV buses at 21:47 on February 12, 2013.

**Sources:**

Licensee Event Report (LER) 293/2013-003-00, "Loss of Offsite Power Due to Winter Storm Nemo", April 8, 2013.

NRC Event Report No. 48736, "Unusual Event Declared Due to Loss of Offsite Power", February 28, 2013.

### *ANO Unit 1 (March 31, 2013)*

At approximately 07:50 on March 31, 2013, with Arkansas Nuclear One Unit 1 (ANO-1) in Mode 6 (refueling) and Unit 2 (ANO-2) in Mode 1 at approximately 100% power, lifting and removal of the ANO-1 original main generator stator was in progress. The temporary lift assembly collapsed due to failure of one of the structural columns. This resulted in the stator falling onto the turbine deck and rolling down into the ANO-1 train bay adjacent to ANO-2. The drop caused one fatality, multiple injuries, and structural damage to the turbine buildings, electrical equipment and non-vital systems. When the stator impacted the ANO-1 turbine deck floor, part of the concrete and steel floor structure collapsed onto electrical buses beneath the turbine deck, resulting in a loss of all offsite power to ANO-1. Both ANO-1 EDGs automatically started and connected to their respective 4.16kV safety buses as designed. Decay heat removal flow for ANO-1 was reestablished after being lost for approximately four minutes. Temperature in the spent fuel pool increased less than three degrees during the interruption. Offsite power was restored to the ANO-1 safety buses at 13:47 on April 6, 2013.

This event also resulted in a scram on the sister ANO Unit 2. Although this did not lead to a total loss of off-site power on Unit 2, the event had significant impacts on that unit. These are summarized in Table 2.2 and the accompanying write-up below.

**Sources:**

LER 313/2013-001-01, "Collapse of a Main Generator Temporary Lift Assembly Results in a Fatality, Multiple Injuries, a Plant Scram, a Notification of Unusual Event, and Dual Unit Structural Damage", August 8, 2013.

NRC Event Report No. 48869, "Notification of Unusual Event Declared Due to a Breaker Explosion in the Protected Area", March 31, 2013.

NRC, "Arkansas Nuclear One - Augmented Inspection Team Report 05000313/2013011 and 05000368/ 2013011", June 7, 2013.

### *LaSalle Units 1 and 2 (April 17, 2013)*

At 14:59 on April 17, 2013, with both units operating at 100% power, a severe thunderstorm was in progress and a lightning strike on 138kV line 0112 resulted in a phase-to-ground fault. At this time, all 345kV oil circuit breakers (OCBs) in the main switchyard opened, resulting in a loss of offsite power and reactor scram on both units. All EDGs automatically started and loaded onto their respective ESF buses. Offsite power was restored to all ESF buses by 23:01 on April 17, 2013. Subsequent inspection of Line 112 identified heavy damage to the phase C insulators.

The root cause of the LOOP event was determined to be degradation of the 138KV switchyard grounding system that allowed a lightning-induced fault to flash over onto the DC protective system. The degradation of the grounding system was determined to be a consequence of poor workmanship during original construction. The degradation allowed a fault initiated by a lightning strike on the L0112C phase capacitance-coupled voltage transformer in the 138kV switchyard to damage the shared DC protection system. A contributing cause to the event was determined to be inadequate lightning shielding of the 138kV switchyard. The ground system in the 138kV switchyard was repaired, and corrective actions included improving lightning shielding.

**Sources:**

LER 373/2013-002-01, "Unusual Event Declared Due to Loss of Offsite Power and Dual Unit Reactor Scram," July 26, 2013.

NRC Event Report No. 48939, "Notification of Unusual Event Declared Due to Loss of Offsite Power From a Lightning Strike," April 17, 2013.

### *Pilgrim (October 14, 2013)*

At 21:21 on October 14, 2013, with the reactor at 100% power and one of two 345kV offsite power lines (342) out of service for a scheduled upgrade, a loss of offsite power occurred due to the loss of the second 345kV line (355). The cause of the loss of the second line was failure of an offsite wooden transmission pole. Following the LOOP, the reactor scrammed and EDGs automatically started and supplied power to the 4.16kV buses.

The offsite wooden pole was replaced and line 355 was energized, restoring offsite power to Pilgrim Station at 20:23 on October 15, 2013, for an outage duration of 23:02 hours.

**Sources:**

LER 293/2013-009-00, "Loss of Offsite Power and Reactor Scram" December 13, 2013.

NRC Event Report No. 49441, "Reactor Scram and Start of Emergency Diesels Due to Partial Loss of Offsite Power", October 14, 2013.

### *Comanche Peak Units 1 and 2 (December 4, 2013)*

At 13:41 on December 4, 2013, with both units at 100% power and one offsite power safeguards transformer (138kV transformer XST1) out of service for modifications, Comanche Peak Nuclear Power Plant experienced a loss of offsite power to safeguards buses for both units. This was the result of cutting an incorrect cable that supplied safeguards loads from 345kV transformer XST2.

All four EDGs automatically started and re-energized all safeguards buses. Both units continued operation at approximately 100% power. Non-safeguards electrical power remained energized by auxiliary transformers supplied by each unit's main generator throughout the event. In addition, power was available for the non-safeguards electrical buses from the 345kV switchyard if it had been needed.

The cable for safeguards transformer XST2 was repaired with an in-line splice and transformer XST2 was declared operable at 17:17 on December 5, 2013.

**Sources:**

LER 445/2013-003-00, "Auto Start of Both Units' Auxiliary Feedwater Pumps and Emergency Diesel Generators due to a Loss of Both Units' Safeguards Electrical Power," January 30, 2014.

NRC Event Report No. 49606, "Unusual Event – Loss of Startup Power Due to a Cut Cable," December 5, 2013.

## Partial Losses of Offsite Power

Selected events involving a partial or no loss off offsite power are summarized in Table 2-2 and described further below. There were seven such events. Reports in categories II, III, and IV are presented in this section. Several uncategorized event reports are described in the next section.

*Table 2-2*
*Partial Losses of Offsite Power at U.S. Nuclear Plants in 2013*

| Date and Category | Plant Name | Summary |
|---|---|---|
| 1/8/2013 III | South Texas Unit 2 | Fault in main transformer caused fire, reactor trip and loss of offsite power to two safety buses. Power was also lost to non-safety buses, requiring a natural circulation cooldown of the unit. Offsite power was restored to affected safety buses in about 2 hours. |
| 2/6/2013 IIa | Point Beach Unit 1 | Spurious opening of high-side switcher for station auxiliary transformer resulted in deenergizing safety buses and starting and loading of diesel generators. The unit continued operation at 100%, and the buses were connected to offsite power from an alternate source in 2:08 hours. |
| 3/31/2013 III | ANO Unit 2 | A reactor trip was caused by vibration from the Unit 1 main generator stator drop. About 80 min later, water from a ruptured firewater pipe migrating into switchgear caused an electrical short, startup transformer lockout, and loss of offsite power to safety buses. One bus transferred to an alternate source, and the other was powered by an EDG. The second bus was reenergized from offsite power 42 hr later. |
| 4/29/2013 III | Turkey Point Unit 4 | With the unit at 29% power, generator testing was in progress following an outage for an extended power uprate when a degraded (low) voltage signal initiated vital bus load shedding, starting and loading of EDGs, and a reactor trip that was complicated by entry into natural circulation cooling. |
| 6/23/2013 IIa | Diablo Canyon Units 1 and 2 | With both units at 100% power, the 230kV offsite power source for both units was lost due to insulator flashovers in heavy fog at a remote facility. Both units continued power operation with the safety buses supplied from the unit auxiliary transformers. The source was placed back in service when the faulted conditions cleared. |
| 8/15/2013 IIa | Diablo Canyon Unit 1 | With the unit at 100% power, the 230kV offsite power source was lost due to failure of the startup transformer load tap diverter switch. The unit continued in power operation with the safety buses supplied by the unit auxiliary transformer. The failed components were replaced and the offsite source was made available. |
| 12/9/2013 III | ANO Unit 2 | ANO-2 experienced an electrical fault on the unit auxiliary transformer bus, resulting in a catastrophic failure of the transformer, fire, reactor trip, loss of one offsite power source and a natural circulation cooldown. One safety bus was supplied by an emergency diesel generator, and the second bus by an offsite source. Unit 1 continued to operate a 100% power with one offsite source unavailable until it was restored. |

### *South Texas Unit 2 (February 8, 2013)*

On January 8, 2013, at 16:40, a fault occurred in the "C" phase of main transformer 2A (MT2A). The fault resulted in a main generator lock out, reactor trip, and partial LOOP. The partial LOOP de-energized two of the three safety buses, and the associated standby diesel generators started and loaded as designed. Power was also lost to the non-safety related buses that supplied the reactor coolant pumps, resulting in decay heat removal and cooldown via natural circulation.

The fault caused a sudden pressure in the transformer tank, rupturing the tank. Spilled oil ignited, causing a fire which was extinguished about 16 minutes later.

Offsite power was restored to the safety buses at 18:43, and the diesel generators were secured. Power was also restored to the non-safety buses, and a reactor coolant pump was started to provide forced coolant circulation. The LOOP duration for the safety buses was 2:03 hours, although Unit 1 was operating at 100% power throughout the event and offsite power could have been made available.

**Sources:**

LER 499/2013-002-00, "Reactor Trip Due to Main Transformer Lockout Relay Trip," March 7, 2013.

NRC Event Report No. 48659, "Unusual Event Declared Due to Main Transformer Fire," January 8, 2013.

NRC Preliminary Notification of Event or Unusual Occurrence, PNO-IV-13-001, January 9, 2013.

### *Point Beach Unit 1 (February 6, 2013)*

At 11:32 on February 6, 2013, the high voltage station auxiliary transformer high side switcher opened spuriously. This resulted in an undervoltage condition on both safety-related buses; separation of the safety-related buses from offsite power as designed; starting of all four emergency diesel generators; and automatic loading of the safety-related bus loads.

Offsite power was restored to the safety-related buses from an alternate feed from a redundant offsite power circuit at 13:40. Both Units 1 and 2 continued to operate at 100% power throughout the event. Although the offsite power feed to the Unit 1 safety-related buses was interrupted for 2 hr 8 min, offsite power was continuously available from the alternate feed during this event.

The root cause of the spurious operation of the switcher was found to be that the original design of the control logic circuitry lacked robustness to mitigate spurious actuations. Modification of the control logic to remove the spurious actuation has been entered into the corrective action program.

**Sources:**

LER 266/2013/001/00, "Loss of Offsite Power to Unit 1 Safeguards Buses," April 5, 2013.

NRC Event No. 48722, "Unusual Event – Loss of Offsite Power to Essential Buses for Greater Than 15 Minutes," February 6, 2013.

### *ANO Unit 2 (March 31, 2013)*

At approximately 07:50 on March 31, 2013, with ANO-1 in MODE 6 (refueling) and Unit 2 (ANO-2) in MODE 1 at approximately 100% power, during lifting and removal of the ANO-1 original main generator stator, the temporary lift assembly collapsed due to failure of one of the structural columns. This resulted in the stator falling onto the turbine deck and rolling down into the ANO-1 train bay adjacent to ANO-2. Dropping of the stator caused one fatality, multiple injuries, and structural damage to the turbine buildings, electrical equipment and non vital systems.

Vibration from the dropped stator resulted in actuation of relays in the ANO-2 switchgear located adjacent to the train bay, subsequently tripping a reactor coolant pump (RCP) motor breaker and initiating a reactor trip. The initial plant response to the trip was normal. At 09:23 on March 31, 2013, however, water from a ruptured firewater pipe migrated into a startup transformer 4.16kV feeder breaker cubicle, resulting in an electrical short and startup transformer lockout. The downstream bus was deenergized as designed, which, in turn deenergized one of two 4.16kV safety buses. The associated diesel generator automatically started and connected to the safety bus. The second safety bus supply was transferred to the second offsite power source. With the loss of the startup transformer, the remaining RCPs were lost, resulting in the need to commence a natural circulation cooldown of ANO-2 using the atmospheric dump valves to remove heat from the steam generators. ANO-2 achieved cold shutdown on April 3, 2013. The safety bus was reenergized from offsite power at 03:27 on April 2, 2013.

**Sources:**

LER 313/2013-001-01, "Collapse of a Main Generator Temporary Lift Assembly Results in a Fatality, Multiple Injuries, a Plant Scram, a Notification of Unusual Event, and Dual Unit Structural Damage", August 22, 2013.

NRC Event Report No. 48869, "Notification of Unusual Event Declared Due to a Breaker Explosion in the Protected Area", March 31, 2013.

### *Turkey Point Unit 4 (April 19, 2013)*

On April 19, 2013 with the unit at approximately 29% of rated power, generator testing was in progress after an outage to implement an extended power uprate. The testing included lowered exciter voltage to establish generator protective

relay settings. At 17:21, a degraded voltage signal was received from the 480V load centers. This signal initiated load shedding of vital buses, starting of EDGs, and loading the vital buses onto the EDGs.

The reactor tripped due to the interruption of power to the RCPs. Because the RCPs were unavailable, it was necessary to employ natural circulation for core cooling.

The vital buses were energized from the startup transformer at 18:24. The vital buses were not powered by offsite power for approximately 1 hr 3 min, although offsite power was available.

The causes of this event were established as:

1. The test instruction did not provide adequate precautions and limitations; did not identify the availability of power to the 480V load centers as a possible limiting consideration; and did not specify the proper method for monitoring load center voltage.
2. Personnel failed to identify the risk associated with performance of this test.

**Sources:**

LER 251/2013/002/00, "Reactor Trip Due to Loss of Offsite Power Resulting From Generator Testing," June 18, 2013.

NRC Event Report No. 48948,"Unusual Event due to Loss of Offsite Power Greater Than 15 Minutes," April 23, 2013.

### *Diablo Canyon Units 1 and 2 (6/23/2013)*

On June 23, 2013, with both units at 100% power, the 230kV offsite power source was lost at 20:20 due to actuation of an offsite transmission relay. This resulted in a valid anticipatory start of all six EDGs (three per unit). Although available for loading, the EDGs did not load onto the associated vital buses because the buses remained energized by unit auxiliary power. The EDGs were restored to standby service later on the same day, and the 230kV system was restored and declared operable at 02:00 on June 24, 2013.

Heavy fog and precipitation caused several insulator flashovers at an offsite switchyard (Morro Bay Power Plant), resulting in a sustained loss of key transmission facilities including the loss of the 230kV offsite power source to Diablo Canyon.

**Sources:**

LER 323/2013/003/00, "Actuation of Six Emergency Diesel Generators Due to Loss of Offsite Power," August 22, 2013.

NRC Event Report No. 49143, "Loss of 230kV Offsite Power Results in the Automatic Start of Emergency Diesel Generators," June 24, 2013.

### *Diablo Canyon Unit 1 (August 15, 2013)*

At 18:24 on August 15, 2013, with Unit 1 at 100% power, its 230kV offsite power source was lost due to failure of the startup transformer 1-1 load tap changer diverter switch. This resulted in a valid anticipatory start of all three EDGs. Although available for loading, the EDGs did not load onto the associated vital buses because the buses remained energized by unit auxiliary power. The EDGs were restored to standby at 19:21.

A failed bolted connection between a flex link and a stationary contact caused the load tap changer diverter switch to fail. The startup transformer load tap changer was replaced. Testing confirmed that the transformer windings and bushings were not damaged during the event, and that the transformer was no longer degraded. The transformer was placed into service at approximately 18:10 on August 18, 2013.

**Sources:**

LER 275/2013/006/00, "Emergency Diesel Generators Valid Start Signal due to Loss of Offsite Power," October 14, 2013.

NRC Event Report No. 49287, "Loss of Startup Power Results in Valid Starts of All Three Emergency Diesel Generators," August 16, 2013.

### *ANO Unit 2 (December 9, 2013)*

At approximately 07:47 on December 9, 2013, ANO-2 experienced an electrical fault on the unit auxiliary transformer buses, resulting in catastrophic failure of the transformer and a fire. This event caused a reactor and turbine trip and loss of one source of offsite power by lockout of the switchyard auto transformer which provides one source of offsite power to both ANO-1 and ANO-2.

ANO-1 continued to operate at about 100% power during the event, with power supplied from the unit's auxiliary transformer, and with one offsite source available. The second offsite source was restored at 14:24 on December 10, 2013.

The loss of one of the two offsite sources for ANO-2 resulted in an auto-start of one EDG, which then supplied one safety bus. The event also resulted in loss of the RCPs and circulating water pumps, necessitating a natural circulation cooldown using the emergency feedwater system and steam generator dump to atmosphere. The fire was extinguished about 1 ½ hours following the initial event. The plant was cooled down to Mode 5 by about 05:23 on December 10, 2013. The second offsite source was restored at 14:24 on December 10, 2013, and the EDG was secured. The duration for the loss of one offsite power source was approximately 30 hr 37 min.

A root cause evaluation determined that a flexible link for the unit auxiliary transformer was not properly installed. This led to an insulation breakdown at a bolted connection. The subsequent explosion and fire resulted from a non-landed wire due to a human performance error that most likely occurred in 1996. The error entailed failure to connect the DC conductor to the output contacts for the associated protective relays. The relays, which were designed to isolate the bus from an electrical fault, actuated. Because of the disconnected lead, however, the main generator lockout relays failed to actuate, leading to the auxiliary transformer failure.

**Sources:**

LER 313/2013/004/00, "Initiation of the Emergency Feedwater System," February 5, 2014.

NRC Event Report No. 49618, "Unusual Event declared Due to Unit 2 Auxiliary Transformer Explosion." December 9, 2013.

## Other Events of Interest

Several events entailed partial losses of offsite power events that are not assigned to one of the categories described above. These events are summarized in Table 2-3. Except for events involving a reactor trip, these events are not included in the LOOP statistical summaries in this report because only one of two or three offsite power sources had become unavailable. Because of the number of such events that occurred in 2013 and the possibility that they could be precursors to more serious events, they have been included for information. The events are listed in chronological order.

*Table 2-3*
*Other Selected Events Involving Partial Losses of Offsite Power*

| Plant Name and Date | Summary |
|---|---|
| Diablo Canyon Unit 2 2/28/2013 | On February 28, 2013, with Unit 2 in a refueling outage and defueled, electrical maintenance personnel were conducting troubleshooting activities on 4kV vital bus G, to determine the cause of a failed potential fuse, and to correct the situation. The activities were performed under a troubleshooting work order. At 21:54, the bus feeder opened, the bus was deenergized, and the associated EDG did not start. Spent fuel pool cooling was never lost during the event. Power was restored to the bus in approximately 6 hours.<br>Before the event, the vital bus was fed from the 500kV system through the unit auxiliary transformer. It was recognized that the troubleshooting activity would create an undervoltage signal which would open the normal bus feeder, start the associated diesel, and initiate a transfer to the startup source, which was tagged out and unavailable due to maintenance on the startup bus. Therefore, steps were provided in the work order to prevent the transfer from the normal feeder to the unavailable startup bus and to prevent starting the diesel. During execution of the activity, the step to prevent transfer to the startup bus was not performed, and the undervoltage condition caused the normal bus feeder to open, with no alternative source or EDG, resulting in a deenergized vital bus.<br>This event is not assigned to one of the LOOP categories in this report. It is described, however, because it may be of interest as a possible precursor, and under different conditions may have resulted in a more serious event.<br>*Sources*: LER 323-2013-001-00, "Valid EDG 2-1 Start Signal Caused by a Loss of 4kV Class 1E Bus G", April 29, 2013.<br>NRC Event Report No. 48796, "Emergency Bus Inadvertently De-energized with Unit Defueled", February 28, 2013. |
| D. C. Cook Units 1 and 2 4/24/2013 | On April 24, 2013, Unit 1 was in a refueling outage and defueled, and Unit 2 was at 100% power. At 14:11, a fault on a 4KV cable connecting vital buses 1C and 1D caused fault protection circuitry to open the 12kV train A offsite power supply to reserve feed auxiliary transformers (RATs) 1-TR101CD and 2-TR201CD on Units 1 and 2, respectively. The loss of train A reserve feed caused a valid actuation of the Unit 1 CD EDG. The EDG started and loaded as designed.<br>Unit 2 remained stable at 100% power during the event, although power was interrupted to the RAT 2-TR201CD. The associated vital bus remained energized by unit auxiliary power during the event. The Unit 2 RAT was restored to service following isolation of the fault. The Unit 1 RAT was restored to service following repair of the faulted power cable.<br>Prior to this event, on April 16, 2003, the supply breaker for the Unit 1 RAT tripped open when performing an equipment clearance restoration of transformer 1-TR-101CD. The incident was investigated, but no failures were identified. Then, on April 24, 2013, the supply breaker for the Units 1 and 2 RATs opened and reserve feed was lost to Train A for both units. Plant personnel in the vicinity of the Unit 1 RAT observed an arc flash and audible indication. Subsequent investigation revealed a faulted power cable. The cause evaluation determined the power cable failure was a reduction of the insulation dielectric strength due to cable age combined with a stressor of a prolonged pressure point from the cable lay path.<br>*Sources*: LER 315/2013/002/00, "System Actuation of the Unit 1 CD Emergency Diesel Generator", June 24, 2013.<br>NRC Event Report No. 48796, "Emergency Bus Inadvertently De-energized with Unit Defueled", February 28, 2013. |

*Table 2-3 (continued)*
*Other Selected Events Involving Partial Losses of Offsite Power*

| | |
|---|---|
| Farley Unit 1<br>6/11/2013 | At 21:05 hours on June 11, 2013, with Farley Unit 1 operating at 100%, the Unit 1 train B startup transformer was automatically deenergized by actuation of a protective relay. This resulted in a LOOP to the train B engineered safety feature (ESF) buses. The associated diesel generator automatically started and reenergized the train B ESF buses, and the associated loss of offsite power loads started. The loss of the transformer also resulted in loss of power to the 1B and 1C reactor coolant pump buses and an automatic reactor trip.<br>The train A ESF buses remained energized from an operable offsite power source via startup transformer 1A throughout the event.<br>Investigation of the event determined that the lightning arrester on the phase 2-230kV terminal of startup transformer 1B had shorted to ground, resulting in protective relay actuation. This actuation opened the switchyard supply breakers to the startup transformer.<br>All three lightening arresters on startup transformer 1B were replaced. The transformer was returned to service, supplying the train B ESF buses on June 13, 2013, at 04:29. Offsite power was unavailable to the Train B ESF buses for 31 hr 24 min.<br>*Sources*: LER 348/2013/001/00, "Automatic Reactor Trip and B-Train Loss of Offsite Power Caused by the Failure of a Startup Transformer Lightning Arrester", August 8, 2013.<br>NRC Event Report No. 49106, "Unit 1 Automatic Reactor Trip Due to the Loss of a Start-Up Transformer", June 12, 2013. |
| Monticello<br>6/13/2013 | On June 13, 2013, Monticello was in cold shutdown with a full scram inserted. Testing for modifications associated with an extended power uprate were in progress; specifically, a momentary loading test to initiate rotation of a condensate pump was underway. When the pump motor breaker was opened after being closed for a couple seconds, an arc fault occurred in the 13.8kV feeder bus bar, causing a lockout of station transformer 2R and loss of normal offsite power. The safety buses automatically transferred to a second source of offsite power via emergency offsite transformer 1AR. Both emergency diesels started, but did not load.<br>The loss of power also resulted in a Group II containment isolation with closure of associated isolation valves. This resulted in a loss of shutdown cooling for the reactor and spent fuel pool. Shutdown cooling for the reactor was restored within 58 minutes, and spent fuel pool cooling was restored 92 minutes after the start of the event. There was no significant temperature rise in either the reactor or the spent fuel pool.<br>No conclusive evidence has been found that would explain the cause of the arc fault. The fault is considered most likely to have been the result of multiple independent conditions existing during the modification testing.<br>*Sources*: LER 263/2013-004-00, "Loss of Normal Off-Site Power as a Result of Switchgear Fault", August 12, 2013.<br>NRC Event Report No. 49113, "Emergency Diesel Generators Start", June 13, 2013. |

*Table 2-3 (continued)*
*Other Selected Events Involving Partial Losses of Offsite Power*

| | |
|---|---|
| Columbia<br>6/15/2013 | On June 15, 2013, Columbia Generating Station was in a refueling outage in Mode 4 when power was lost from the 115kV offsite power source at 12:22 due to a momentary line fault caused by a range fire under the line. There are two offsite sources; both were in service with the critical switchgear buses aligned to the 115kV source. The division 1 and 2 critical switchgear buses deenergized and were restored by EDGs within 15 seconds. The division 2 critical switchgear bus was transferred to the 230kV startup transformer (second offsite source) at 12:59. The division 1 critical switchgear bus was transferred to the 230kV startup transformer at 13:13, and the 115kV transformer was returned to service at 18:24.<br>Shutdown cooling was not in operation at the time of the power loss.<br>*Sources*: LER 397/2013-005-00, "Momentary Loss of 115kV Offsite Power", August 12, 2013.<br>NRC Event Report No. 49120, "Division 1 and 2 Emergency Diesel Generators Power Buses after Momentary Offsite Power Loss", June 15, 2013. |

# Section 3: Evaluation of Operating Experience

This section summarizes the rate at which events occurred in 2013 and describes the trends over the past 10 years.

## Experience for 2013

Table 3-1 summarizes the loss of offsite power experience for the year 2013. The number of Category I LOOPs in a given year has historically been six or less, depending on weather and other initiating events. In the past two years (2012 and 2013) the number of Category I LOOPs has been 5 and 8, respectively.

A common characteristic of previously reported partial losses of offsite power was that the main generating unit and the reactor tripped in the course of the event. In 2013, there was one partial LOOP event that included a trip of the main generating unit and/or a reactor trip. Other events involving partial losses have been included for information, as some of these may have involved circumstances or conditions that could be precursors to more serious events.

## Summary of Experience for 2004 – 2013

Experience is tracked over a rolling ten-year period. It is important to base projections of LOOP experience on the most recent and relevant operating experience, reflecting current plant and grid configurations and operating practices, which change relatively frequently.

Tables 3-2 and 3-3 illustrate the overall experience involving losses of offsite power for the 10-year period 2004 through 2013. There were 39 total losses of offsite power (categories Ia and Ib) in a total of 1032.97 generating unit years (Table 3-6). This is equivalent to 0.038 events per generating unit year. Data collected over the long term would indicate that the event frequency appears to be increasing over the past five years (although it is similar today to that from a decade ago). It is clear, however, that the frequency of losses of offsite power is affected significantly by weather and grid conditions beyond the plant switchyards.

*Table 3-1*
*Number of Offsite Power Events at U.S. Nuclear Plants (By Generating Unit) for Year 2013*

| Category | Number of Events | Rate (per unit calendar-yr)* |
|---|---|---|
| Ia. Total loss longer than 30 min | 8 | 0.079 |
| Ib. Total loss less than 30 min | 0 | 0 |
| Total for categories Ia and Ib | 8 | 0.079 |
| IIa. Loss of startup/shutdown source; main generator remains online and power available to safety buses from auxiliary transformer. | 4 | 0.039 |
| IIb. Questionable supply from startup/shutdown source; main generator remains online and power available to safety buses from auxiliary transformer. | 0 | 0 |
| III. Unit auxiliary source of power for the safety buses becomes de-energized or unavailable, but offsite power is available from a startup/shutdown source. | 4 | 0.039 |
| IV. Total loss of offsite power during cold shutdown due to outage-related maintenance activities. | 0 | 0 |
| Total for all Categories in 2013 | 16 | 0.16 |

*Based on 101.31 unit calendar-years of operation in 2013. Four units permanently ceased operation in 2013 (Crystal River, Kewaunee, and San Onofre Units 2 and 3), leaving 100 operating units in the United States.

*Table 3-2*
*Losses of Offsite Power at U.S. Nuclear Plants for (2004 through 2013)*

| Category | Number of Events | Rate (per unit calendar-yr)* |
|---|---|---|
| Ia. Total loss longer than 30 min | 39 | 0.038 |
| Ib. Total loss less than 30 min | 0 | 0 |
| Total for categories Ia and Ib | 39 | 0.038 |
| IIa. Loss of startup/shutdown source; main generator remains online and power available to safety buses from auxiliary transformer. | 10 | 0.010 |
| IIb. Questionable supply from startup/shutdown source; main generator remains online and power available to safety buses from auxiliary transformer. | 7 | 0.007 |
| III. Unit auxiliary source of power for the safety buses becomes de-energized or unavailable, but offsite power is available from a startup/shutdown source. | 6 | 0.006 |
| IV. Total loss of offsite power during cold shutdown due to outage-related maintenance activities. | 8 | 0.007 |
| Total for all Categories (I-IV) (2004 – 2013) | 70 | 0.068 |

*Based on 1032.97 unit calendar-years of operation.

*Table 3-3*
*Losses of Offsite Power at U.S. Nuclear Plants by Event Category and Year (2004 through 2013)*

| Year | Ia | Ib | IIa | IIb | III | IV | Partial | Total |
|---|---|---|---|---|---|---|---|---|
| 2004 | 7 | 0 | 0 | 0 | 0 | 0 | 5 | **12** |
| 2005 | 1 | 0 | 1 | 2 | 0 | 0 | 1 | **5** |
| 2006 | 4 | 0 | 0 | 1 | 0 | 2 | 4 | **11** |
| 2007 | 1 | 0 | 1 | 0 | 0 | 2 | 0 | **4** |
| 2008 | 4 | 0 | 0 | 1 | 0 | 2 | 4 | **11** |
| 2009 | 2 | 0 | 0 | 0 | 0 | 0 | 5 | **7** |
| 2010 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | **5** |
| 2011 | 7 | 0 | 3 | 3 | 0 | 1 | 0 | **14** |
| 2012 | 5 | 0 | 1 | 0 | 2 | 1 | 2 | **11** |
| 2013 | 8 | 0 | 4 | 0 | 4 | 0 | 5 | **21** |
| **Total** | **39** | **0** | **10** | **7** | **6** | **8** | **31** | **101** |

It is instructive to examine the distribution of events involving the total loss of offsite power and their duration (Category Ia and Ib) during the 10-year period 2004 through 2013. This is shown below in Table 3-4 and Figure 3-1, "Category I Events by Initiating Situation". In Table 3-4, the letters following the durations (W= weather related; S=seismic related) indicate the types of events. The chart presents this type of information graphically, by initiating situation, e.g., weather, plant problems, or switchyard/transmission system problems.

*Table 3-4*
*Category I Losses of Offsite Power at U.S. Nuclear Plants for (2004 through 2013)*

| Year | Number of Events | Durations |
|---|---|---|
| 2004 | 7 | 2:47(W), 0:30, 1:04, 1:04, 1:04, 11:07(W), 10:13(W) |
| 2005 | 1 | 88:57(W) |
| 2006 | 4 | 6:40, 6:27, 7:19, 12:00 |
| 2007 | 1 | 17:28(W) |
| 2008 | 4 | 0:37, 0:57, 1:29, 27:36 |
| 2009 | 2 | 2:00, 1:30(W) |
| 2010 | 0 | — |
| 2011 | 7 | 3.49(S), 3.57(S), 5.46(W), 7.04(W), 124:00(W), 124:00(W), 124:00(W) |
| 2012 | 5 | 2:57, 5:26, 5:34, 14:21(W), 33:53 |
| 2013 | 8 | 8:02 (W), 8:02 (W), 23:02, 27:36, 27:36, 30:43 (W), 40:00 (W), 150:57 |

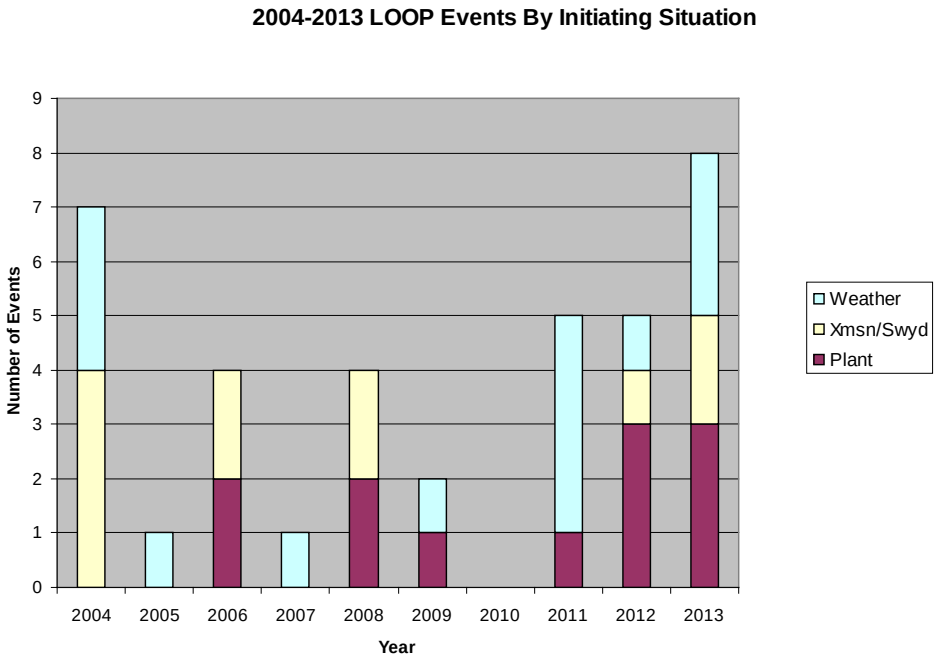


*Figure 3-1*
*Category I Events by Initiating Situation*

A compilation of the initiating events and complicating factors for the 39 events in Category Ia or Ib that occurred in the ten-year period from 2004 through 2013 is presented in Table 3-5.

The median duration of all 39 events involving a total loss of offsite power during the past 10 years was 7.32 hr. This is somewhat larger than the median duration of approximately 4 hr for the ten-year period from 1996 through 2005. The median duration of the 16 weather-related events during the most recent ten-year period was about 12.7 hours, while the median duration of the 23 non-weather-related losses of all offsite power was 5.4 hours. Equipment failure events in either the plant, the switchyard, or the transmission system caused losses with median durations of 6.4 hours.

*Table 3-5*
*Losses of Offsite Power at U.S. Nuclear Plants for (2004 through 2013)*

| Nature of Event | Number of Events | Median Dur. (hr) | Complicating Factors | No. Events Potentially Avoidable |
|---|---|---|---|---|
| Weather - related | 16 | 12.7 | Transmission equipment failure (8 events) | 3 |
| Equipment failure/ degradation in plant | 8 | 6.4 | Design (4 events) Workmanship (1 event) Degradation (1 event) | 5 |
| Equipment failure/ degradation in switchyard or transmission system | 7 | 6.4 | Design (3 events) Degradation (1 event) | 3 |
| Animal or bird intrusion | 3 | 1.0 | Transmission equipment failure (1 event) | 3 |
| Earthquake | 2 | 3.5 | | 0 |
| Workmanship Error | 2 | 27.6 | | 2 |
| Miscellaneous | 1 | 0.6 | | 0 |

Figure 3-2 presents the median LOOP duration (in hours) and the event category I median LOOP duration (hours) and the event frequency for the ten-year periods ending in 2009 through 2013 for category I events. Note that since 2010, there has been an increasing trend both in the duration of category I LOOP events and in their frequency. While weather was a predominant cause of these events in several of the years, it is not the only significant factor. In the EPRI summary of LOOP experience through 2012[1], the statement was made that "many of the events might have been terminated without progressing to a total LOOP had it not been for complications occurring after the initiating event." In 2013, for all categories, seven instances (design, workmanship, installation, unrecognized degradation, etc.) were significant in the initiation of events resulting in a LOOP or a partial LOOP. Following the triggering event, there were at least three events that could have been avoided or for which severity could have been limited were it not for secondary complications.

[1] *Losses of Offsite Power at U.S. Nuclear Power Plants: Summary of Experience Through 2012*. Electric Power Research Institute Report 3002000697, July 2013.

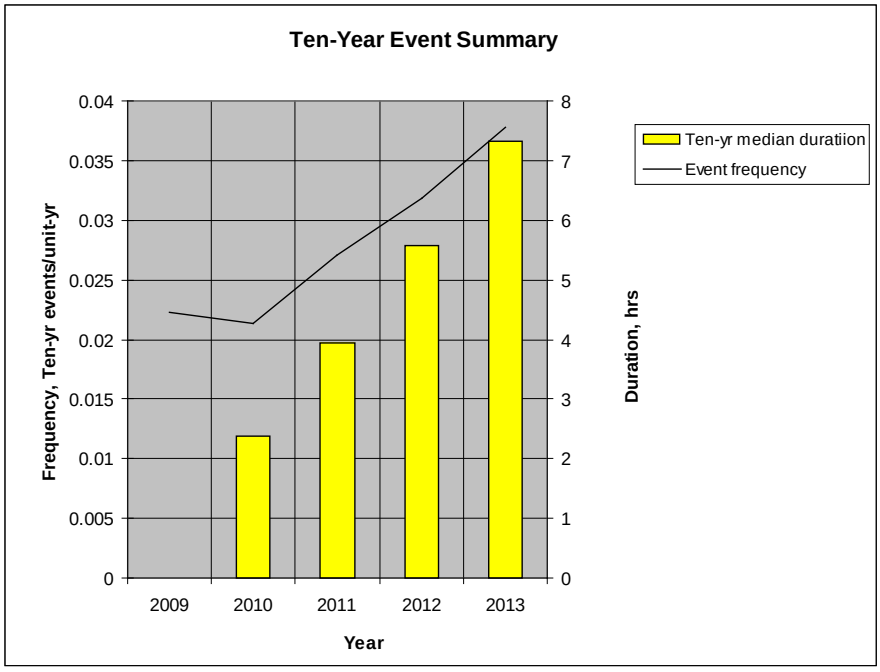


*Figure 3-2*
*Ten-Year Category I Frequency and Duration Summary*

Weather continues to be an important factor in long-term offsite power experience. In the ten-year period from 2004 through 2013, 16 of the 39 LOOP events were related to weather. In 2013, four LOOP events, with a median duration of 19.4 hours, occurred as a result of weather, including storm "Nemo" and a Midwestern thunderstorm. There were, however, two partial losses of offsite power that were weather related, and one partial loss of offsite power due to a range fire under a transmission line. In 2011, severe weather (tornados) in the Southeast contributed to all of the weather-related events that occurred in mid to late April. In 2005, Hurricane Katrina caused a LOOP that lasted 3½ days. Three LOOPs that occurred in 2004 were caused by hurricanes. The longest of these lasted about 11 hours. The one loss of all offsite power that occurred in 2007 was caused by weather and lasted 17 hours. During 2008, Hurricane Gustav caused a unit to be taken off-line for an extended period but did not cause a loss of all offsite power.

It is appropriate to recall that severe weather can cause multiple failures over an extended transmission system area and can affect many facilities. Transmission system degradation, failure diagnostics and corrective actions are not under the immediate control of nuclear plant personnel. It can require considerable effort and time to locate and recover from such failures. At plants near the ocean, salt spray can impact entire switchyards. In contrast, non-weather related LOOPs typically involve single equipment failures. There is usually redundant equipment available that can be placed in service to recover from such LOOPs. Thus, it is reasonable to expect, as a general rule, that weather-caused LOOPs last longer than non-weather caused LOOPs.

An exception to this was the March 2013 event that occurred at ANO, where the drop of the main generator stator affected plant switchgear and offsite power availability for both units. One unit (in refueling shutdown) was without offsite power for 150.57 hours, while the second unit suffered a trip and partial loss of offsite power lasting 42.04 hours.

This event had characteristics that were similar to those that occur as a result of extreme weather. In particular, this event resulted in significant damage to multiple plant structures, systems, and components. Thus the extended LOOP times for this event are explained by its severity.

For reference purposes, the number of unit calendar-years for operating plants is summarized by year in Table 3-6.

*Table 3-6*
*Number of Generating Unit Calendar Years for 2004 - 2013*

| Year | Unit Calendar-Years |
|---|---|
| 2004 | 103.0 |
| 2005 | 103.0 |
| 2006 | 103.0 |
| 2007 | 103.66* |
| 2008 | 104.00 |
| 2009 | 104.00 |
| 2010 | 104.00 |
| 2011 | 104.00 |
| 2012 | 104.00 |
| 2013 | 101.31** |
| **Total** | **1032.97** |

*Browns Ferry 1 returned to service in May of 2007.

** The following four plants permanently ceased operation in 2013:

- Crystal River (2/5/2013)
- Kewaunee (5/7/2013)
- San Onofre 2 & 3 (6/6/2013)

# Appendix A: Loss of Offsite Power Events – 2004 Through 2013

## Category Ia Events[2]

### *ANO Unit 1: 3/31/2013*

**Restore Time: 150:57, Refueling Shutdown); LER (313) 2013-001-01, dated 08/22/2013; NRC "Arkansas Nuclear One - Augmented Inspection Team Report 05000313/2013011 and 05000368/2013011," dated June 7, 2013**

At approximately 07:50 on 03/31/2013 with Arkansas Nuclear One Unit 1 (ANO-1) in MODE 6 (refueling) and Unit 2 (ANO-2) in MODE 1 at approximately 100% power, during lifting and removal of the ANO-1 original Main Generator Stator, the temporary lift assembly collapsed due to failure of one of the structural columns. This resulted in the stator falling onto the turbine deck and rolling down into the ANO-1 train bay adjacent to ANO-2; causing one fatality, multiple injuries, structural damage to the turbine buildings, electrical equipment and non vital systems. When the stator impacted the ANO-1 turbine deck floor, part of the concrete and steel floor structure collapsed onto electrical buses beneath the turbine deck, resulting in a loss of all offsite power to ANO-1. Both ANO-1 emergency diesel generators (EDGs) automatically started and connected to their respective 4160 volt safety buses as designed. ANO-1 decay heat removal flow was reestablished after being lost for approximately four minutes. The spent fuel pool temperature increased less than three degrees during the interruption. Offsite power was restored to the ANO-1 safety buses at 13:47 on April 6, 2013.

[2] There were no Caetegory Ib events in the period 2004 – 2013.

## *Braidwood 2: 07/30/09*

**Restore time, 12:36; Power, 100%; LER (457) 09-002 dated 09/28/09.**
**On 07/30/09 at 20:59 hours, Braidwood Unit 2 lost all offsite power and tripped off-line from 100% power. The initiating cause of this event was a sudden pressure relay actuation at one of the Unit's two system auxiliary transformers.**

Unit 2 has two system auxiliary transformers (SATs) that are powered from a common line from a 345kV switchyard and two unit auxiliary transformers (UATs) that are powered from the generator output. A fault on either SAT will cause loss of the common line and isolate both SATs. The plant is designed that on a loss of the SATs, the non-ESF (4- and 6.9kV) buses will transfer to the UATs.

During normal operation, two of the four reactor coolant pumps (RCPs) are powered from the SATs and two from the UATs. When there is a SAT or UAT failure, the affected RCP should automatically switch to receive its power from the alternate source.

During this event, the 2C RCP inappropriately tripped on overcurrent following the bus transfer because elements of its overcurrent relay were out of tolerance. In turn, the main Unit tripped off-line because there were less than four RCPs in operation while reactor power was above 30%. Loss of the main Unit de-energized both UATs. Hence, both the two SATs and two UATs were de-energized, and the Unit was without a source of normal offsite power. The 2A and 2B emergency diesel generators successfully started and loaded.

The safety buses at both Braidwood 1 and 2 can manually be switched in less than two hours to receive power from the comparable buses of their sister Unit. No bus alterations are required. This option was available throughout this event. However because the EDGs were operating as intended, the safety buses were not switched back to offsite until later at a more convenient time. In this situation, the duration of the LOOP is properly the period until offsite power could have been restarted which was something less than about 2 hours.

The restoration of normal offsite power required significant testing, analysis and bus alterations. Normal offsite power was restored on 08/02/09 at 12:36 hours.

## *Browns Ferry 1, 2, and 3: 4/27/11*

**Restore Time: 5 days, 4 hours (124 hrs); LER (259) 11-001 dated 6/27/11**

On 04/27/11, severe weather, including tornadoes and accompanying grid instability caused the loss of all seven 500kV offsite lines that connect the three generating Units at the Browns Ferry site to the grid. The first 500kV line was lost at 15:39 hours and the last (seventh) at 16:36 at which time all three main generating Units automatically tripped off-line. Prior to tripping, Units 1 and 2 were at about 75% power and Unit 3 was at full power. One of the sites two incoming 161kV transmission lines was lost at 16:22. The other 161kV

transmission line remained in service throughout this event and provided offsite power to a selected, limited number of plant loads. The four EDGs (A, B, C and D) for Units 1 and 2 started and loaded. Three of Unit 3's EDGs (3A, 3C and 3D) started and loaded. The Unit 3B EDG was out of service for maintenance.

At 23:38 on 04/28/2011, about 31 hours after the event began, the Units 1 and 2 "C" EDG developed a governor oil tubing leak which caused frequency fluctuations and required that the EDG be shutdown. The Unit 2 RHR pump was started within about 4 minutes. During this period, the Unit 2 reactor coolant system temperature did not change. The Unit 1 Group 2 signal was reset after 47 minutes, which restored cooling. During this period, the Unit 1 reactor coolant temperature had increased about 20°F.

At 06:30 on 05/02/11, about 4 ½ days after the event began, the Unit 1 and 2 "A" EDG tripped due to a faulty overspeed sensing switch. This shutdown the spent fuel cooling pumps and the water cleanup system and control rod drive system pumps. After about 54 minutes, these loads were restored from the sites second source of 161kV power. During this period, Unit 1 reactor coolant system temperatures rose about 25°F. The spent pool temperature did not change.

By 20:50 on 05/02/11, about 5 days and 4 hours after the event began, all plant loads (Unit 1, Unit 2 and Unit 3) had been restored to offsite power and all EDGs to standby readiness and the site exited the declaration of a "Notice of Unusual Event." This occurred five days and a little over four hours after the event began.

The overall response of the three Browns Ferry generating Units to this LOOP event can be summarized as follows:

- There were no safety system functional failures.
- For Units 1 and 3, offsite power losses resulted in a loss of RPS power which led to MSIV closure and subsequent loss of feedwater flow and main condenser vacuum. Decay heat was transferred to the suppression chamber (torus) via manual operation of the steam relief values and HPCI in its pressure control mode.

For Unit 2, there was no loss of normal heat removal capability.

### *Brunswick 1: 08/14/04*

**Restore Time, 2:47; Power, 67%; LER (325) 04-002, dated 10/03/04.**

At the time of this event Brunswick 1 was at 67% power output and Brunswick 2 at 100%. The Brunswick 1 switchyard is connected to the grid via four 230kV transmission lines and the Brunswick 2 switchyard via another (different) four 230kV lines. Brunswick 2 was not involved in this event and remained at 100% output.

This event began when, while experiencing severe weather associated with Hurricane Charley, a fault occurred on the Weatherspoon 230kV transmission line, one of the four lines that connect Unit 1 to the grid. The Unit 1 230kV switchyard has two main buses, 1A and 1B. Each transmission line terminates in two circuit breakers, one to bus 1A and one to bus 1B. To clear the Weatherspoon line fault, both breakers must open. In this instance, the circuit breaker that connects the Weatherspoon line to bus 1B developed an internal fault itself when called on to isolate the Weatherspoon fault. This required that the backup differential relays isolate all of 230kV bus 1B by opening all bus 1B circuit breakers. (Bus 1A remained energized.)

The startup auxiliary transformer was aligned to bus 1B as a source and was supplying the Unit 1 emergency buses and the Unit 1 reactor coolant recirculation pumps. Hence, when bus 1B deenergized, these loads also lost power. The loss of the reactor coolant recirculation pumps caused Brunswick 1 to trip off-line. The emergency diesel generators started and reenergized the emergency buses.

The startup auxiliary transformer was reenergized by connecting it to bus 1A 2:47 after the event began. It could have been repowered sooner had the need existed. However, the diesel generators started and loaded successfully and it was judged prudent to deal with other important plant parameters and to further evaluate the plant's status.

## *Brunswick 2: 11/01/06*

**Restore Time, 12:00; Power, 100%; LER (324) 06-002, dated 12/29/06.**

With Unit 2 at 100% power output, one of the output bus bar connections of the Unit's startup transformer failed. Because the reactor recirculation pumps were being powered from the startup transformer, the Unit was manually tripped to preclude potential thermal-hydraulic instability. The Unit trip in-turn deenergized the unit auxiliary transformer. With deenergization of both the startup and unit auxiliary transformers, there was a loss of all offsite power to the Unit's safety buses. Both of Unit 2's emergency diesel generators started and loaded. The high voltage switchyard remained energized from offsite power throughout this event.

Had the need existed, offsite power could have been restored to the Unit 2 safety buses in something less than 12 hours, perhaps substantially less. However, to be conservative, the LOOP duration has been indicated at 12 hours. Because the Unit's two EDGs were operating without problems, the transfer back to offsite power was made at a later convenient moment in the overall recovery effort. This occurred 23:22 after the event began.

## *Byron 2: 03/25/08*

**Restore Time, 1:29; Power, 100%; LER (455) 08-001, dated 03/27/08**

Unit 2 offsite power is supplied from the transmission system. From the switchyard two electrically and physically separated lines provide power through two system auxiliary transformers (SAT)s to the two Engineered Safety feature (ESF) buses. The two SATs have a common feed in the switchyard. Each ESF bus also has a reserve offsite power feed via a crosstie to a corresponding Unit 1 bus. In addition each ESF bus has a dedicated emergency diesel generator (EDG).

In this event, an insulator on one phase of one of the two system auxiliary transformers failed. Because the two SATs have a common feed from the switchyard, both became de-energized. Both the 2A and 2B EDGs started and loaded and re-energized the safety feature buses. 1:29 after the event began, the safety feature buses were cross-tied to the Unit 1 ESF buses and the EDGs were shutdown. Unit 2 remained at full power throughout this event. Unit 1 was in the refueling mode and was unaffected.

## *Byron 2: 01/30/2012*

**Restore Time, 33:52, Power 100%, LER (455) 2012-001-00, dated 03/30/2012**

The Byron Unit 2 electrical system consists of four non-safety-related 6.9-kilovolt (kV) buses, two non-safety-related 4.16kV buses, and two 4.16kV engineered safety features (ESF) buses. The two 4.16kV ESF buses and two of the non-safety-related 6.9kV station buses normally are supplied by one of the two station auxiliary transformers (SATs) connected through one 345kV offsite circuit. The remaining two non-safety-related 6.9kV station buses and two non-safety-related 4.16kV station buses normally are supplied by one of two unit auxiliary transformers (UATs) when the main generator is online. The four reactor coolant pumps (RCP) are powered from four 6.9kV buses. Each 4.16kV ESF bus has a dedicated standby emergency diesel generator.

On 01/30/2012 at approximately 10:02 CST, Byron Unit 2 experienced a mechanical failure of an underhung porcelain insulator on one phase of the 345kV switchyard supply connecting to the system auxiliary transformers (SAT). The nature of the failure resulted in a sustained open phase event to the SAT supply and a low level ground fault on the SAT side of the open phase. The SATs normally supply the two 4KV ESF buses and two non-safety related buses that supply two reactor coolant pumps (RCP).

The insulator failure caused an open phase in the supply to the SATs, resulting in an undervoltage condition on the associated RCP buses which caused a reactor trip. The open phase also caused an unbalanced condition on the ESF buses which was not automatically detected and did not result in an automatic start of the associated emergency diesel generators. At this time, the ESF bus supply from the SATs was inoperable. Following the reactor trip, the main generator

tripped, resulting in a transfer of the buses fed from the unit auxiliary transformer (UAT) to the SATs that were still energized with two phases from the 345kV system. The unbalanced condition caused all four RCPs and other equipment on the non-safety buses to trip on overcurrent. (With the main unit, SATs and RCPs unavailable, the plant was in a condition requiring natural circulation for decay heat removal and cooldown.)

Operators recognized the problem with the non-safety buses and were verifying the ESF buses, and noted that one of the phase to phase voltages was abnormally low. Based on this information, and operator observation of what appeared to be smoke (later diagnosed as water vapor) coming from the vicinity of the SAT, operators opened the SAT feeder breakers to the ESF buses. This intentionally caused an undervoltage condition on all three phases of the ESF buses, resulting in the associated diesel generators starting and all safe shutdown loads sequenced on to the buses, as designed. The 4KV non-safety buses were then cross-tied to the ESF buses and the SAT 345KV supply breaker was opened.

The unit was in cold shutdown at 02:28 hours on January 31, 2012. The failed insulator was replaced and at 19:55 hours on January 31, 2012, the diesel generators were secured and offsite power was restored to the ESF buses.

The insulator failure was caused by service propagation of a large manufacturing material defect, and all inverted insulators associated with the SATs and main power transformers have been replaced with insulators from a different manufacturer. Also, design vulnerabilities existed in the protective relaying schemes regarding the lack of single open phase detection that complicated operator response by not automatically isolating all three phases of the affected line. The vulnerability will be addressed with a means to eliminate this vulnerability in single open phase detection scheme.

NRC Information Notice 2012-03, Design Vulnerability in Electric Power System, March 1, 2012

## *Catawba 1 and 2: 05/20/06*

**Unit 1: Restore Time, 6:40; Power, 100%; LER (413) 06-001 dated 07/19/06**
**Unit 2: Restore Time, 6:27; Power, 100%; LER (413) 06-001 dated 07/19/06**

Both Catawba Units tripped automatically from 100% power and there was a loss of all offsite power to both units. The two Catawba Units feed into a 230kV switchyard. The switchyard is also the offsite power source for the plant loads of both units. The switchyard has a breaker and one half arrangement with two main buses and 24, 230kV circuit breakers.

The event was initiated by the failure of a current transformer associated with one of the switchyard breakers. Per the design and without further problems, this fault would have isolated without either Unit tripping or losing offsite power. However the initial fault conditions somehow also induced a failure in a current transformer at another breaker. Also certain of the differential relay tap settings

were incorrect due to a change notice oversight in 1981. The combined result was that various differential relays activated and both main 230kV switchyard buses were isolated. Both Units 1 and 2 tripped automatically and were disconnected from their sources of offsite power. Each Unit has two emergency diesel generators (EDGs). All four EDGs started and loaded.

Offsite power was restored to the Unit 1, 6.9kV buses that power plant loads 6:40 after the event began. Offsite power was restored to the Unit 2, 6.9kV buses after 6:27. Because the EDGs were operating successfully and offsite power was available if needed, the transfer of the 4.16kV essential auxiliary (safeguard) buses to offsite power could be initiated at a more convenient moment in the overall recovery effort. This occurred several hours later.

### *Catawba 1 and 2: 04/04/2012*

**Unit 1: Restore Time, 5:26; Power 100%**
**Unit 2: Restore Time 5:34; 0% Power, Cold Shutdown**
**LER (413) 2012-001-0 dated 06/04/2012 for both units**

On 04/04/2012 at 20:03 (EDT), Unit 1 tripped from 100% power as a result of low reactor coolant system flow following loss of a reactor coolant pump due to a ground fault. As anticipated, a unit/generator trip ensued, followed by isolation of the unit from the grid due to unexpected instantaneous underfrequency relay action. Isolation from the grid created a loss of offsite power (LOOP) situation. Unit 2 was in cold shutdown with its essential buses powered from unit 1, and the unit 1 LOOP also resulted in a unit 2 LOOP. Both emergency diesels on each unit started and powered their respective essential buses. A residual heat removal pump was started to restore core cooling for unit 2, and unit 1 was stabilized on natural circulation with residual heat removal via auxiliary feedwater and secondary steam relief.

Approximately 5 ½ hours later, after confirming that the sources of the electrical fault were cleared offsite power was restored to one essential bus on each unit.

The LOOP occurred as a result of inadequate design input specification and insufficient control over vendor outsourcing in conjunction with underfrequency relay modifications.

### *Comanche Peak Units 1 and 2: 12/04/2013*

**Restore Time; 27:36, Power 100%; LER (445) 2013-003-00 dated 01/30/2014**

On 12/04/2013 at 13:41 CST, with both units at 100% power and one offsite power- safeguards transformer (138kV XST1) out of service for modifications, Comanche Peak Nuclear Power Plant experienced a loss of offsite safeguards power to both units due to an incorrectly cut cable supplying safeguards loads from 345kV transformer XST2.

All four Emergency Diesel Generators automatically started and re-energized all safeguards buses. Both units continued operation at approximately 100% power. Non-safeguards electrical power remained energized by auxiliary transformers supplied by each unit's main generator. Additionally, 345kV switchyard power was available for the non-safeguards electrical buses if required.

The XST2 transformer safeguards cable was repaired with an in-line splice and XST2 was declared operable at 17:17 hours on December 5.

### *Dresden 3: 05/05/04*

**Restore Time, 0:30; Power, 100%; LER (249) 04-003 dated 07/06/04**

Dresden Unit 3 tripped off and a LOOP occurred when 345kV switchyard breaker CB 8-15 was opened to support the testing of a 345kV offsite transmission line. "C" phase of CB 8-15 failed to open which caused multiple protective relays and local breaker backup relays to operate. Their operations caused the 345kV Unit 3 ring bus to isolate and opened the crosstie to the Unit 2 ring bus. This disconnected Unit 3's generator from the switchyard and deenergized the Unit 3 Reserve Auxiliary Transformer, resulting in a LOOP. The two emergency diesel generators started and repowered their respective safeguard buses. The Unit 2 Reserve Auxiliary Transformer remained energized from offsite power throughout the event and could have been utilized to repower the Unit 3 safeguard buses within 30 minutes if needed (only switching is required). However the diesel generators were operating as designed and this transfer could be delayed until more urgent tasks were completed. Offsite power was restored to Unit 3 at a convenient moment about two hours after the event began.

### *Duane Arnold: 02/24/07*

**Restore Time, 17:28; Power, Shutdown for Refueling; LER (331) 07-004 dated 04/26/07**

On February 24, 2007, while the Unit was shut down for refueling, a severe winter storm brought rain, ice and high winds to the Duane Arnold plant's transmission grid area. At 16:54 on 02/24/07, transmission lines to the plant began to be lost due to the severe weather. At 18:20, both EDGs loaded as the result of a degraded voltage condition that lasted about 8 seconds. The EDGs powered the essential buses throughout the event. The startup transformers remained energized from offsite power and the non-essential buses continued to be powered from offsite power throughout the event.

While the offsite sources at the plant remained energized, the storm put the grid in a degraded condition. The plant became isolated from most offsite sources and at times only one or two of the 6 transmission lines into the plant were energized. Grid repair and recovery allowed an essential bus to be transferred from its EDG

back to offsite power at 11:48 on 02/25/07. This was 17:28 after the event began. This event has been placed in Category Ia, because it did not come about because of refueling outage activities. It might have occurred even if the Unit was at power.

### *LaSalle Units 1 and 2 April 17, 2013*

**Restore Time, 8:02; Power 100%; LER (373) 2013-002-01, dated 07/26/2013**

On 04/17/2013 at 14:59 hours with both units operating at 100% power, a severe thunderstorm was in progress and a lightning strike on 138kV line 0112 resulted in a phase to ground fault. At this time, all 345kV oil circuit breakers (OCB) in the main switchyard opened, resulting in a loss of offsite power (LOOP) and reactor scrams on both units. All emergency diesel generators automatically started and loaded on to their respective ESF buses.

Offsite power was restored to all ESF buses by 23:01 hours on 4/17/2013.

The initiating event was a lightning strike on 138KV line 0112 in the main 345/138kV switchyard. Line 0112 was inspected in the field and had sustained heavy damage to phase "C" insulators.

The root cause of the LOOP event was determined to be degradation of the 138KV switchyard grounding system that allowed a lightning induced fault to flash over onto the DC protective system. The grounding system degradation was due to poor workmanship during original construction. The degradation allowed a fault initiated by a lightning strike on the L0112C phase capacitance coupled voltage transformer in the 138kV switchyard to damage the shared DC protection system. A contributing cause to the event was determined to be inadequate lightning shielding of the 138kV switchyard. The ground system in the 138kV switchyard was repaired, and corrective actions included improving lightning shielding.

### *Millstone: 05/24/08*

**Restore Time, 0:57; Power, 0.01%, LER (336) 08-004, dated 07/14/08**

At the time of this event, reactor startup was in progress and power was below the point of adding heat. Plant power was being supplied from the reserve station service (startup) transformer (RSST). The loss of offsite power occurred when the low side breakers from the RSST to the 4.16kV and 6.9kV buses unexpectedly opened. This resulted in a reactor trip. The two emergency diesel generators started and repowered the vital (safety) buses. The most probable cause for the RSST low side breakers opening was a spurious primary audio tone trip signal that was not sufficiently filtered by the audio tone circuitry due to filter circuitry degradation.

Offsite power was restored to the "C" 4.16kV vital bus 0:57 after the event began. Unit 3 was unaffected by this incident.

### *Nine Mile Pt. 1: 05/13/08*

**Restore Time, 0:37; Power, 100%; LER (220) 08-001, dated 07/07/08**

Offsite power is supplied to Unit 1 via two 115kV lines (Line 1 and Line 4). Prior to this event, l=Line 1 had been removed from service for planned maintenance. Line 4 continued to supply offsite power to Unit 1 and its vital buses. While in this electrical configuration, Line 4 experienced a fault at an offsite location and deenergized. This resulted in deenergization of Unit 1's two 4.16kV vital buses. Both of their emergency diesel generators started and loaded. Line 1 was placed back in service 0:37 after the event began. Unit 1 remained on-line throughout this event. Unit 2 was unaffected.

### *North Anna 1 and 2: 08/23/11*

**Restore Time, 3:49 and 3:57; Power 100%; LER (338) 11-003 dated 10/20/11**

On 08/23/11 at 13:51 hours with both Units 1 and 2 at 100% power output, a magnitude 5.8 earthquake occurred approximately 11 miles WSW of North Anna Power Station. The earthquake caused the automatic trip off-line of both Units from various signals.

The quake caused multiple auxiliary transformers to lock out due to activation of their sudden pressure relays. The sudden pressure relays operated as a result of earthquake induced pressure pulses, not electrical faults.

The deenergization of the auxiliary transformers in the switchyard removed the source of operating power for the main Units. The emergency diesel generators started and loaded as designed.

It is significant that the grid remained energized and there was offsite power to the plant switchyard throughout the event, though the switchyard breakers tripped open and auto-reclosed after design time delays. But because key auxiliary transformers were open, there was a loss of offsite power for operating plant equipment. Offsite power for plant equipment was restored when the auxiliary transformers were reenergized. The listed outage durations indicate when the first safety bus on each Unit was reenergized from offsite power. For both units, the second safety bus was energized from offsite power about 7 hours after the event began.

### *Oyster Creek: 07/12/09*

**Restore Time, 1:30; Power, 100%; LER (219) 09-005 dated 09/10/09**

On 07/12/09 the Oyster Creek nuclear unit lost all 34.5kV offsite power for a duration of 1:30 hours. The main Unit also tripped off-line from 100% power at the time offsite power was lost.

Oyster Creek has two startup transformers. Both are fed from the 34.5kV switchyard. The initiating event was a lightning strike on a 34.5kV transmission line that is owned and operated by a neighbor company and that terminates at Oyster Creek. A 34.5kV breaker that is maintained by the neighbor company at the remote terminal of the line failed to open as quickly as required due to mechanical binding. This caused the plant's 34.5kV bus expanded zone backup relays to actuate which de-energized the 34.5kV switchyard at Oyster Creek. The resulting grid disturbances caused voltage swings and elevated voltage that caused a main Unit trip due to over-excitation.

## *Oyster Creek: 10/29/2012*

**Restore Time: 14:21; 0% Power; Cold Shutdown for Refueling; LER (219) 2012-002-00, dated 12/28/2012**

On 10/29/2013 at 20:18 hours, with the unit in cold shutdown during a planned refueling outage, a Loss of Offsite Power (LOOP) event was experienced due to equipment damage caused by the winds associated with hurricane Sandy. Upon loss of power, both emergency diesel generators associated with the safety buses started and reenergized the buses. Shutdown cooling and spent fuel pool cooling were interrupted during the LOOP, and were expeditiously restored with power from the diesel generators.

At 10:39 hours on 10/30/2013, power was restored on one emergency bus and the associated diesel generator was secured. At 03:46 hours on 10/31/2013 a planned contingency offsite power backfeed path was established to repower loads associated with the second emergency bus, and its diesel generator was secured. At 21:32 hours on 11/01/2013, the planned contingency offsite power backfeed was secured.

## *Palo Verde 1, 2 and 3: 06/14/04*

**Unit 1: Restore Time, 1:04; Power, 100%; LER (528, 529, 530) 04-006, dated 08/13/04**
**Unit 2: Restore Time, 1:04; Power, 100%; OE 18583, dated 06/16/04**
**Unit 3: Restore Time, 1:04; Power, 100%; OE 18790 – Update of OE 18583**
**NRC Augmented Inspection Team Report Number 05000528/2004012**

At 07:41 MST a fault to ground occurred on the Westwing to Liberty 230kV transmission line about 47 miles northeast of the Palo Verde Nuclear Power Station. The fault is believed to have been initiated by a waste streamer from a large bird falling on a 230kV line insulator. The fault and line should have been cleared within a few cycles. However a defective relay at Westwing failed to open one of the 230kV line breakers and the fault persisted for approximately 38 seconds and eventually became a three phase fault. During this period the fault was fed by the 230kV system and by three 525 / 230kV transformers in the Westwing switchyard. Eventually, all local transmission lines became deenergized and disconnected from the Palo Verde Switchyard. All three Palo Verde Units were tripped by their generator protection relays. Six additional nearby

generation units shut down representing a total loss of nearly 5,500 MWe. All of the EDGs (for all three units) started and loaded. However the Unit 2 "A" EDG failed after about 26 seconds (because of a failed diode in its excitation control circuit.

All three Palo Verde 525 to 13.8kV startup transformers were energized and offsite power was available within 1 hour and 4 minutes after the inception of the event. The emergency safety feature buses were transferred back to offsite power at convenient times after offsite power was available. It should be noted that in addition to its emergency diesel generators, the Palo Verde station has two redundant 3400 kW station blackout gas turbine generator sets.

Arizona Public Service is using what has been learned from this experience to examine and, where appropriate, upgrade its transmission system relaying.

This event has been reported extensively. The listed references are recommended for further information.

### *Pilgrim Two Related Events: February 8 and 10, 2013*

**First Event (2/8/2013) Restore Time, 30:43; Power 100%**
**Second Event (2/10/2013), Restore Time, 40:00; Power: Cold Shutdown**
**LER (293) 2013-003-00, dated 4/8/2013**

On 02/08/2013 at 21:17 hours, Pilgrim Nuclear Power Station (PNPS) experienced a loss of offsite power (LOOP) associated with severe winter storm Nemo; a subsequent load rejection from 85% power and a reactor scram. Emergency diesel generators automatically started and powered the two safety-related buses. All other safety systems functioned as required and the plant stabilized in Hot Shutdown.

PNPS is connected to the grid by two 345 kV lines connected to a ring bus located within the station's 345 kV switchyard. The ring bus also connects to the main transformer and the startup transformer (SUT). The ring bus design locates the power transmission bus sections such that a failure of any one bus section will not result in the loss of the other bus section. Either of the two 345 kV lines is capable of carrying full station output and supplying station loads via the SUT.

In addition to the preferred 345 kV offsite power lines, PNPS has a secondary offsite power source, a 23 kV line that provides power to a shutdown transformer.

In anticipation of a major winter storm impacting PNPS, the station entered procedures for dealing with severe weather. Station risk level was elevated to yellow. On Friday 02/08, meteorological instruments at PNPS recorded sustained wind speeds between 42 and 49 mph through 2228 hours at which time the plant information system stopped recording weather data until the following day.

On Friday, 02/08/2013 at 20:18 hours, the shutdown transformer was declared inoperable due to repeated offsite alarms and reports regarding power loss at the line's terminal point, and offsite substation.

At 21:02 hours, a major fault occurred on line 342 (one of the two 345 kV lines) and the line remained deenergized for the remainder of the storm. At 21:17 hours a fault on line 355 (the second 345kV line) occurred resulting in the LOOP previously described.

The LOOP was initiated by severe weather causing faults on both 345kV transmission lines connected to the PNPS ring bus. One of the 345kV transmission lines was restored to reenergize the SUT at 22:11 hours. However, two subsequent bus faults associated with the SUT precluded energizing the safety buses from offsite power until one safety bus was reenergized at 04:00 hours on February 10, followed by energizing the second safety bus at 08:30 hours.

On 2/10/2013 at 14:01 hours with the unit in cold shutdown, a second LOOP occurred initiated by a flashover fault on one phase of the SUT bus section. The flashover fault was due to salt-contaminated ice bridging on the phase insulator. The single remaining breaker on the 345 kV ring bus supplying the SUT opened, resulting in a loss of power to the two safety-related buses, followed by starting of the associated diesel generators and powering the safety-related buses. At 0601 hours on 2/12/2013 offsite power was restored to one safety-related bus through the Main/Unit auxiliary transformers. Offsite power was restored to all 4160 kV buses at 21:47 hours on 02/12/2013.

### *Pilgrim: October 14, 2013*

**Restore Time, 23:02); Power 100%; LER (293) 2013-009-00, dated 12/13/2013**

On 10/14/2013 at 21:21 hours (EDT) with the reactor critical at 100% power and one of two 345kV offsite power lines (342) out of service for a scheduled upgrade, a loss of offsite power occurred due to the loss of the second 345kV line (355). The cause of the loss of the second line was failure of an offsite wooden transmission pole. Following the LOOP, the reactor scrammed and emergency diesel generators automatically started and supplied power to all 4.16kV buses.

The offsite wooden pole was replaced and line 355 was energized, restoring offsite power to Pilgrim Station at 20:23 hours on October 15, for an outage duration of 23:02 hours.

PNPS is connected to the grid by two 345 kV lines connected to a ring bus located within the station's 345 kV switchyard. The ring bus also connects to the main transformer and the startup transformer (SUT). The ring bus design locates the power transmission bus sections such that a failure of any one bus section will not result in the loss of the other bus section. Either of the two 345 kV lines is capable of carrying full station output and supplying station loads via the SUT.

## *Point Beach 1: 01/15/08*

**Restore Time, 27:36; Power, 100%; LER (266) 08-001, dated 03/16/08**

On 01/15/08 Point Beach 1 experienced a loss of the Low Voltage Station Auxiliary Transformer 1x04 (13.8/4.16kV). This transformer supplies power for the two Unit 1 safeguard buses 1A05 and 1A06. The emergency diesel generators successfully started and repowered the safeguard buses.

The nature and location of the fault was not readily apparent. While the Unit 1 safeguard buses can be fed from Unit 1's unit auxiliary transformer and also via crossties from Unit 2's 4.16kV buses 2A03 and 2A04, the prime consideration was to proceed cautiously so as to not make switching errors that could reclose on the fault or further damage equipment, or endanger the backup offsite sources. With the EDGs performing well, proceeding cautiously was the prudent approach. Unit 1 was manually shutdown 24 hours after the event began, to meet a Limited Condition for Operation requirement.

Offsite power was restored to the Unit 1 safeguard buses via cross connections from Unit 2, 27:36 after the event began. Unit 2 was unaffected by this event and remained at full power. Shutdown began on Unit 1, 24 hours after the event began to satisfy an LCO. The fault was ultimately determined to be in a 4.16kV cable that goes from transformer 1x04 to non-safeguard bus 1A03. Transformer 1x04 was undamaged.

## *Saint Lucie 1 and 2: 09/25/04*

**Unit 1: Restore Time, 11:07; Power, Shutdown for Hurricane Jeanne; LER (335) 04-004 dated 11/24/04**
**Unit 2: Restore Time, 10:13; Power, Shutdown for Hurricane Jeanne; LER (335) 04-004 dated 11/24/04**

St. Lucie Units 1 and 2 were shut down at noon on September 25, 2004 in preparation for the arrival of Hurricane Jeanne. At 23:56 on that same day, with the Hurricane in full force, both Units lost all offsite power to both of each unit's two startup transformers (two per unit, a total of four). All four emergency diesel generators successfully started and loaded.

The St. Lucie 230kV switchyard has a conventional breaker and one-half arrangement with four crossties (bays) between the main buses. Each crosstie has three circuit breakers and can terminate two sources, loads, or lines, for a switchyard total of eight. The 230kV switchyard provides switching capability for the two main generator outputs, four startup transformers, (two terminations with two transformers per termination), three outgoing transmission lines and one distribution substation.

When this LOOP occurred, two of the switchyard crossties had previously been opened in order to take the two main Units out of service. The LOOP occurred when faults occurred both in the feed to the distribution substation and the

connection to one of the three transmission lines. The locations of these faults were such that clearing required that the other two crossties be opened. While two transmission lines and the West 230kV main bus remained energized, the configuration that resulted from the particular location of these faults removed all paths for getting power to the startup transformers. The cause of the faults was salt spray that accompanied the hurricane.

The deenergized transmission line was reenergized about 8 minutes after the initiation of the LOOP. Had the need existed it is probable that offsite power could have been made available at this time via the startup transformers. However the need was not urgent and the decision was made to not restore power to the startup transformers until switchyard inspections were made. Because of the conditions that existed, the indicated LOOP times are for the period until offsite power was actually restored.

## *Surry 1: 10/07/06*

**Restore Time, 7:19; Power, Unit 1 100%; LER (281) 06-002 dated 12/05/06**

With both Units 1 and 2 at 100% power, a spurious protection signal momentarily closed the Unit 2 turbine governor and intercept valves. They immediately reopened when the signal cleared. About 20 seconds after the initial alarms, and after learning of a steam leak in the turbine building, operators manually tripped Unit 2.

The reported steam leak was actually the lifting of the Unit 2 cross-under safety valves. The safety valve discharge caused turbine building siding to detach and contact the bus bars on 2 of the plant's 3 Reserve Station Service Transformers. The result was that offsite power was lost to both of Unit 1's two safety buses and one of Unit 2's two safety buses. The other Unit 2 safety bus continued to be energized from offsite power throughout the event. EDG 3 repowered the Unit 2 safety bus that lost offsite power. EDG 1 repowered one of the Unit 1 safety buses that lost offsite power. Reenergization of the other Unit 1 safety bus from an AAC EDG was delayed about 2 hours because its EDG load breaker would not close due to a control circuit design deficiency.

Offsite power was available to power both Units' safety buses 7:19 after the event began. Because the EDGs were successfully powering the Unit 1 safety buses, and one Unit 2 safety bus had offsite power, and EDG 2 had become available to power the other Unit 2 safety bus, the transfer back to offsite power for all the safety buses was made at a later more convenient moment in the overall recovery effort. This occurred 9:01 after the event began.

## *Surry 1 and 2: 04/16/11*

**Restore Time: 5:46 and 7:04, Power 100%, LER (280) 11-001 dated 06/14/11**

On 04/16/11 at 18:49 with Unit 1 at 100% power and Unit 2 at 98.3%, a tornado touched down in the station's switchyard. Both Units tripped off-line and experienced a loss of all offsite power. The Unit 1 reactor was tripped by a loss of coolant flow as a result of loss of power to the station service buses. Unit 2 was tripped by a Unit output 500kV differential relay.

The plant has three emergency diesel generators (EDGs) for the plant's four safety buses (two safety buses per unit). The plant also has what is called a station blackout diesel (SBO diesel).

When this event occurred, the three EDGs and the SBO diesel started and repowered the four safety buses (two per Unit). Offsite power was restored to the plant's two reserve station service transformers 5:03 after the event began. A Unit 1 safety bus had offsite power restored 5:46 after the initial loss, and a Unit 2 safety bus had offsite power after 7:04. The second safety bus for each Unit was energized from offsite a half day later.

The switchyard suffered substantial damage. In the 500kV switchyard, there was damage to transformers and other components. The condensate systems of both Units experienced waterhammer as a result of the sudden loss of flow and pressure in the condensate and feed systems. Immediately following the trip of the Unit 2 turbine/ generator, the emergency bus that powers the bearing lift pump was de-energized. This resulted in damage to the main generator bearings.

## *Waterford 1: 08/29/05*

**Restore Time, 3 days plus 16:57; Power, Shutdown prior to Hurricane Katrina; LER (382) 05-004 dated 10/27/05**

The Waterford Unit was taken off-line on 08/28/05 at 13:16 in preparation for the arrival of Hurricane Katrina. Seventeen hours later, on 08/29/05 at 6:24, offsite power was declared inoperable because of high grid voltage caused by a loss of loads, such as much of the city of New Orleans. Subsequently, changing system generating and transmission line conditions also resulted in periods of low grid voltage. About 11/2 hours after offsite power was declared inoperable a complete loss of all offsite power (LOOP) occurred.

Offsite power was not again declared operable for a period of 3 days plus 16:57. It can be noted that offsite power became available about 4 hours earlier than this but its voltage and conditions was unassured. The durations shown under "Restore Time" is from when offsite power was declared "inoperable" to when it was declared "operable" some 3 days later.

It is worth noting that in anticipation of the loss of offsite power and the need to rely on the EDGs, temporary portable diesel generators were brought onsite on 08/28/05 and installed with the capability of being manually connected to one of the safety buses if needed.

## *Wolf Creek: 1/31/2012*

**100% power before event, restore time 2:57 hours; LER (482) 2012-001-00 dated 3/12/2012**

On 01/13/2012 at 14:03 CST, Wolf Creek experienced an unplanned automatic shutdown from full power operation followed by/coincident with a loss of all offsite power.

The initiating event was a failure of a main generator output breaker due to an internal flashover across the "C" phase of the breaker and associated ground fault. Internal particulate contamination has been identified as the cause of the breaker failure.

Although the offsite transmission lines were energized during this event, offsite power was not available to the emergency buses as described below: Following the main generator breaker failure, the East 345kV Bus was automatically isolated, resulting in the loss of offsite power to emergency bus NB01. Also, the generator trip resulted in interruption of power to the unit auxiliary transformer (the normal supply to the non-safety related buses), and initiated a fast transfer to the startup transformer, which was powered from offsite sources. The startup transformer de-energized due to relay action, which also locked out the West 345kV bus and its offsite sources. At this time all offsite power to the station was lost, and emergency diesel generators started and powered the emergency buses.

After 2 hrs and 57 minutes, offsite power was restored to emergency bus NB01 at 17:00 hours, and the diesel generator powering NB01 was placed in standby. However, the startup transformer remained unavailable. With the main unit off line, the startup transformer is necessary for operation of reactor coolant pumps, therefore, a natural circulation cooldown was initiated with Mode 4 entered on 01/14/2012 at 0112 CST, and Mode 5 was entered at 0750 CST on 01/14/2012. Only one offsite power source is required in Mode 5.

Emergency bus NB02 remained powered by its diesel generator until 1/15/2012 at 0626, at which time the bus was powered by its alternate offsite power supply.

The cause of the relay action that deenergized the startup transformer was not determined until after 02/13/2012 when power was again lost to the startup transformer during an attempt to start a reactor coolant pump for troubleshooting. The cause of the relay action was subsequently determined to be a phase-to-phase short circuit between two unused high side current transformer taps. The taps had missing insulation sleeves that apparently were removed and not replaced during previous outage work.

On 03/27/2012 the plant was restarted following completion of repairs to the electrical distribution system.

**Category Ib Events: There were no category Ib events in the ten-year period of 2004-2013.**

## Category IIa Events

**Four category IIa events occurred in 2013.**

### *Byron 1: 02/28/2012*

**Restore time: 4:24; LERs 454/2012-001-00 and - 01, Unit 2 dated 09/28/2012**

The Byron Unit 1 electrical system consists of four non-safety-related 6.9-kilovolt (kV) buses, two non-safety-related 4.16kV buses, and two 4.16kV engineered safety features (ESF) buses. The two 4.16kV ESF buses and two of the non-safety-related 6.9kV station buses normally are supplied by one of the two station auxiliary transformers (SATs) connected through one 345kV offsite circuit. The remaining two non-safety-related 6.9kV station buses and two non-safety-related 4.16kV station buses normally are supplied by one of two unit auxiliary transformers (UATs) when the main generator is online. The four reactor coolant pumps (RCP) are powered from four 6.9kV buses. Each 4.16kV ESF bus has a dedicated standby emergency diesel generator.

On 02/28/2012 at approximately 17:30 CST, Byron Unit 1 experienced a failure of an underhung porcelain insulator in the switchyard on one phase of the 345kV supply connecting to the system auxiliary transformers (SAT). The failure caused one phase to open and a short.

In this event, an insulator failed on one phase of the common feed to the SATs. Because the two SATs have a common feed from the switchyard, both became de-energized resulting in the loss of the offsite power supply to the safety buses. The 1B EDG was running as part of a planned monthly surveillance and the 1A EDG started and the EDGs loaded and re-energized the ESF buses. At 21:54 hours, 4:24 hours after the event began, the ESF buses were cross-tied to the Unit 2 ESF buses and the EDGs were shutdown. The reserve offsite power source, via the Unit 2 SAT was operable and available during this event. Unit 1 remained at full power throughout this event. Unit 2 was at full power during this event. On 02/29/2012 at 18:17, switchyard repairs were completed and the normal offsite power source to Unit 1 was restored.

## *Diablo Canyon 2: 11/19/05*

**Power, Unit 2 100% and Unit 1 Shutdown for refueling; LER (323) 05-002 dated 01/18/06**

At the time of this event, Unit 2 was at 100% power and Unit 1 was shutdown for refueling. Both units were receiving their plant power, including the 4kV vital buses, from their respective unit auxiliary transformers. The startup transformer (230/12kV) for each unit is powered from a 230kV switchyard from a single breaker. The startup sources for both units were in service but were not powering the vital buses.

During testing of the load tap changer diverter valve for the Unit 1 startup transformer, the testing inadvertently activated the 86 lockout relay which tripped the 230kV breaker. This resulted in the deenergization of the startup power to both the Unit 1 and Unit 2 startup transformers. However, since the safeguard buses of each unit were being powered from its unit auxiliary transformer, operation was unaffected. The EDGs for Unit 2 started, but didn't load.

## *Diablo Canyon 2: 05/12/07*

**Power, 100%; LER (275) 07-001 dated 07/11/07**

On May 12, 2007 at 10:25, with Diablo Canyon Unit 1 shutdown and the reactor defueled, and Unit 2 at 100% power, 230kV startup power for both units was lost due to an offsite transmission system insulator failure and an unanticipated protective relay response. Unit 2 remained at 100% power. During normal operation, the 4.16kV vital buses for each Unit are powered from the unit auxiliary power system. The 230kV transmission system provides offsite power for each Unit's startup, shutdown; emergencies and other times when the unit auxiliary sources are not available.

Unit 1 EDGs 1-1 and 1-2 started and loaded because alternate power from the normal Unit 1 source was not available due to scheduled maintenance underway on the 500kV main output transformers. Unit 2's EDGs started but did not load since its vital buses remained energized from their normal source.

The 230kV offsite power source was reenergized 1:02 after the fault occurred and offsite power to Unit 2 was restored 0:14 after this for a total loss of the Standby 230kV offsite source of about 1:16. The Standby 230kV offsite power was also available to Unit 1 at about this time, however because the Unit was shutdown for refueling, final switching was carried out later at a more convenient moment in the overall recovery effort.

For Unit 2 this was a Category IIa event wherein the startup/shutdown sources of offsite power for the safety buses become deeneergized but the main generator remains on-line and power for the safety buses is available from a unit auxiliary transformer.

For Unit 1 this was a Category IV event because the plant was in a condition and configuration that does not occur when at power. If Unit 1 had been at power this would have been a Category IIa event for it.

## *Diablo Canyon 1: 05/17/11, 05/26/11, 05/27/11*

**Power, 100%; LER (275) 11-004 dated 06/30/11 and (275) 11-005 dated 11/08/11**

Category IIa events are applicable to Units that are powering their safety buses from a Unit auxiliary transformer that is supplied from the main generator and have lost backup offsite power from the startup/shutdown source. At most plants, the safety buses are powered from one or several startup transformers that receive their power from the grid. If the main Unit trips off, the safety buses continue to be powered from offsite. At a fewer number of plants, the safety buses are normally powered from a Unit auxiliary transformer that receives its power from the main generator output. If the main Unit trips off, the safety buses automatically transfer to startup sources that receive their input from the grid. At least in one way, Category IIa events pose less risk than typical LOOP events where the safety buses are normally fed from offsite power. When the normal safety bus feed is from offsite power and power is lost, it is truly a LOOP event and the EDGs must power the safety buses. But, with a Category IIa event, the safety buses continue to be powered from the Unit auxiliary transformers which are fed from the main generator output. The EDGs are not called on to power the safety buses unless the main turbine generator also trips off.

While plants that feed the safety buses from their Unit auxiliary transformers can operate normally with their startup sources out of service, this is not an accepted operating practice. Whenever the offsite source does become unavailable to any safety bus, its EDG automatically starts and will automatically load if the main Unit trips off or the safety bus de-energizes for any reason.

The three occurrences that comprise this entry are examples of Category IIa events. In each instance, offsite power was unavailable to the safety buses for the indicated period. Work was being performed during a refueling outage for Unit 2. The work being performed resulted in a loss of offsite power to Unit 1, which was at 100% power and supplied power to its emergency buses. Diesel generators started and were available to assume vital loads if required.

| **Date– Duration (hr:min)** | **Cause** |
|---|---|
| 05/17/11 – 1:31 | Vibration during work on a relay panel caused a relay to actuate and open a breaker to a 12kV startup bus. |
| 05/26/11 – 14:44 | Test equipment was misconnected. Diagnosis of the problem required an extensive and time-consuming effort. |
| 05/27/11 – 1:25 | Test equipment was misconnected. |

### *Diablo Canyon Units 1 and 2: 6/23/2013*

**Restore Time: 5:40, Power Level: 100%,: LER (323) 2013/003/00, dated 8/22/2013**

On 06/23/2013 with both units 1 and 2 at 100% power, the 230kV offsite power source was lost at 20:20 PDT due to an offsite transmission relay actuation. This resulted in a valid anticipatory start of all six emergency diesel generators (EDG), three per unit. Although available for loading, the EDGs did not load onto the associated vital buses because the buses remained energized by unit auxiliary power. The EDGs were restored to standby service later on 06/23/2013, and the 230kV system was restored and declared operable at 02:00 on 06/24/2013.

Heavy fog and precipitation caused several insulator flashovers at an offsite switchyard (Morro Bay Power Plant), resulting in a sustained loss of key transmission facilities including the loss of the 230kV offsite power source to Diablo Canyon.

### *Diablo Canyon Unit 1: August 15, 2013*

**Restore time: 47:46, Power Level: 100%; LER 275/2013/006/00, dated 10/14/2013**

On 08/15/2013 at 18:24 PDT, with Unit No. 1 at 100% power, the Unit 1 230kV offsite power source was lost due to failure of the startup transformer 1-1 load tap changer diverter switch. This resulted in a valid anticipatory start of all three emergency diesel generators (EDG). Although available for loading, the EDGs did not load onto the associated vital buses because the buses remained energized by unit auxiliary power. The EDGs were restored to standby at 19:21 PDT.

A failed bolted connection between a flex link and a stationary contact caused the load tap changer diverter switch to fail. The startup transformer load tap changer was replaced, and testing confirmed that the transformer windings and bushings were not damaged during the event, and that the transformer was no longer degraded. The transformer was placed into service at approximately 18:10 PDT on 08/18/2013. The duration of the startup power source outage was approximately 47:46 hours.

### *Point Beach Unit 1: February 6, 2013*

**Restore Time: 2:08; Power Level 100%; LER (266) 2013/001/00, dated 4/5/2013**

On 02/06/2013 at 11:32 hours CST, the high voltage station auxiliary transformer high side switcher opened spuriously. This resulted in an undervoltage condition on both safety-related buses; separation of the safety-related buses from offsite power as designed; starting of all four emergency diesel generators and automatic loading of the safety-related bus loads.

Offsite power was restored to the safety-related buses from an alternate feed from a redundant offsite power circuit at 13:40 hours. Both Units 1 and 2 continued to operate at 100% throughout the event. Although the offsite power feed to the Unit 1 safety-related buses was interrupted for 2:08 hours, offsite power was continuously available from the alternate feed during this event.

The root cause of the spurious operation of the switcher was found to be the original design of the control logic circuitry lacking robustness to mitigate spurious actuations. Modification of the control logic to remove the spurious actuation has been entered into the corrective action program.

## Category IIb Events

**No category IIb events occurred in 2013.**

## *Dresden 2 and 3: 06/23/05*

**Unit 2: Power, 99%; LER (237) 05-003 dated 08/22/05**
**Unit 3: Power, 99%; LER (237) 05-003 dated 08/22/05**

On 06/23/05 at 1549 (CDT), with both Units 2&3 at about 99% power, the station was notified by Bulk Power Operations that the predicted switchyard voltage following a Unit trip and loss of coolant accident safety system activation would be 342.5kV for Unit 2 vs. a minimum required voltage of 345.8kV. The corresponding predicted voltage for Unit 3 was 342.3kV vs. a minimum required voltage of 343.7kV. The predicted unit trip/accident switchyard voltage for Unit 2 recovered and exceeded specified values after about 2 hours and for Unit 3 after about 4 hours.

A new reserve auxiliary (startup) transformer that can change taps under load has been installed on Unit 2 to help deal with this problem. It is planned that a similar transformer will be installed on Unit 3 during the next refueling outage in year 2006. The plant is seeking licensing approval to allow it to operate these tap changers under automatic control. During this incident, the Unit 2 tap changer was being operated in manual mode, hence could not automatically respond to the reduction in switchyard voltage.

## *Ginna: 07/17/06*

**Power, 100%; LER (244) 06-002 dated 09/12/06**

The referenced LER describes 3 instances when a post-contingency low voltage alarm was received at Ginna for the offsite power system. These were received on 07/17/06 (duration 0:30), 08/01/06 (duration 8:21) and 08/02/06 (duration 5:28). They were reported in one LER and are reported in this one entry because of their common nature. Subsequent re-analysis demonstrated that on 07/17/06,

post-trip voltages would have been above the alarm setpoints and that event has been retracted from the LER. The minimum required post-contingency 115kV switchyard voltage is 108.9kV. Below this the calculated post-contingency low voltage alarm is activated.

Ginna has initiated a number of actions to correct this problem. They have asked RG&E to review and where appropriate improve the accuracy of the state estimator model. One improvement is to have the estimator model make its determinations based on the grid's generator voltage regulators being on automatic. Another action is for the New York Independent System Operator to provide additional voltage support (reactive power) on the 345kV system when an alarm occurs. In the longer term RG&E plans to add substantial additional capacitor capacity to their transmission system and to strengthen the ties between Ginna and the 345kV transmission system.

### *Prairie Island 2: 06/27/11*

**Power, 100%; LER (306) 11-003 dated 08/23/11**

At Prairie Island 2, there are four possible paths between the offsite transmission system and the 4.16kV safety buses. On 06/27/11, a bus phase to ground fault resulted in breaker operations that resulted in a single path from the transmission system to the safety buses. Subsequently, the transmission system operator determined that, due to summer grid conditions, the 345kV grid voltage could not be maintained at the minimum level needed to assure specified safety bus voltage levels and capacities. Eleven hours and twenty minutes (11:28) after the bus fault, by shutting down a cooling tower pump and fans, the required minimum transmission system voltage was met and determined to be sustainable. The path to the transmission system was declared operable. Unit 2's EDGs were available but not required to run during the period of inoperability.

### *River Bend: 09/01/08*

**Power, Shutdown; LER, None**

AT 18:02 on 09/01/08, the River Bend Unit was taken off-line due to the potential for grid instability in the area due to Hurricane Gustav and because of the reduced need for power. Fortunately the grid at River Bend Station remained stable throughout Gustav. The EDGs were never needed and were never started or loaded.

However there was reduced offsite source redundancy. The River Bend Unit went back on line at 07:52 on 9/23/08.

### *San Onofre 2 and 3: 02/03/06*

**Unit 1: Power, Shutdown for Refueling; LER (361) 06-002 dated 04/03/06**
**Unit 2: Power, 100%; LER (361) 06-002 dated 04/03/06**

On 02/03/06 at 16:46 PST the Devers – Palo Verde 500kV transmission line tripped. Following this the Grid Control Center notified San Onofre that its nomograms indicated offsite power voltage at San Onofre would not be within limits if San Onofre 3 were to trip. Additional generation was added to the system and offsite power was declared operable 1:57 after the Devers – Palo Verde line tripped.

### *Sequoyah 1 and 2: 04/27/11*

**Power, Unit 1 – 100%, Unit 2 – 92%; Sequoyah Significant Event No. 46797 dated 04/27/11**

At 19:29 on 04/27/11, both of the AC power sources to Sequoyah Unit 1 and Unit 2 were declared inoperable due to the effects of severe storms on the TVA transmission system. This determination was made after a review of grid conditions confirmed that pre-analyzed grid/offsite power requirements could not be met. Although offsite power did not meet pre-analyzed requirements, the offsite sources remained connected to Sequoyah and Unit 1 remained at 100% output and Unit 2 at 92%. During this precautionary declaration, neither Units' EDGs ran or were required to run. The precautionary condition existed for 5 hours and 50 minutes.

## Category III Events

**Four category III events occurred in 2013.**

### *ANO Unit 2: March 31, 2013*

**Restore time: 42:04; Power 100%; LER (313) 2013-001-01, dated 8/22/2013**

At approximately 07:50 on 03/31/2013 with Arkansas Nuclear One Unit 1 (ANO-1) in MODE 6 (refueling) and Unit 2 (ANO-2) in MODE 1 at approximately 100% power, during lifting and removal of the ANO-1 original Main Generator Stator, the temporary lift assembly collapsed due to failure of one of the structural columns. This resulted in the stator falling onto the turbine deck and rolling down into the ANO-1 train bay adjacent to ANO-2; causing one fatality, multiple injuries, structural damage to the turbine buildings, electrical equipment and non vital systems. Vibration from the dropped stator resulted in actuation of relays in the ANO-2 switchgear located adjacent to the train bay, subsequently tripping a reactor coolant pump (RCP) motor breaker and initiating a reactor trip. The initial plant response to the trip was normal; however, at 09:23 on 03/31/2013, water from a ruptured firewater pipe migrated into a Startup Transformer 4160 volt feeder breaker cubicle, resulting in an electrical short and Startup Transformer lockout. The downstream bus was

deenergized as designed, which, in turn deenergized one of two 4160 volt safety buses. The associated diesel generator automatically started and connected to the safety bus. The second safety bus supply was transferred to the second offsite power source. With the loss of the Startup Transformer, the remaining RCPs were lost resulting in the need to commence a natural circulation cooldown of ANO-2 using the atmospheric dump valves to remove heat from the steam generators. ANO-2 achieved cold shutdown on 04/03/2013. The safety bus was reenergized from offsite power at 03:27 on 04/02/2013.

### *ANO Unit 2: December 9, 2013*

**Restore time: 30:37; Power 100%; LER (313) 2013/004/00, dated 2/5/2014**

On 12/09/2013 at approximately 07:47 CST, with the unit at 100% power, ANO-2 experienced an electrical fault on the Unit Auxiliary Transformer buses, resulting in catastrophic failure of the transformer and fire. This event caused a reactor and turbine trip, loss of one source of offsite power by lockout of the switchyard auto transformer which provides one source of offsite power to both ANO Unit 1 and ANO Unit 2.

ANO-1 continued operation at about 100% power during the event, with power supplied from the unit's auxiliary transformer, and one offsite source available. The second offsite source was restored at 14:24 on 12/10/2013.

The loss of one of the two offsite sources for ANO-2 resulted in an auto-start of one emergency diesel generator which then supplied one safety bus. The event also resulted in loss of reactor coolant pumps and circulating water pumps, necessitating a natural circulation cooldown with emergency feedwater system actuation and steam generator dump to atmosphere. The fire was extinguished about 1 ½ hours following the initial event. The plant was cooled down to Mode 5 at about 05:23 on 12/10/2013. The second offsite source was restored at 14:24 on 12/10/2013, and the diesel generator was secured. The duration for the loss of one offsite power source was approximately 30:37 hours.

A root cause evaluation determined that a flexible link for the Unit Auxiliary Transformer was not properly installed which led to an insulation breakdown at a bolted connection. The subsequent explosion and fire resulted from a non-landed wire due to a human performance error most likely occurring in 1996 that failed to connect the DC conductor to the output contacts for the associated protective relays. The relays, designed to isolate the bus from an electrical fault actuated but because of the disconnected lead, the Main Generator lockout relays failed to actuate, leading the Auxiliary Transformer failure.

## *Comanche Peak 1 and 2: 05/15/03*

**Unit 1: Power, 100%; LER (445) 03-003 dated 07/14/03 OE 16364 dated 06/09/03**
**Unit 1: Power, 100%; LER (445) 03-003 dated 07/14/03 OE 16364 dated 06/09/03**

With both Unit 1 and Unit 2 at 100% power a fault occurred about four miles from the plant on one of the five 345kV lines that terminate in the Comanche Peak switchyard. The fault was not weather related; a charred Great Blue Heron was found at the fault location. Neither the primary or backup relays of the faulted line operated as they should have to clear the fault. As a result, the other four 345kV transmission lines and the two generating units at Comanche Peak fed the fault through the Comanche Peak switchyard. To clear the fault the four 345kV lines opened at their remote terminals and the two Comanche Peak generating units tripped.

The safety buses did not lose offsite power during this event. In addition to the 345kV switchyard, Comanche Peak has a 138kV switchyard that terminates two incoming 138kV transmission lines. The 138kV system remained energized throughout this event. One of the plant's two startup transformers is powered from the 138kV switchyard and normally powers the Unit 2 safety buses. Hence the Unit 2 safety buses remained energized.

Unit 1's safety buses are normally powered from a startup transformer whose source is the 345kV switchyard. When this source deenergized, Unit 1's safety buses automatically transferred over to the 138kV powered startup transformer. The emergency diesel generators were available but did not start or load because the safety buses did not lose offsite power.

## *FitzPatrick: 11/11/2012*

**Power 100%, LER (333) 2012-008-00 dated 01/10/2013**

On 11/11/2012 at 03:55 hours an electrical arcing fault occurred on James A. FitzPatrick Nuclear Power Plant Main Transformer 71T-1A. This fault resulted in a main turbine trip; an automatic reactor scram from 100% power; and a fire in the main transformer and associated ductwork. Auxiliary electrical loads (including the safety buses) automatically transferred to the normal reserve sources. Offsite power transmission lines were operable and onsite emergency power remained available during this event.

A failure analysis of Transformer 71T-1A is planned.

## *Grand Gulf: 04/24/03*

**Power, 100%; LER (416) 03-002 dated 06/23/03 OE 16220 dated 05/19/03**

This event occurred during a severe thunderstorm while at 100% power. Prior to the storm, a breaker in the 500kV switchyard had been removed from service for maintenance. Its disconnect switches had been opened and the breaker's phases grounded. The storm's high winds mechanically forced one of the breaker's disconnect switches to move toward the closed position and make contact which put a three phase ground fault on the 500kV West bus.

Because of several failures of 500kV relaying to perform properly, the fault did not isolate correctly and both 500kV offsite transmission lines into Grand Gulf deenergized. The ground fault caused an immediate deenergization of the West bus. The main generator tripped about one minute later which deenergized the East 500kV switchyard bus. This was immediately followed (in about 1.5 seconds) by automatic reenergization of one of the 500kV transmission lines and the East 500kV bus from offsite power.

An additional source of offsite power was available throughout the event to all three ESF buses from the 115kV Port Gibson line. However there was no need to use the 115kV source because the 500kV source was available and because the EDGs for all three safety buses started and loaded.

## *Indian Point 2: 08/03/03*

**Power, 100%; LER (247) 03-004 dated 10/02/03**

With Indian Point 2 at 100% output, lightning struck one of the two transmission lines that terminate at the Buchanan 345kV substation north ring bus. Because of a relaying malfunction, the breakers for both transmission lines opened, causing Indian Point 2 to lose its load and to trip. Two of the unit's four, 480 V safety buses, were being fed from the unit's output via the unit auxiliary transformer. They deenergized when the unit tripped per the plant design and were immediately reenergized by one of the unit's emergency diesel generators. Offsite power was restored to these in less than an hour. The other two of the unit's 480 V safety buses were being fed from and remained energized from, offsite power throughout the event.

## *Oyster Creek: 07/23/2012*

**Power, 100%, LER (219) 2012-001-02, dated 12-12-2012**

On 07/23/2012 at 03:29 AM, with the unit at 100% power, a reactor trip occurred after all 230kV transmission paths from the station tripped following a single phase to ground fault on one of the three lines. The fault was caused by a tree contacting one transmission line, and the other two 230kV lines tripped on an incorrect directional overcurrent signal. Subsequently, the 34.5 bus feeder (an offsite power source) was overloaded by the Main Generator output. The

overloaded line tripped, however the 34.5kV system was available for operator connection immediately following the trip of the Main Generator. The loss of the 230kV lines is considered to be a loss of one offsite power source.

Both Emergency Diesel Generators automatically started and assumed loads on the safety buses. All safety systems functioned as required. Offsite power was restored at 04:57 am on 07/23/2012. The safeguards buses were not connected to offsite power for 1:28 hours.

The cause of this event was the current transformer used to provide a directional signal for fault indication was incorrectly landed. The root cause was determined to be a failure to adequately maintain configuration and validate the proper functionality of transmission system protective relays following transformer replacement activities in 2010.

### *South Texas Unit 2: February 8, 2013*

**Restore Time: 2:03, Power Level 100%; LER (499) 2013-002-00, dated 3/7/2013**

On 01/08/2013 at 16:40 hours, a fault occurred in the "C" phase of Main Transformer 2A (MT2A). The fault resulted in a main generator lock out, reactor trip, and partial loss of offsite power (LOOP). The partial LOOP de-energized two of the three safety buses and the associated standby diesel generators started and loaded as designed. Power was also lost to the non-safety related buses that supplied the reactor coolant pumps, resulting in a natural circulation cooldown / decay heat removal situation.

The fault caused a sudden pressure in the transformer tank, rupturing the tank. Spilled oil ignited, causing a fire which was extinguished about 16 minutes later.

Offsite power was restored to the safety buses at 18:43 hours and the diesel generators were secured. Power was also restored to the non-safety buses and a reactor coolant pump was started and provided forced coolant circulation. The LOOP time for the safety buses was 2:03 hours, although Unit 1 was operating at 100% power throughout the event and offsite power could have been made available.

### *Turkey Point Unit 4: April 19, 2013*

**Restore Time: 1:03, Power Level 29%; testing in progress; LER (251) 2013/002/00, dated 6/18/2013**

On 04/19/2013 with the unit at approximately 29% of rated power, generator testing was in progress after an extended power uprate outage. The testing included lowered exciter voltage to establish generator protective relay settings. At 17:21 hours, a degraded voltage signal was received from the 480 volt load centers, which initiated vital bus load shedding; starting of Emergency Diesel Generators and loading on to the vital buses.

The reactor tripped due to the loss of reactor coolant pumps. Because the reactor coolant pumps were unavailable, it was necessary to employ natural circulation for core cooling.

The vital buses were energized from the startup transformer at 18:24 hours. The vital buses were not powered by offsite power for approximately 1:03 hours, however, offsite power was available.

The causes of this event were established as: 1. The test instruction did not provide adequate precautions and limitations and did not identify 480 V load centers as possible limiting conditions, and did not specify the proper method for monitoring load center voltage. 2. Personnel failed to identify the risk associated with performance of this test.

## Category IV Events

**No category IV events occurred in 2013.**

### *Browns Ferry 3: 05/05/08*

**Power, Shutdown for Refueling; LER (296) 08-001, dated 07/07/08**

At the time of this event, Unit 3 was shutdown and in a refueling outage. Operations personnel were in the process of returning one of the Unit 3, 4kV buses (Unit Board 3B) to service after planned maintenance activities. While transferring the bus to the normal feed there was an indication of disagreement between the desired breaker position and the actual breaker position. The cause was later found to be misalignment of the breaker indicating switch mechanism. An attempt was made to return bus 3B to the alternate power supply but the alternate breaker failed to close. Because bus 3B powers 4kV shutdown boards (safety buses) 3EC and 3ED, they also lost offsite power. Their emergency diesel generators (EDGs) 3EC and 3ED, started and repowered these buses. Offsite power was restored to these buses approximately 6:12 after the event began. Unit 3's other safety buses did not lose offsite power. Unit 3 has a total of four safety buses and four EDGs and also has extensive interties to the Units 1 and 2 safety buses and EDGs. This is a Category IV event because the plant was in an electrical configuration and had a scope of activities underway that wouldn't occur when at power. The safety consequences of this event were not significant.

### *Diablo Canyon 1: 05/12/07*

**Power, Shutdown for refueling; LER (275) 07-001 dated 07/11/07**

On May 12, 2007 at 10:25, with Diablo Canyon Unit 1 shutdown and the reactor defueled, and Unit 2 at 100% power, 230kV startup power for both units was lost due to an offsite transmission system insulator failure and an unanticipated protective relay response. Unit 2 remained at 100% power. During

normal operation, the 4.16kV vital buses for each Unit are powered from the unit auxiliary power system. The 230kV transmission system provides offsite power for each Unit's startup, shutdown; emergencies and other times when the unit auxiliary sources are not available.

Unit 1 EDGs 1-1 and 1-2 started and loaded because alternate power from the normal Unit 1 source was not available due to scheduled maintenance underway on the 500kV main output transformers. Unit 2's EDGs started but did not load since its vital buses remained energized from their normal source.

The 230kV offsite power source was reenergized 1:02 after the fault occurred and offsite power to Unit 2 was restored 0:14 after this for a total loss of the Standby 230kV offsite source of about 1:16. The Standby 230kV offsite power was also available to Unit 1 at about this time, however because the Unit was shutdown for refueling, final switching was carried out later at a more convenient moment in the overall recovery effort.

For Unit 1 this was a Category IV event because the plant was in a condition and configuration that does not occur when at power. If Unit 1 had been at power this would have been a Category IIa event.

For Unit 2 this was a Category IIa event wherein the startup/shutdown sources of offsite power for the safety buses become deeneergized but the main generator remains on-line and power for the safety buses is available from a unit auxiliary transformer.

### *Millstone 3: 04/25/07*

**Power, Shutdown for refueling; LER (423) 07-002 dated 06/11/07**

On April 25, 2007, with the Millstone Unit 3 shutdown and the reactor defueled, a switching error in the offsite transmission system caused a loss of all offsite power to Unit 3. Millstone Unit 2 remained at 100% power and connected to the grid throughout the event. The Unit 3 A EDG started and loaded. The B EDG was out of service for planned maintenance.

At the time of this event the Reserve Station transformer (Startup transformer) was out of service for maintenance as a part of outage activities. Power for the plant was being backfed through the main Unit output transformer and then via a Unit auxiliary transformer. Because of problems elsewhere on the transmission system, system operators needed to take one of the transmission lines to the Millstone switchyard out of service. During the switching for this, a switchyard breaker in the backfeed circuit for Unit 3 was inadvertently opened and the LOOP occurred. Offsite power was restored to Unit 3 after about one hour.

This is a Category IV event because the plant was in a condition and configuration that does not occur when at power. The main Millstone switchyard buses remained connected to offsite power throughout this event.

## *Point Beach 1: 11/27/11*

**Power, 0%, Mode 5 following refueling; Restore time: 04:12; LER (266) 11-001-00, dated 01/25/12**

At Point Beach, offsite power is supplied by four transmission lines that connect the offsite transmission system to the switchyard. Offsite power can be supplied to the two 4.16KV safety buses on each unit through high voltage (345/13.8KV) and low voltage (13.8/4.16KV) station auxiliary transformers, including unit cross-ties from similar systems on the other unit. In addition, diesel generators, the unit's main step-up transformer and a gas turbine powered generator are capable of providing power to the safety buses.

Point Beach Unit 1 was in Cold Shutdown with the primary system filled, vented, and pressurized following a refueling shutdown. Restoration of the normal offsite electrical power switchyard alignment to the unit safeguards buses was in progress. The initial alignment consisted of offsite power being supplied to the Unit 1 safeguard buses from Unit 2 through a crosstie on the 13.8KV buses. The following events then occurred:

- With the 13.8KV crosstie closed, the Unit-1 offsite power supply was connected by paralleling to the energized Unit 1 and Unit 2 13.8KV buses by closing the high-side circuit switcher (1F89-112) on the Unit 1 high voltage (345/13.8KV) station auxiliary transformer .
- The crosstie from Unit 2 was opened at 0226 CDT, and a low voltage condition was sensed on the Unit 1 safeguard buses, resulting in starting of diesel generators, separation of the Unit 1 safeguard buses from offsite power and loading a diesel generator on each of the two Unit 1 buses. Plant safety systems functioned as expected. Because the steam generators were available, decay heat removal capability was never lost. Residual heat removal pump forced flow was restored by starting a residual heat removal pump within 46 seconds. Unit 2 remained at power throughout the event with offsite power available and capable of supplying the Unit 1 safety buses.
- Investigation revealed that the high-side circuit switcher was overheating (glowing hot) and had failed. The switcher was isolated.
    - Subsequent investigation of the circuit switcher failure revealed that the internal contacts were not properly made up in any of the three phases resulting in limited capacity current pathway. When the crosstie was opened the impaired current capacity of the switcher was exceeded resulting in a decrease of voltage on the safeguards buses.
- After assessing the cause of the loss of offsite power and confirming that the redundant (Unit 2) circuit for offsite power remained available, offsite power was restored to the Unit 1 safeguards buses by synchronizing the running EDGs to the grid and closing the alternate feed from offsite power (the Unit 2 crosstie) at 0700 CDT. The duration of the loss of offsite power for this event was four hours and 12 minutes (04:12)

This was a classified as a category IV event because the unit was in cold shutdown with the offsite electrical supply in an alternate, permitted condition.

### *Wolf Creek: 04/07/08*

**Restore Time, 2:16; Power, Shutdown for Refueling; LER (482) 08-004, dated 06/06/08**

During preventive maintenance testing in the switchyard, a loss of offsite power event (LOOP) was initiated when incorrect trip links were closed during transmission line breaker failure trip testing. At the time of this LOOP the plant was in a refueling outage with the reactor fuel off-loaded to the spent fuel pool.

One of the unit's two safety buses and its EDG (the "A" train) were out of service for maintenance. The other safety bus (the "B" train) was being energized from offsite power. When the LOOP occurred, this safety bus lost offsite power but was reenergized by its EDG which started and loaded.

Offsite power was restored to the in-service safety bus 2:16 after the event began. This is a Category IV event because the plant was in an electrical configuration and had a scope of activities underway that wouldn't be permitted when at power.

## Selected Partial Losses of Offsite Power

Significant partial loss of offsite power events are presented in this section. Four such events occurred in 2013.

### *Beaver Valley 2: 100% Power, 02/14/2012*

On 2/4/12, at 00:16, Unit 2 experienced a loss of one offsite power source that supplies one of the two ESF buses. The source was lost when the Unit 2 Offsite Source Transformer 2A was deenergized when the breakers associated with the transformer opened. Approximately two minutes later, the breakers were reclosed and the offsite source was restored. This event was repeated during testing at 23:58 on the same day, and the transformer was deenergized for approximately two hours until the associated breakers were reclosed.

The cause of the inadvertent opening of the transformer breakers was later determined to be actuation of breaker relays that occurred due to a DC ground of sufficient magnitude that was introduced when an unrelated annunciator panel test switch was actuated. A degraded wire contributed to this event.

Unit 2 was at 100% power throughout these events.

## *Browns Ferry 3: 19% Power During Startup, 05/22/2012*

**Power 19% during startup, not connected to grid; LER (296) 2012-003-00 dated 07/23/2012**

With Unit 3 at approximately 19% rated thermal power during startup and the unit not connected to the grid, at 02:49 (CDT) the reactor automatically scrammed due to deenergization of the reactor protection system. The power supply for the 4KV unit 3 board 3C was being transferred from 161KV alternate power to 500KV normal power when a differential relay (387SA) actuated resulting in a loss of 500KV power. All unit 3 diesel generators started and tied to their respective shutdown boards. Although not connected, 161kV offsite power remained available during the event. Subsequently, 500kV power was restored through alternate feeder breakers to unit 3 4KV unit boards at 04:30 (CDT). Offsite power was restored in about 1:41 hours.

The differential relay that actuated was installed with incorrect design calculation settings. The root cause for this condition was inadequate procedural guidance.

## *Brunswick 1: 0% Power, Cold Shutdown, 04/09/2012*

**LER (324) 2012-003-00 dated 06/07/2012**

During diesel generator testing activities with the unit in cold shutdown, electrical power to 4.16KV emergency bus E1 was lost at 05:29 (EDT) when the normal supply breakers to the bus opened on relay action as a result of connecting a recorder to incorrect terminals. The associated diesel generator started and re-energized the bus per the plant design. Normal power was restored to the bus and the diesel generator was shut down at 07:01 (EDT). Although the bus supply breakers were opened, offsite power was available up to the breakers during this event.

## *Calvert Cliffs 1 and 2: 02/18/10*

**Unit 1: Power, 92.8%; LER (317) 10-001 dated 04/15/10**
**Unit 2: Power, 99.5%; LER (318) 10-001 dated 04/15/10**

On 02/18/10 both Unit 1 and Unit 2 experienced a partial loss of offsite power and both Units tripped off-line. Unit 1 tripped from a power output of 92.8% and Unit 2 from 99.5% Each Unit lost offsite power to one of its two safety buses while on each Unit the other safety bus continued to be powered from offsite.

The initiating causes of this upset were a ground fault in the 13kV feed to one of Unit 1's reactor coolant pumps, and in addition, a ground protection relay for this feed failed to operate. As a result, the faulted feed to this pump was not isolated as it should have been and backup relaying activated that de-energized a wide scope of equipment.

All plant power for Units 1 and 2 comes from two 500kV to 13kV Service Transformers. The plant loads for Unit 1 and Unit 2 are divided strategically between these two transformers. For example, one of the safety buses on each Unit is normally fed from one of the Service Transformers and the other safety bus from the other Service Transformer.

In this event, the failure of Unit 1's faulted reactor pump circuit to open caused one of the two 500kV to 13kV Service Transformers to isolate in order to clear the fault. This removed offsite power from one of each Unit's two safety buses. It also removed power from reactor coolant pumps on each Unit and caused main Unit trips because of low reactor flow.

While offsite power was interrupted to one of each Units two safety buses at the time of this event, backup offsite power was available and there existed alternate paths for bringing this power to these two buses. These paths could be placed in service by operator-initiated switching.

## *Columbia: 6/15/2013*

**Restore Time: 0:37; Power: Refueling Shutdown; LER (397) 2013-005-00, dated 8/12/2013**

On June 15, 2013, Columbia Generating Station was in a refueling outage in Mode 4 when power was lost from the 115kV offsite power source at 12:22 PDT due to a momentary line fault caused by a range fire under the line. There are two offsite sources, both were in service with the critical switchgear buses aligned to the 115kV source. The Division 1 and 2 critical switchgear buses deenergized and were restored by Emergency Diesel Generators within 15 seconds. The Division 2 critical switchgear bus was transferred to the 230kV startup transformer (second offsite source) at 12:59. The Division 1 critical switchgear bus was transferred to the 230kV startup transformer at 13:13 and the 115kV transformer was returned to service at 18:24.

Shutdown cooling was not in operation at the time of the power loss.

## *Crystal River: 09/06/04*

**Power, 97%; LER (302) 04-003 dated 10/29/04**

This event resulted in a partial loss of offsite power. One of the unit's two safety buses remained energized from offsite power throughout the event. The main unit did trip off-line.

During strong winds associated with Tropical Storm Francis, a fault occurred on a 230kV transmission line that terminates in the Crystal River switchyard. The fault occurred about two miles from the switchyard and was caused by the mechanical failure of a vertical string of insulators. The two appropriate circuit breakers opened and cleared the line and fault. The switchyard arrangement is such that the opening of these breakers also deenergized one of the two sources

that supply the Startup Transformer and the Backup Engineered Safeguards Transformer. Forty-nine minutes later a separate fault occurred at a breaker that is located on the 230kV switchyard south bus. The cause of this fault was contamination from wind and salt spray that accompanied Tropical Storm Francis. Primary and backup bus differential relays activated to deenergize the 230kV switchyard south bus and clear the fault. This caused seven additional circuit breakers to open which removed the remaining source of power to the Startup Transformer and the Backup Engineered Safeguards Transformer. This also deenergized the Train B Engineered Safeguards 4.16 V bus. The Train B emergency diesel generator started and loaded.

## *D.C. Cook: 4/24/2013*

**Power: Unit 1 – Refueling, Unit 2 – 100%, LER (315) 2013/002/00, dated 6/24/2013**

On 04/24/2013, Unit 1was in a refueling outage and defueled, and Unit 2 was at 100% power. At 14:11 hours, a fault on a 4KV cable connecting vital buses 1C and 1D caused fault protection circuitry to open the 12kV Train A offsite power supply to reserve feed auxiliary transformers (RAT) 1-TR101CD and 2-TR201CD on Units 1 and 2, respectively.

The loss of Train A reserve feed caused a valid actuation of the Unit 1 CD emergency diesel generator (EDG). The EDG started and loaded as designed.

Unit 2 remained stable at 100% power during the event, although power was interrupted to the 2-TR201CD Reserve Feed Transformer. The associated vital bus remained energized by unit auxiliary power during the event.

The Unit 2 reserve feed transformer was restored to service following isolation of the fault. The Unit 1 reserve feed transformer was restored to service following repair of the faulted power cable.

Preceding the afore-described event on 04/16/2003, the supply breaker for the Unit 1 RAT tripped open when performing an equipment clearance restoration of transformer 1-TR-101CD. Based on an investigation, no failures were identified. Then, on 04/24/2013, the supply breaker for the units 1 and 2 RATs opened and reserve feed was lost to Train A for both units. Plant personnel in the vicinity of the Unit 1 RAT observed an arc flash and audible indication. Subsequent investigation revealed a faulted power cable. The cause evaluation determined the power cable failure was a reduction of the insulation dielectric strength due to cable age combined with a stressor of a prolonged pressure point from the cable lay path.

## *Diablo Canyon 2: 2/28/2013*

**Power: Refueling Shutdown; LER 323-2013-001-00, dated: 4/29/2013**

On 02/28/2013, with Unit 2 in a refueling outage and defueled, electrical maintenance personnel were conducting troubleshooting activities on 4kV vital Bus G, to determine the cause of a failed potential fuse, and correct the situation. The activities were performed under a troubleshooting work order. At 21:54 hours the bus feeder opened, the bus was deenergized, and the associated diesel generator did not start. The unit was shut down and defueled, and spent fuel pool cooling was never lost during the event. Power was restored to the bus in approximately 6 hours.

Before the event, the vital bus was fed from the 500 kV system through the unit auxiliary transformer. It was recognized that the troubleshooting activity would create an undervoltage signal which would open the normal bus feeder, start the associated diesel, and initiate a transfer to the startup source which was tagged out and unavailable due to maintenance on the startup bus. Therefore, steps were provided in the work order to prevent the transfer from the normal feeder to the unavailable startup bus and to prevent starting the diesel. During execution of the activity, the step to prevent transfer to the startup bus was not performed, and the undervoltage condition caused the normal bus feeder to open, with no alternative source or diesel generator resulting in a deenergized vital bus.

This event is uncategorized, however it is included because it is of interest as a possible precursor, and under different conditions may have resulted in more serious event.

**Sources:**

LER 323-2013-001-00, "Valid EDG 2-1 Start Signal Caused by a Loss of 4kV Class 1E Bus G", dated 4/29/2013;

NRC Event Report 48796, "emergency Bus Inadvertently De-energized with Unit Defueled", dated 02/28/2013

## *Farley 1: 04/06/2012*

**0% Power, Refueling Shutdown; LER (348) 2012-004-00 dated 05/31/2012**

During a refueling shutdown on 4/6/12, maintenance/testing activities in the switchyard caused a feeder breaker to trip isolating offsite power to the 1B startup transformer and related 4KV emergency bus at 14:44 (CDT). The breaker on the redundant offsite source for the 1B startup transformer was open and out of service at the time. The emergency bus sequencer initiated a valid load shed/diesel start signal, however, the associated diesel was removed from service and none of the bus loads started. The residual heat removal pump on the redundant emergency train remained in service for shutdown cooling throughout the event.

The bus was restored to service at 15:42 (CDT) on 4/6/12. The bus was out of service for 58 minutes during this event. Investigation revealed technical inadequacy in the instructions used during the switchyard maintenance activity.

## *Farley Unit 1: 6/11/2013*

**Power Level: 100%, LER (348) 2013/001/00, dated 8/8/2013**

At 21:05 hours on 06/11/2013 with Farley Unit 1 operating at 100%, the Unit 1 B-Train Startup Transformer (XFMR) was automatically deenergized by protective relay actuation. This resulted in a B-Train Engineered Safety Bus Loss of Offsite power. The associated diesel generator automatically started and reenergized the B train ESF buses, and the associated loss of offsite power loads started. The loss of the XFMR also resulted in loss of power to the 1B and 1C reactor coolant pump buses and an automatic reactor trip.

The A-train ESF buses remained energized from an operable offsite power source via the 1A Startup Transformer throughout the event.

Investigation of the event determined that the lightning arrester on the phase 2 230KV terminal of the 1B startup transformer had shorted to ground resulting in protective relay actuation which opened the switchyard supply breakers to the startup transformer.

All three lightening arresters on the 1B Startup Transformer were replaced and the transformer was returned to service, supplying the B-Train ESF buses on 06/13/2013 at 04:29 hours. Offsite power was unavailable to the B-Train ESF buses for 31:24 hours.

**Sources:**

LER 348/2013/001/00, "Automatic Reactor Trip and B-Train Loss of Offsite Power Caused by the Failure of a Startup Transformer Lightning Arreste,r" dated 08/08/2013.

NRC Event Report No. 49106, "Unit 1 Automatic Reactor Trip Due to the Loss of a Start-Up Transformer," dated 06/12/2013.

## *Fermi 2: 06/0610*

**Power, 100%; LER (341) 10-002 dated 08/03/10**

On 06/06/10, Fermi 2 experienced a partial loss of offsite power and tripped off-line from full power. Two of the Unit's four safety buses lost offsite power while the other two safety buses continued to be powered from offsite. Their EDGs repowered the two safety buses that lost offsite power.

The initiating cause of this event was severe weather that caused failure of the two 345kV lines that connect the Fermi generator to the grid. The National Weather Service identified a tornado in the Fermi area when power was lost.

With no path for its output, the main generator tripped off. These two 345kV lines are also a source of power for two of the Unit's four safety buses, hence the loss of offsite power to these two safety buses.

Fermi also has three 120kV supply lines. These lines serve as an additional source of power for plant loads and normally power the other two of the four safety buses. Two of these 120kV lines were also lost due to the storm. However, one of the 120kV lines remained in service and powered the two safety buses that depend on the 120kV source.

This was a severe storm and caused some damage to the plant's buildings and structures. All plant equipment operated as designed during the event.

### *Fermi 2: 09/14/2012*

**Restore Time: 03:27; 68% Power; LER (341)2012-005-00 dated 11/05/2012**

With the unit at 68% power, a fault occurred on the 13.2kV side of 120kV Transformer 1 at approximately 16:03 hrs EDT. This caused a loss of emergency buses 64B and 64C and balance of plant bus 64A, and resulted in a reactor trip. Diesel generators automatically started and loaded the emergency buses and isolations and actuations occurred as expected.

The cause of the fault was determined to be animal (bird) intrusion that initiated a ground fault at the Z-phase surge arrestor on the secondary side of Transformer 1. The surge arrestor and associated jumpers were replaced.

Offsite power was restored to the buses at 21:22 hours on 9/14/2012, for an offsite power outage duration of 5:19 hours. Power was restored to the switchyard on 9/16/2012 at 00:08 hours.

### *Ginna, 06/03/2012*

**100% Power, LER (244) 2012-001-00 dated 07/26/2012**

With the unit at full power at 02:39 (EDT), offsite power circuit 767 and safeguards buses 16 and 17 were deenergized due to a fault caused by wildlife (raccoon) intrusion. The associated emergency diesel generator started and reenergized the safeguards buses. Offsite power from the second offsite source remained available, and was connected to the safeguards buses at 03:18 and the diesel generator was subsequently shut down. The offsite power outage duration was about 39 minutes.

## *Grand Gulf: 04/02/2012*

**0% Power, Cold Shutdown; LER (416) 2012-003-00 dated 06/01/2012**

While in cold shutdown on 4/2/12 at 11:51 CDT, one of two 500kV offsite feeders tripped due to a lightning strike during severe weather on an offsite power source causing a drop in grid voltage and a trip of an ESF bus feeder. The associated high pressure core spray (HPCS) diesel generator automatically started and energized the bus. The other two ESF buses remained energized and shutdown cooling remained in service. Two additional offsite power sources remained in service.

The 500kV feeder was restored at 1515 CDT and the ESF bus was transferred back to offsite power and the diesel secured. The 500kV feeder was out of service for 3:24 hours.

## *Limerick 2: 06/22/04*

**Power, 100%; LER (353) 04-001 dated 08/23/04 and OE 18705 dated 07/12/04**

Limerick Unit 2 tripped from 100% power when a fault occurred in a breaker in the 500kV switchyard. The fault occurred on the B-phase of breaker CB-135 when it was opened in preparation for breaker maintenance. Four 500kV circuit breakers correctly opened (including the main generator output breakers) to isolate the fault. A concurrent failure of the secondary wiring of a current transformer in the 500kV switchyard, in combination with the ground fault current from the initial fault, caused an additional four 500kV circuit breakers to open. Unit 2 did not lose offsite power during this event. Its reserve auxiliary (startup) transformer remained energized from the 220kV switchyard.

## *Monticello: 09/11/08 and 09/17/08*

**On 09/11/08; Power, 100%; LER (263) 08-005, dated 11/10/08**
**On 09/17/08; Power, 0%; LER (263) 08-006, dated 11/14/08**

On the above two dates, two partial loss of offsite power events occurred that were similar. The plant has three transformers that can power the plant's safety buses. All three have adequate capacity to power all safe shutdown loads.

The three transformers are:

- Primary station Auxiliary Transformers 2R. It is fed from a 345kV source.
- Reserve Transformer 1R. It is fed from a 115kV source.
- Reserve Auxiliary Transformer 1AR. It is fed from two separate 13.8kV sources.

On 09/11/08 while the plant was operating at 100% power with transformer 1R out of service for planned maintenance, transformer 2R tripped open because of a fault in its incoming cable. A main Unit trip occurred and the safety buses were automatically repowered from transformer 1AR. Both EDGs started but did not need to load.

On 09/17/08 the plant was still shutdown for recovery from the transformer loss on 09/11/08 and transformer 2R was still out of service with the safety buses being powered from transformer 1R. While in this configuration a man-lift came in contact with a 115kV line which deenergized transformer 1R. Again transformer 1AR was available to power the safety buses, however the relaying is such that in these particular circumstances the EDGs automatically start and load, with transformer 1AR providing a backup offsite source.

## *Monticello: 6/13/2013*

**Power Level: Refueling Shutdown, LER 263/2013-004-00, dated 8/12/2013**

On June 13, 2013, Monticello was in cold shutdown with a full scram inserted. Testing for modifications associated with an Extended Power Uprate were in progress; specifically, a momentary loading test to initiate rotation of a condensate pump. When the pump motor breaker was opened after being closed for a couple seconds, an arc fault occurred in the 13.8kV feeder bus bar and causing a lockout of the 2R station transformer and loss of normal offsite power. The safety buses automatically transferred to a second source of offsite power via the 1AR emergency offsite transformer. Both emergency diesels started, but did not load.

The loss of power also resulted in a Group II containment isolation with associated isolation valve closures. This resulted in a loss of shutdown cooling for the reactor and spent fuel pool. Shutdown cooling for the reactor was restored within 58 minutes and spent fuel pool cooling was restored 92 minutes after the start of the event. There was no significant temperature rise in either the reactor or the spent fuel pool.

No conclusive evidence has been found that would explain the cause of the arc fault. However, the fault was most likely caused as a result of multiple independent conditions existing during the modification testing.

**Sources:**

LER 263/2013-004-00, "Loss of Normal Offsite Power as a Result of Switchgear Fault", dated 08/12/2013.

NRC Event Report No. 49113, "Emergency Diesel Generators Start", dated 06/13/2013.

## *Nine Mile Point Unit 2: 10/29/2012*

**Power 100%, LER (410) 2012-005-00 dated 12/21/2012**

With Nine Mile Point (NMP) Unit 2 at 100% power, a loss of one source of offsite power occurred on 10/29/2012 at 21:00 hours. Line 5, the 115kV offsite power source for Division I was deenergized due to a faulted condition when high winds associated with hurricane Sandy caused a lightning mast to fall in close proximity to the Scriba substation bus supplying the line. The Division I diesel generator actuated automatically in response to the loss of offsite power. The unit continued to operate at 100% throughout the event, and line 5 was restored at 03:26 hours on 10/30/2012. The diesel generator was secured at 04:47 hours on 10/30/3012. The duration of the offsite power outage was 6:26 hrs.

The Scriba substation faulted condition also contributed to a trip of NMP Unit 1 from 100% power. A polarity wiring error within the generator step up transformer neutral ground current transformers also contributed to the event. However, the unit trip response was not complicated, and offsite power was available to the unit.

## *North Anna 1 and 2: 12/09/09*

**Unit 1: Power, 100%; LER (338) 09-004 dated 02/03/10**
**Unit 2: Power, 97%; LER (338) 09-004 dated 0203/10**

On 12/09/09 both North Anna Unit 1 and Unit 2 experienced a partial loss of offsite power and Unit 2 tripped off-line. At the time of the event, Unit 1 was operating at 100% power and Unit 2 at 97%. The event was initiated by the inadvertent opening of a switchyard breaker during the testing of protective relay circuitry. The opening of this breaker removed offsite power to the "C" Reserve Station Service Transformer (RSST). Both North Anna Unit 1 and Unit 2 each have two emergency buses. At the time of this event, the "C" RSST was powering one of the two emergency buses on each Unit. The other emergency bus on each Unit was being powered by an RSST that was unaffected by this event, and these did not lose offsite power. When offsite power was lost to the one of two emergency buses on each Unit, their emergency diesel generators started and repowered these buses. Offsite power remained and was at all time available for each Unit's non-affected emergency bus.

The de-energization of the "C" RSST and loss of offsite power to one of its two emergency buses was not the direct cause of Unit 2 tripping off-line. These losses by themselves would not cause a main Unit trip. The Unit trip was caused by a secondary problem. A fast-transfer relay should have automatically transferred the Unit 2 circulating water pump loads from the "C" RSST to the "B" RSST when under-voltage occurred. However, the fast transfer breaker did not close prior to an under-voltage relay lockout operation because the under-voltage relay's timer was miscalibrated. The loss of these pumps resulted in a loss of condenser vacuum and this caused the automatic turbine and reactor trips.

## *North Anna 2: 05/28/10*

**Power, 100%; LER (339) 10-002 dated 07/26/10**

On 05/28/10, North Anna 2 experienced a partial loss of offsite power and main Unit trip from full power. One of the Unit's two safety buses lost offsite power at a time that its EDG was out of service for planned maintenance.

The initiating cause of this event was a lightning strike in the high voltage switchyard which caused a differential relay actuation. This resulted in the deenergization of various transformers and buses including the above referenced safety bus.

The loss of power to the safety bus resulted in a complex sequence of events that improperly caused the standby main feedwater pump to autostart. This autostart resulted in a voltage dip and series of interactions that caused a reactor coolant pump to shutdown.

This in turn caused the reactor and hence main Unit to trip. Post-event analysis showed that the main Unit trip was caused by specified undervoltage relay setpoints for the safety buses and reactor coolant pumps that did not properly coordinate.

## *Oconee 3: 05/15/06*

**Power, Shutdown for refueling; LER (287) 06-001 dated 07/14/06**

During an Oconee 3 refueling outage, relay maintenance was underway when a differential relay was inadvertently jarred and picked-up, causing the Unit 3 startup transformer to trip and lockout. The Keowee Hydro Station, which is the emergency power source at Oconee in lieu of emergency diesel generators, started and reenergized the Unit 3 emergency buses.

Offsite power was at all times available throughout this event. One available source was from either Central Switchyard or from Lee Steam Station via a 100kV line and transformer CT-5. Another source of offsite power was the Unit 2 startup transformer. These sources were at all time available if needed. Because Keowee was operating without problems, a transfer to offsite power via transformer CT-5 was made at a later convenient moment in the overall recovery effort.

## *Peach Bottom 2 and 3: 09/15/03*

**Unit 1: Power, 100%; LER (277) 03-004 dated 11/07/03 and OE 16925 dated 09/22/03**
**Unit 2: Power, 90%; LER (277) 03-004 dated 11/07/03 and OE 16925 dated 09/22/03**

On 09/15/03, with Unit 2 at 100% output and Unit 3 at 90%, lightning struck the 230kV Planebrook to Bradford transmission line. The line protection relays at the Bradford substation, which is about 35 miles from the Peach Bottom plant, did not operate properly. This resulted in a brief loss (16 seconds) of two of three offsite power sources to the Peach Bottom plant. A third offsite source was unaffected. Units 2 and 3 both scrammed because of a brief dip in voltage to their reactor protection systems.

The dip in bus voltage also caused the two emergency diesel generators for each unit (four total) to start and load. However, the normal sources of offsite power were again available almost immediately if needed. With the diesel generators operating, the return of offsite power to the safety buses was deferred until the evolution of plant operations presented a logically convenient moment. About one hour after loading, one diesel generator did trip do to jacket coolant system low pressure. Offsite power was available throughout this event.

## *River Bend: 08/15/04*

**Power, 100%; LER (458) 04-001 dated 10/14/04**

This event resulted in a partial loss of offsite power. Two of the unit's safety buses remained energized from offsite power throughout the event. The main unit did trip off-line. While the event had low safety significance, it did reveal a subtle breaker maintenance problem.

While River Bend was at 100% power, a tower failed on one of the four 230kV transmission lines that connect River Bend to the 230kV grid and resulted in an electrical fault. The line's circuit breaker at the River Bend switchyard received a trip signal but the breaker's mechanical operation was somewhat slow. This resulted in activation of the backup protection system which signaled for all the circuit breakers on the switchyard's north bus to open, but two of these circuit breakers also experienced slow operation. The fault eventually isolated, but not before the main generator output transformer ground fault relay also activated because of the extended fault duration. This resulted in a main unit trip.

The initial line fault also resulted in a fault on an adjacent transmission line, and this line's breaker at River Bend also experienced problems and resulted in the loss of offsite power to one of the 3 River Bend safety buses. Two of the 3 safety buses remained energized from offsite power throughout this event.

## *River Bend: 10/01/04*

**Power, 100%; LER (458) 04-002 dated 11/29/04**

While at 100% power, a flashover across a post insulator in the 230kV station transformer yard caused the loss of Reserve Station Transformer No. 1 which interrupted power to the Division 1 standby bus. The Division 1 diesel generator started automatically and restored power to the bus. Thirteen minutes later, a second flashover occurred across a 230kV post insulator on the main generator output line, causing a main Unit trip. The other two standby buses remained energized from offsite power throughout the event.

The flashover of the insulators was caused by contaminants in conjunction with heavy fog. The contaminants were a buildup over time of solids carried by cooling tower drift. This buildup was worsened by months of abnormally low rainfall that resulted in little or no natural cleaning.

## *Robinson: 03/28/10*

**Power, 99.5%; LER (261) 10-002 dated 05/27/10**

On 03/28/10 the Robinson Nuclear Unit experienced a partial loss of offsite power and the main Unit tripped from a 99.5% power level. The Unit lost offsite power to one of its two safety buses while the other safety bus continued to be powered from offsite. The safety bus that lost offsite power was re-energized by its EDG.

From a loss of offsite power perspective, this was not a particularly notable event. Offsite power was at all times available from the grid through the plant's 115kV switchyard via the startup transformer. These kept one safety bus energized from offsite during and following the event. However, this upset has received considerable attention because of operational problems that occurred during or were identified by the incident.

All plant operating power for the Robinson Nuclear Unit comes from two sources. These are the Unit auxiliary transformer which is fed from the main generator output and the startup transformer which is fed from the 115kV switchyard. The initiating cause of this event was the failure of a cable that feeds non-vital 4kV, Bus 5. The failure occurred where the cable enters Bus 5. When the fault occurred, the power for Bus 5 was coming from the unit auxiliary transformer which in turn is connected to the main generator output. The 4kV circuit breaker just upstream of Bus 5 should have opened and cleared the fault. But it did not because its trip circuit power supply was de-energized due to mechanical failure of the fuse that feeds the trip circuit.

As a result, the fault persisted and caused the unit auxiliary transformer to fail. Since the unit auxiliary transformer is fed directly from the main generator output, the main generator and unit auxiliary transformer isolated together to clear the fault and the Unit tripped off-line. The unit auxiliary transformer's

loads, along with the fault were automatically transferred to the startup transformer. The breaker that was now feeding Bus 5 from the startup transformer sensed the fault and opened, clearing the fault.

Several hours later, when operators were attempting to reset the generator lockout relay, this same breaker was inadvertently sent a signal to reclose. This re-energized the faulted cable and switchgear compartment from the startup transformer and caused additional collateral damage. The fault caused the breaker to re-open.

As initially pointed out, while this was a complex event, offsite power was at all times available.

### *Sequoyah 1 and 2: 03/26/09*

**Unit 1: Power, 96%; LER (327) 09-003 dated 05/22/09**
**Unit 2: Power, 100%; LER (327) 09-003 dated 05/22/09**

On 3/26/09 both Sequoyah Unit 1 and Unit 2 tripped off-line and experienced a partial loss of offsite power. At the time of the event, Unit 1 was operating at 96% power and Unit 2 at 100%. The underlying cause of this event was a fault on the output bus (6.9kV) of common station service transformer (CSST) D. The 161kV source that feeds CSST D also feeds CSST C, hence when CSST D was isolated to clear the fault, CSST C was also de-energized. CSST C was powering 2 of the 4 reactor coolant pumps (RCPs) on each Unit. The loss of power to these RCPs caused both Unit 1 and Unit 2 to trip off-line. At the time of this event, CSST C was also feeding the A train safety/shutdown buses on both Units. These lost offsite power and were repowered by their emergency diesel generators. The B train safety bus on each Unit continued to be powered by offsite power from CSST B throughout this event. Hence, at no time did either Unit experience a loss of all offsite power.

The above failure would not have caused any loss of offsite power had not, prior to this event, preparations been underway for a Unit 1 refueling outage. Unit 1 was coasting down, and as part of these preparations, CSST A which normally is one source for the safety buses of both Units 1 and 2 had been removed from service, and the buses transferred to their backup source (CSST B). Hence, the backup offsite source was already being utilized at the time of this event and was not available to automatically accept (fast transfer) the CSST C loads including power to the safety bus on each Unit that lost its source of offsite power.

### *Sequoyah 1 and 2: 02/12/2012, Significant Event No. 47660*

**Unit 1: 100% Power**
**Unit 2: 100% Power**

On 2/12/12 at 07:56 EST, both Unit 1 and Unit 2 experienced a common loss of one offsite power source due to the catastrophic failure of one phase of a PCB in the 161kV switchyard.

Both units remained stable at 100% power, and the ESF buses for both units remained energized, being powered from the main units through the unit auxiliary transformers. The second source of offsite power was verified as available.

At 02/12/12 at 10:19 EST, the faulted condition was cleared and the offsite power source was restored. The offsite source was inoperable for 02:23 hours.

### *South Texas 1 and 2: 01/19/03*

**Unit 1: Power, 100%; LER (498) 03-001 dated 03/20/03 and OE 15526 dated 02/18/03**
**Unit 2: Power, Mode 3; LER (498) 03-001 dated 03/20/03 and OE 15526 dated 02/18/03**

Each of the three ESF buses of both Units 1 and 2 has four sources of offsite power. These are the Unit's auxiliary transformer (there is a generator output breaker), the Unit's standby (startup) transformer, the other Unit's standby (startup)transformer and a 138kV separate source emergency transformer. At the time of the event the Unit 2 auxiliary transformer was out of service and one ESF bus on Unit 2 was being cross-fed from the Unit 1 standby transformer.

When closing in a shunt reactor on to the 345kV switchyard north bus, only two of the circuit switcher's 3 phases closed. Relaying isolated the north bus. After relaying cleared the shunt reactor, all north bus breakers automatically reclosed. Unit 1 remained at 100% power and Unit 2 remained in mode 3 throughout the event.

Since the Unit 1 standby transformer is connected to the 345kV north bus, it was deenergized for about one minute. Two of the three ESF buses on Unit 1 were deenergized by the momentary interruption but each had three other energized alternate sources of offsite power if needed. One of the three ESF buses on Unit 2 was affected but it had two other energized alternate sources of offsite power. The relaying is such that the EDGs provided the first response in reenergizing the safety buses. However, the multiple offsite sources were available if needed.

### *St. Lucie: 10/03/2012*

**Unit 1: 100% Power**
**Unit 2: 0% Power, de-fueled; LER (389) 2012-002-00 dated 11/27/2012**

On 10/3/2012 at 08:43 hrs, with unit-2 in a defueled condition, a fault on the 6.9kV non-segregated bus for the 2B startup transformer resulted in loss of the transformer and a partial loss of offsite power to unit-2. Unit-1 continued operation at power with one offsite circuit out of service.

The 2-B diesel generator started and loaded, and all equipment responded as expected. The startup transformer was returned to service within the time period specified by the Technical Specifications.

The fault was caused by collapse of a corroded bus vent assembly onto the bus bars. Corrective actions include improving periodic maintenance of associated bus run vent assemblies.

### *Summer: 06/12/04*

**Power, 100%; LER (395) 04-002 dated 08/11/04**

This was a several second long partial loss of all offsite power during a severe thunderstorm. The Unit remained at 100% power throughout the event. Summer Nuclear Station has two sources of offsite power for the two emergency safeguard buses. One source comes from the plant's 230kV switchyard and the other from a 115kV transmission line that originates at the Parr Substation. Power from the 230kV source was unaffected. A lightning strike upstream of the Parr Substation caused multiple breakers at Parr to cycle and resulted in a several second loss of power on the 115kV transmission line to Summer. The "A" EDG started and loaded. Although the 115kV source was reenergized in seconds, operators felt it prudent to stay on the "A" EDG, for several hours to further assure of the offsite source's reliability. Subsequent to the event, personnel found a faulty breaker at the Parr Substation. This was the underlying cause of the brief loss of 115kV power to Summer.

### *Surry 2: 12/29/2012*

**Power 100%; LER (281) 2013-001-00 dated 02/15/2013**

On 12/29/2012 at 08:03 hours, a pelican contacted the overhead lines from the switchyard to the B reserve station service transformer (RSST). The supply breaker to the RSST tripped open as a result of instantaneous overcurrent of the B and C phases. The B RSST locked out and resulted in a loss of normal off site power to one emergency bus - 2H. The associated emergency diesel generator started and loaded on to the emergency bus as designed.

Visual inspections verified that there was no damage to the lines, supply breaker, or RSST. The normal source of offsite power to the emergency bus 2H was restored at 12:42 hours, for an outage duration of 4:39 hours.

### *Susquehanna 1 and 2: 06/28/2012*

**Unit 1, Power 0%, Cold Shutdown; Unit 2, Power 100%; LER (388) 2012-008-00 dated 08/24/2012**

On 06/28/2012 at 1353 hours, with Unit 1 in cold shutdown and the Unit 2 at full power, the station experienced a loss of one (of two) offsite power sources for both units when startup transformer (T-20) was deenergized.

All ESF buses powered by this transformer automatically transferred to the second startup transformer (T-10) which was in service and supplied by a second offsite source.

The deenergization interrupted power to several plant systems including the shutdown unit's residual heat removal (RHR) system. This system was restored within one hour. The operating unit continued to operate at power.

The deenergization of the transformer was initiated by a defective selector switch for electrical current indication. The switch had foreign material from the manufacturing process that prevented a switch contact from closing. This, in turn, caused an invalid phase current imbalance indication that was detected by protective relaying resulting in loss of the transformer. One of the contributing causes of the event was in the design of the protective relaying scheme that included a shared metering function.

### *Turkey Point 3 and 4: 02/26/08*

**Unit 3: Power, 100%; LER (250) 08-001, dated 04/25/08**
**Unit 4: Power, 100%; LER (250) 08-001, dated 04/25/08**

On February 26, 2008, a momentary grid voltage disturbance occurred that caused a trip of both Turkey Point Units 3 and 4. The undervoltage condition resulted from a 138kV transmission system fault at an offsite electrical substation. The fault remained on the system for approximately 1.7 seconds. The units tripped off-line because both channels of each Unit's safety related 4kV bus undervoltage relays actuated after a one second time delay. The Units automatically trip when both channels are activated. However the emergency diesel generators did not auto-start or load because the grid's voltage level at the plant recovered by the time switchyard breakers repositioned to place the startup transformers in service and repower the safety buses. There was at all times ample grid capacity available to supply the plants safe shutdown loads.

### *Turkey Point 4: 10/31/05*

**Unit 4: Power, Hot standby; LER (251) 05-005 dated 12/22/05**

Unit 4 was in hot standby when 240kV switchyard protection relays actuated causing a loss of power to the Unit 4 startup transformer. The cause was salt contamination on switchyard insulators from hurricane Wilma. Offsite power to the two Unit 4 safety buses was interrupted and the two Unit 4 EDGs started and loaded these buses. Unit 3 was at 60% power and was unaffected by this event.

Backup offsite power was at all times available from two other sources. The two sources were the 4C bus transformer and the Unit 3 startup transformer. Hence there never was a loss of all offsite power. While these sources of offsite power were available, they were not required because the Unit 4 EDGs responded as designed.

## *Wolf Creek: 08/19/09*

**Restore time: seconds; Power, 100%; LER (482) 09-002 dated 10/17/09**

On 08/19/09 the Wolf Creek Nuclear Unit experienced a momentary loss of all offsite power (a few seconds) and a main Unit trip. The suspected initiating cause was a lightning strike that caused a transient ground fault on one of the three 345kV transmission lines that terminate at Wolf Creek. During the fault, which cleared the first 345kV line, a carrier signal system failed on the second 345kV line and caused the distance relays to extend their reach and open the second 345kV line and left Wolf Creek connected to the grid on the last remaining line. This had always been understood to be an unstable unit condition and resulted in the remote relays tripping the last remaining line due to three-phase instability. This resulted in the momentary LOOP and a main Unit trip because of the loss of load. Within one minute, the 345kV switchyard was reenergized by reclosing one of the 345kV lines. The input from the remaining two lines was restored minutes later. Any one of the plant's three 345kV lines can supply all safeguard loads.

Both emergency diesel generators (EDGs) started and reenergized their safety buses at the time of the momentary interruption. While offsite power was again available in less than a minute, if needed, the plant remained on the EDGs until more urgent recovery steps were completed and an appropriate moment became available for switching back to offsite power. This occurred several hours after the interruption.

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