Texas Reliability Entity
Event Analysis

Event:
October 2, 2010 Event
Category 3 Event

Texas Reliability Entity
July 2011

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Executive Summary

On October 2, 2010, a phase-to-ground fault condition occurred on the 345 kV Substation A to Substation B transmission line near the Substation A power plant, resulting in tripping Substation A Units C and D, removing 1060 MW of net generation from the ERCOT Region. This report provides: (1) an overview of the event; (2) background on system conditions just prior to the event; (3) the detailed sequence of events; (4) an analysis of the causal and contributing factors for three concerns that arose in this event; and (5) action plans to address concerns discovered from review of the event.

I. Event Overview

At approximately 04:37:38 on October 2, 2010, a single phase-to-ground fault condition occurred on the 345 kV Substation A to Substation B transmission line near the Substation A power plant. Transmission Entity A reported the transmission line fault was most likely caused by insulator contamination caused by bird/buzzard excrement due to the large number of birds that roost on the transmission towers. Per the oscillographic records, the fault was calculated to be approximately 1.5 miles from the Substation A plant. The Substation A circuit breakers tripped in 2.5 cycles, interrupting approximately 24,300 amps of fault current. The Substation B circuit breakers tripped in 5 cycles. Both ends successfully reclosed.

During the event, Substation A Units C and D tripped on primary reverse power relaying, removing 1150 MW gross (1060 MW net) generation from the ERCOT Region. System frequency dropped from 60.01 Hz to 59.886 Hz as a consequence of the loss of generation. The drop was arrested by governor action of ERCOT Region generators, aided by deployment of 448 MW of Responsive Reserve Service, as well as the natural frequency response of system load.

Sequence of Events:

Prior to event	Substation A Unit C operating at 576 MW gross
	Substation A Unit D operating at 574 MW gross
04:37:38	345 kV Substation A to Substation B line fault occurs
	345 kV bus voltage drops from 203 kV (l-n) to 15 kV (l-n)
	Substation A station voltage drops from 4 kV to 3.2 kV
	Substation A station 480 V system voltage drops from 480 V to 33 V
	Substation A station 120 V system voltage drops from 120 V to 82.5 V
04:37:38.1	345kV Substation A to Substation B line fault is cleared
	System voltages return to normal
04:37:44	Negative duct pressure caused high limit to trip Unit C draft booster fan
04:37:45	Negative duct pressure caused high limit to trip Unit D draft booster fan

04:42:03	Unit D Main/Reheat steam temperature rated of change alarm
04:42:17	Unit D Main/Reheat steam temperature rated of change trip
04:42:26	Unit D reverse power trip
04:45:56	Unit C high waterwall outlet temperature alarms
04:47:12	Unit C high waterwall outlet temperature trip
04:47:18	Unit C reverse power trip

This event was considered reportable to NERC due to the loss of more than 1,000 MW of generation in the ERCOT Region and met the definition of a Category 3.a. event under NERC's Event Analysis Working Group procedure.

There was a subsequent event impacting Substation A Unit C on October 16, 2010 at 03:58. A similar close-in fault on the 345 kV transmission system caused the unit to trip for the same reason as on October 2, 2010. Substation A Unit D was off-line on 10/16/2010 for a planned outage and was not affected. Transmission Entity A reported the transmission line fault was most likely caused by insulator contamination caused by bird/buzzard excrement due to the large number of birds that roost on the transmission towers. Per the oscillographic records, the fault was calculated to be approximately 4.2 miles from the Substation A plant. The Substation A circuit breakers tripped in 2.5 cycles, interrupting approximately 18,600 amps of fault current. The Substation B circuit breakers tripped in 4.5 cycles. Both ends successfully reclosed.

II. Forecasts and Initial System Conditions Prior to Event

10/02/2010 Current Day Report forecast reflecting 17:00 Peak (Pk):

Forecasted Pk HR Demand:	39580 MW @ 1100 HR
Generation for Pk HR Demand	43652 MW @ 1100 HR
Schedule Gen for Pk HR Demand	38297 MW@ 1100 HR
Balancing Energy at Pk HR Load	1283 MW@ 1100 HR
Potential for (EEA1)	Low @ 1100 HR
Potential for Deploying LaaR (EEA2A)	Low @ 1100 HR
Potential for Deploying IEL (EEA2B)	Low @ 1100 HR
Potential for Firm Load Shed (EEA3)	Low @ 1100 HR

Initial system conditions just before the event of October 2, 2010 were:

System Frequency:	60.010 Hz
System Load:	23682 MW
Adjusted Responsive Reserves:	4846 MW

III. Response

A. Response

The October 2, 2010 event did not follow the typical pattern for the loss of a major generation station since the units did not trip simultaneously. Since the two units tripped approximately four minutes and 35 seconds apart, there was sufficient time for responsive reserve and governor response to react as if the two unit trips were independent events. The Balancing Authority (BA) used the Region's resources and reserves to balance resources and demand and return system frequency to pre-disturbance frequency well within the BAL-002 R4 Standard's 15 minute requirement.

ERCOT Region frequency was at 60.01 Hz immediately prior to the disturbance. Immediately after the disturbance, system frequency dropped to 59.886 Hz. The BA deployed 448 MW of Responsive Reserve Service from actual adjusted Responsive Reserve of 4846 MW.

B. Generation Entity A Response and Mitigation Process

Generation Entity A returned Substation A Unit C to operation at 16:25 CST on 10/02/10. Substation A Unit D was brought back on-line at 03:12 CST on 10/03/10.

Generation Entity A conducted an initial analysis to determine the cause of the induced draft booster fan loss and determined that the cause of the fan loss was high negative duct pressure caused by inadvertent operation of the inlet dampers to the fan. The cause of the misoperation of the inlet dampers was confirmed to be the baghouse Programmable Logic Controller (PLC) units. The investigation determined that the baghouse PLCs were designed and installed as a part of a turnkey baghouse installation project.

IV. Analysis of Event

A. Transmission Entity A Transmission Line Trips

The root cause of the 345 kV Substation A to Substation B Switch transmission line fault at 04:37 on 10/02/2010 was a flashover due insulator contamination caused by bird/buzzard excrement due to the large number of birds that roost on the transmission towers. The fault was cleared in 5 cycles (83 ms) by transmission line relays and both ends had a successful automatic reclosure. The estimated fault location was 1.5 miles from the Substation A power plant. All protection systems for the transmission operated as designed.

The root cause of the 345 kV Substation A to Substation B Switch transmission line fault at 03:58 on 10/16/2010 was a flashover due insulator contamination caused by bird/buzzard excrement due to the large number of birds that roost on the transmission towers. The fault was cleared in 4.5 cycles (75 ms) by transmission line relays and both ends had a successful automatic reclosure. The estimated fault location was 4.2 miles from the Substation A power plant. All protection systems for the transmission operated as designed.

Transmission Entity A crews patrolled up to ten miles out of Substation A and found no clear evidence of the specific locations of the faults, although high concentrations of birds were noted 1.5 miles and 7 miles out of the Substation A plant. As a result, Transmission Entity A installed bird guards at those locations as a preventive measure.

B. Substation A Unit C Trips

The root cause of the trip of Substation A Unit C was a critical PLC unit power supply was not connected to an Uninterruptible Power Supply (UPS). The transmission line fault event caused a low voltage to the PLC which controlled the environmental controls to baghouse. The baghouse is part of the environmental controls for removing particulates in the boiler exhaust gas. The PLC power supplies have a minimum detection voltage of 88 Volts. During the event, the voltage on the station's 480 volt system was calculated to be as low as 330 volts and the voltage on the station's 120 volt system was as low as 82.5 volts. Tests on the PLC indicated the controller can fail to operate properly when supply voltage drops below 94.5 Volts. The interaction between the PLCs operating with a low voltage supply had an effect on the baghouse control damper positioning. During the low voltage condition, communications between the baghouse PLC's and the power plant's Digital Control System (DCS) were also interrupted, which resulted in a loss of data during the period of the low voltage condition.

The baghouse control damper operation resulted in increased negative duct pressure at

the inlet to the induced draft booster fans on the units. The damper operation caused the associated high limit to trip the induced draft booster fan. Upon the loss of the induced draft booster fan, half of the operating lignite pulverizers automatically shut down due to loss of air flow. This results in an immediate imbalance in the boiler feed water-to-fuel firing ratio. When this condition occurs, the DCS system is programmed to automatically reduce boiler feed water flow in an attempt to balance the feed water, fuel flow, and air flow. The loss of this boiler fan caused an unsuccessful unit runback due to high boiler waterwall outlet temperature. The waterwall outlet temperature increase resulted in a boiler master fuel trip at 04:47:12 and the generator experienced a normal reverse power trip at 04:47:18.

Substation A Unit C tripped again on 10/16/2010 at 03:58 for the same reason. In the October 16, 2010 event, the baghouse control damper operation resulted in increased negative duct pressure at the inlet to the induced draft booster fans on the units. The damper operation caused the associated high limit to trip the induced draft booster fan. The loss of the induced draft booster fan caused an automatic unit runback. The runback was unsuccessful and the unit tripped due to loss of flame in the boiler. The flame loss caused a boiler master fuel trip at 03:59:55:12 and the generator experienced a normal reverse power trip at 04:01:08.

C. Substation A Unit D Trip

The root cause of the trip of Substation A Unit D was a critical PLC unit power supply was not connected to a UPS, identical to Substation A Unit C.

The baghouse control damper operation resulted in increased negative duct pressure at the inlet to the induced draft booster fans on the units. The damper operation caused the associated high limit to trip the induced draft booster fan. The loss of this boiler fan caused an unsuccessful unit runback due to Main/Reheat steam temperature rate of change. The Main/Reheat steam temperature rate of change exceeded the limit at 04:42:03 and the generator experienced a normal reverse power trip at 04:42:26.

V. Action Items and Recommendations

Generation Entity A provided the following mitigation activities for this event.

1) **Activity:** Conduct an analysis of the affected PLCs.
   Results: This activity was completed by 10/28/2010. Generation Entity A conducted a bench test on the PLCs and determined that the PLC processors stop functioning at 94.5 Volts.

2) **Activity:** Analyze the affected PLC power source.

Results: This activity was completed by 10/28/2010. Generation Entity A determined the baghouse PLCs were not connected to a UPS and developed the plans indicated below to modify the power source for the baghouse PLCs. Contrary to Generation Entity A's normal plant practices, the baghouse PLCs were powered by 120 Volt AC power from the baghouse Motor Control Centers (MCCs), and were not connected to a UPS.

- Move the Unit C baghouse PLC primary power source to the Unit 1 Boiler Control System Primary distribution panel which is powered by a 35 KVA UPS with its own 125 Volt DC battery. The AC feed to the 35 KVA UPS is supplied by the common MCC that is fed from Unit C or Unit D. Move the Unit C baghouse PLC alternate power source to the Boiler Control System Alternate distribution panel which is powered by an isolation/regulation transformer fed from the Shutdown Bus MCC.
- Move the Unit D baghouse PLC primary power source to the Unit D Boiler Control System Primary distribution panel which is powered by a 35 KVA UPS with its own 125 Volt DC battery. The AC feed to the 35 KVA UPS is supplied by the common MCC that is fed from Unit C or Unit D. Move the Unit D baghouse PLC alternate power source to the Boiler Control System Alternate distribution panel powered by an isolation/regulation transformer fed from the Shutdown Bus MCC.
- Generation Entity A indicated that modifications to the DCS system and boiler controls was not an option to mitigate the unit runback from this contingency and avoid tripping the units.

3) **Activity:** Complete the analysis of the interaction of the PLCs with the baghouse functions.

4) **Activity:** Implement power source modifications for the Substation A baghouse PLCs. Unit outages are required to modify to power sources to the baghouse PLCs. Substation A Unit 2 baghouse PLC power source modifications were completed during a recent unit planned outage. Substation A will also utilize any forced outages of sufficient duration that may occur to implement power source modifications.

Texas RE has the following recommendations for this event.

1) Generation Entity A should conduct a review of UPS power sources to critical control components, in addition to the baghouse PLC units, that can cause a generator runback or shutdown.