UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
1600 EAST LAMAR BOULEVARD
ARLINGTON, TEXAS 76011-4511

March 26, 2018

Mr. William F. Maguire, Site Vice President
Entergy Operations, Inc.
River Bend Station
5485 US Highway 61N
St. Francisville, LA 70775

SUBJECT: RIVER BEND STATION – NRC INSPECTION OF TEMPORARY INSTRUCTION 2515/194, INSPECTION OF THE LICENSEE'S IMPLEMENTATION OF INDUSTRY INITIATIVE ASSOCIATED WITH THE OPEN PHASE CONDITION DESIGN VULNERABILITIES IN ELECTRIC POWER SYSTEMS (NRC BULLETIN 2012-01) – INSPECTION REPORT 05000458/2018010

Dear Mr. Maguire:

On February 8, 2018, the U.S. Nuclear Regulatory Commission (NRC) completed an inspection at the River Bend Station. On February 8, 2018, the inspectors discussed the results of this inspection with you and other members of your staff. The results of this inspection are documented in the enclosed report.

The NRC inspectors did not identify any findings or violations of more than minor significance.

This letter, its enclosure, and your response (if any) will be made available for public inspection and copying at http://www.nrc.gov/reading-rm/adams.html and at the NRC Public Document Room in accordance with 10 CFR 2.390, "Public Inspections, Exemptions, Requests for Withholding."

Sincerely,

/RA/

Gregory E. Werner, Chief
Engineering Branch 2
Division of Reactor Safety

Docket No. 50-458
License No. NPF-47

Enclosure:
Inspection Report 05000458/2018010
w/ Attachments: 1. Table 1 – Information Gathered
for Temporary Instruction 2515/194
2. TI 2515/194 Inspection Documentation Request

U.S. NUCLEAR REGULATORY COMMISSION
Inspection Report

Docket Number:	05000458
License Number:	NPF-47
Report Number:	05000458/2018010
Enterprise Identifier:	000512/05000458/I-2018-010-0019
Licensee:	Entergy Operations, Inc.
Facility:	River Bend Station
Location:	Saint Francisville, Louisiana
Inspection Dates:	February 5, 2018, to February 8, 2018
Inspectors:	S. Graves, Team Lead, Senior Reactor Inspector, Region IV S. Makor, Reactor Inspector, Region IV
Accompanying Personnel:	G. Matharu, Senior Electrical Engineer, NRR/DE/EEOB K. Nguyen, Electrical Engineer, NRR/DE/EEOB J. Quichocho, Chief, NRR/DE/EEOB
Approved By:	G. Werner, Branch Chief, Engineering Branch 2

Enclosure

SUMMARY

The U.S. Nuclear Regulatory Commission continued monitoring licensee's performance by conducting Temporary Instruction 2515/194, "Inspection of the Licensees' Implementation of Industry Initiative Associated with the Open Phase Condition Design Vulnerabilities in Electric Power Systems (NRC Bulletin 2012-01)," at River Bend Station, in accordance with the Reactor Oversight Process. The Reactor Oversight Process is the Nuclear Regulatory Commission's program for overseeing the safe operation of commercial nuclear power reactors. Refer to https://www.nrc.gov/reactors/operating/oversight.html for more information.

List of Findings and Violations

None.

Additional Tracking Items

None.

INSPECTION SCOPE

This inspection was conducted using Temporary Instruction 2515/194 (ADAMS Accession No. ML17137A416), dated October 31, 2017. The inspectors reviewed the licensee's implementation of Nuclear Energy Institute voluntary industry initiative in compliance with Commission guidance. The team discussed the licensee's open phase condition system design and ongoing implementation plans with plant staff, Entergy Corporate staff and vendor staff. The team reviewed licensee and vendor documentation, and performed system walkdowns to verify that the installed equipment was supported by the design documentation. The team verified that the licensee had completed the installation and testing of equipment (with the exception of the tripping functions), installed and tested alarming circuits both local and in the control room, and analyzed potential impacts associated with the design implementation on the current licensing basis.

OTHER ACTIVITIES – TEMPORARY INSTRUCTIONS, INFREQUENT AND ABNORMAL

Temporary Instruction 2515/194 - Inspection of the Licensees' Implementation of Industry Initiative Associated With the Open Phase Condition Design Vulnerabilities in Electric Power Systems (NRC BULLETIN 2012-01)

The objective of Temporary Instruction 2015/194 is to verify that licensees have appropriately implemented the Nuclear Energy Institute voluntary industry initiative including updating their licensing basis to reflect the need to protect against open phase conditions and to gather the information necessary for Office of Nuclear Reactor Regulation staff to determine whether the licensees have adequately addressed potential open phase conditions.

Temporary Instruction 2515/194-03.01 - Voluntary Industry Initiative (Part 1)

River Bend Station selected the open phase detection system designed and manufactured by PCS2000 Solutions, LLC, as the design vendor for the open phase condition system. At the end of this inspection the PCS2000 system was still in the "monitoring mode" of operation to facilitate continued data gathering of grid perturbations for evaluation of alarm and trip setpoints. The open phase condition equipment was installed on the preferred station service transformers RTX-XSR1C and RTX-XSR1D which power the station vital busses. The licensee was scheduled to transition the PCS2000 system to full implementation (tripping functions enabled) in December 2018. The licensee was preparing the full implementation engineering changes and associated documents for this transition, however they were not available for review at the time of inspection.

Section 03.01 of the Temporary Instruction required the determination whether the licensee appropriately implemented the voluntary industry initiative, dated March 16, 2015 (ADAMS Accession No. ML15075A454), by verifying the following:

a. Detection Alarms and General Criteria

    1. Either open phase conditions are detected and alarmed in the control room, or (a) The licensee has demonstrated that open phase conditions do not prevent the functioning of important-to-safety systems, structures, and components, (b) open phase condition detection will occur within a reasonably short period of time (e.g., 24 hours), and (c) the licensee has established appropriate documentation regarding open phase condition detection and correction.

2. Either detection circuits are sensitive enough to identify an open phase condition for credited loading conditions (i.e., high and low loading), or if automatic detection may not be possible in very low or no loading conditions when offsite power transformers are in standby mode, automatic detection must happen as soon as loads are transferred to this standby source. Additionally, the licensee has established appropriate shiftily surveillance requirements to look for evidence of open phase conditions.

3. Open phase condition design/protective schemes minimize misoperation or spurious action in the range of voltage unbalance normally expected in the transmission system that could cause separation from an operable off-site power source. Licensees have demonstrated that the actuation circuit design does not result in lower overall plant operation reliability.

4. New non-Class-1E circuits are not used to replace existing Class-1E circuits.

5. The updated safety analysis report has been updated to discuss the design features and analyses related to the effects of, and protection for, any open phase condition design vulnerability.

b. Protective Actions

1. If the licensee determines there is no single credible failure that could cause an open phase condition, then verify that the licensee has developed and issued a full engineering evaluation to document the basis for open phase condition as a non-credited event. The Bruce Power and Forsmark operating experience must be considered as part of this analysis.

2. With open phase condition occurrence and no accident condition signal present, either an open phase condition does not adversely affect the function of important-to-safety systems, structures, and components, or (a) technical specification limiting condition for operation are maintained or the technical specification actions are met without entry into Technical Specification Limiting Condition for Operation 3.0.3 (or equivalent), (b) important-to-safety equipment is not damaged by the open phase condition, and (c) shutdown safety is not compromised.

3. With open phase condition occurrence and an accident condition signal present, automatic detection and actuation will transfer loads required to mitigate postulated accidents to an alternate source and ensure that safety functions are preserved as required by the current licensing bases, or the licensee has shown that all design basis accident acceptance criteria are met with the open phase condition, given other plant design features. Accident assumptions must include licensing provisions associated with single failures. Typically, licensing bases will not permit consideration of the open phase condition as the single failure since this failure is in a non-safety system.

4. Periodic tests, calibrations, setpoint verifications, or inspections (as applicable) have been established for any new protective features. The surveillance requirements have been added to the plant Technical Specifications, if necessary to meet the provisions of 10 CFR 50.36.

Temporary Instruction 2515/194-03.02 - Information Gathering for Voluntary Industry Initiative Assessment (Part 2)

Section 03.02 of the Temporary Instruction required information gathering as part of the initial inspections to enable the Nuclear Reactor Regulation staff to determine whether the modifications implemented by the licensee of each unique open phase condition system design for the voluntary industry initiative adequately address potential open phase conditions. The information gathered for this section is tabulated in, "Table 1 – Information Gathered for Temporary Instruction 2515/194," to this report.

INSPECTION RESULTS

Based on interviews and discussions with the licensee and the vendor, review of available design, testing, grid data trending results documentation, tour of the vendor facility, and walkdowns of installed equipment, the team had reasonable assurance the licensee appropriately implemented, with noted exceptions discussed below, the voluntary industry initiative.

Temporary Instruction 2515/194-03.01 - Voluntary Industry Initiative (Part 1)

a. Detection Alarms and General Criteria

(1) The team determined by walkdowns and observation that open phase conditions will be detected and alarmed in the control room.

(2) The team determined that detection circuits were sensitive enough to identify an open phase condition for all credited loading conditions.

(3) No Class-1E circuits were replaced with non-Class 1E circuits in the design.

b. Protective Actions Criteria

(1) The team determined the licensee identified they were susceptible to an open phase condition and were implementing design changes to mitigate the effects.

(2) The team determined that with an open phase condition present and no accident condition signal, the PCS2000 system would not adversely affect the function of important-to-safety systems, structures, and components.

No findings were identified, however the team identified the following exceptions to the Temporary Instruction criteria resulting from the incomplete design modifications:

c. Detection Alarms and General Criteria Exceptions

(1) The licensee's design was operating in the monitoring mode to gather data to ensure the open phase condition design and protective schemes would minimize misoperation, or spurious action in the range of voltage unbalance normally expected in the transmission system. Because actual demonstration of this criterion requires the system to be in operation with final trip setpoints established, the team was not able to fully verify this criterion. After discussions with licensee and vendor staff, and design document and test results reviews, the team had reasonable assurance that the actuation circuit design would not result in lower overall plant operation reliability. The team did not identify any issues of concern.

(2) The Updated Safety Analysis Report had not been updated at the conclusion of the onsite inspection. The team held discussions with the licensee concerning their interpretation of the guidance in the voluntary industry initiative related to adding open phase condition related entries to their licensing basis documents. The licensee entered this issue into their corrective action program as Condition Report CR-RBS-2018-00891 to determine if the Updated Safety Analysis Report would be updated prior to initiating the full design (trip functions enabled) or during the next normal final safety analysis report (FSAR) update cycle. The team did not identify any issues of concern.

d. Protective Actions Criteria Exceptions

(1) The licensee's open phase condition design solution used the existing load transfer scheme for safety-related accident loads; only a new tripping condition (open phase) had been added to the electrical faults which result in safety-related loads being transferred to the onsite emergency power system. Because actual demonstration of this criterion requires the system to be in full operation, the team was not able to fully verify this criterion. Through review of available design documents and discussions with plant engineering and vendor staff, the team had reasonable assurance that with an open phase condition present and an accident condition signal, the PCS2000 system automatic detection and actuation would transfer loads required to mitigate postulated accidents to an alternate source and ensure that safety functions are preserved, as required by the current licensing bases. The team did not identify any issues of concern.

(2) The licensee had not finalized documentation for periodic tests, calibrations, setpoint verifications, or inspection procedures for open phase condition-related components at the time of this inspection. The licensee had initiated action requests to establish these activities. The team reviewed the action requests (AR283793 and AR283795) documents outlining the proposed periodic testing and periodicities for the newly installed equipment, reviewed historical system logs related to system performance, reviewed and discussed planned testing, calibration, and inspections. The team also held discussions on the licensee's plans to include open phase condition-related components into the Maintenance Rule (10 CFR 50.65) program. The licensee entered this issue into their corrective action program as Condition Report

CR-RBS-2018-00893. Existing plant equipment will continue to be maintained according to the licensee's current preventative maintenance program. The licensee planned to use guidance in the North American Electric Reliability Council's Reliability Standard PRC-005 and vendor maintenance guidance to maintain the added switchyard relaying equipment for the PCS2000 design. The team did not identify any issues of concern.

EXIT MEETINGS AND DEBRIEFS

On February 8, 2018, the team presented the Temporary Instruction 2515/194 inspection results to Mr. W. Maguire, Site Vice President and other members of the licensee staff. The inspectors verified no proprietary information was retained or documented in this report.

DOCUMENTS REVIEWED

Inspection Procedure	Type	Designation	Description or Title	Revision/ Date
TI 2515/194	Calculations	G13.18.3.6-026	River Bend Open Phase with Loss-of-Coolant Accident Analysis	0
		G13.18.3.6-025	River Bend Open Phase Feasibility Analysis	1
		G13.18.3.6*018	Electrical Transient Analysis Program Database Input Source Study	5
		E-216 (ECN 55751)	Normal Battery BYS-BAT01 B Duty Cycle, Current Profile and Size Verification	1
		E-222-NJS-LDC1 QR	E-222-NJS-LDC1 QR, 480 VAC Normal Load Center and Motor Control Center Load Tabulation including Cable Verification	1
	Drawings	0242.112-027-020	Outline – Type SL Transformer, 230kV/4160V	
		0242.112-027-025	RTX-XSR1C Power Transformer Open Phase Detection 3-Line AC Schematic	0
		0242.112-027-026	RTX-XSR1D Power Transformer Open Phase Detection 3-Line AC Schematic	0
		0242.112-027-034	RTX-XSR1C Power Transformer OPD Sensor, and CT Mounting Layout and Details	0
		0242.112-027-035	RTX-XSR1D Power Transformer OPD Sensor, and CT Mounting Elevation and Details	0

Inspection Procedure	Type	Designation	Description or Title	Revision/ Date
		0242.112-027-040	RTX-XSR1D Power Transformer OPD Sensor, and CT Mounting Layout and Details	0
		0242.112-027-041	RTX-XSR1D Power Transformer OPD Sensor, and CT Mounting Elevation and Details	0
		EE-003ZQ	RTX-XSR1D Power Transformer Open Phase Detection 3-Line AC Schematic Asset Numbers	0
		EE-030A	Arrangement Transformer Yard Unit 1	10
		EE-030E	Sections and Details Transformer Yard 2A	3
		EE-040A	Conduit Plans and Details Transformer Yard Area	4
		EE-040B	Conduit Plans and Details Transformer Yard Area	2
		ESK-08SPR18	Elementary Diagram 125VDC Control Circuit Preferred Station Service XFMR Protection	6
		ESK-08SPR19	Elementary Diagram 125VDC Control Circuit Preferred Station Service XFMR Protection	7
		EE-001AC	Start-Up Electrical Distribution Chart	56
		ESK-08SPR04	Elementary Diagram 125VDC Control Circuit Preferred Station Service XFMR Backup Protection	23
		ESK-08SPR07	Elementary Diagram 125VDC Control Circuit Preferred Station Service XFMR Backup Protection	25

Inspection Procedure	Type	Designation	Description or Title	Revision/ Date
		ESK-08SPR15	Elementary Diagram 125VDC Control Circuit Preferred Station Service XFMR Backup Protection	27
		ESK-08SPR17	Elementary Diagram 125VDC Control Circuit Preferred Station Service XFMR Backup Protection	8
		EE-003ZS	Wiring Diagram Open Phase Detection Panel RTX-XSR1C	0
		EE-003ZT	Wiring Diagram RTX-XSR1D Open Phase Detection Panel	0
		0242.112-027-048	Connection Diagram Power Transformer System 1 and 2 Open Phase Detection RTX-XSR1C	0
		0242.112-027-049	Connection Diagram RTX-XSR1D Power Transformer System 1 & 2 Open Phase Detection	0
		ESK-11SPF01	Elementary Diagram Station Protection Reserve Station Service Line	9
		ESK-11SPF02	Elementary Diagram Station Protection Reserve Station Service Line	8
		ESK-08SPR20	Elementary Diagram 125VDC Control Circuit Dual Channel Transfer Trip ACB 06, 07, 11	7
		ESK-08SPR21	Elementary Diagram 125VDC Control Circuit Dual Channel Transfer Trip ACB 15, 26, 27	7
	Engineering Changes	EC 47357	Design Change to Detect Open Phase Condition on Primary Side of RTX-XSR1C and RTX-XSR1D (BYRON EVENT) IER-L2-12-14, Condition Report CR-RBS-2012-1000, SIPD 2015	0

Inspection Procedure	Type	Designation	Description or Title	Revision/ Date
		EC 47359	RTX-XSR1C, Design Change to Detect Open Phase Condition	0
		EC 47360	RTX-XSR1D, Design Change to Detect Open Phase Condition	0
		EC 56100	ECN to Revise PMTP of 47360	0
	Engineering Reports	RBS-EE-17-00002	RBS Open Phase Detection Monitoring Period Report March 2015 - January 2016	0
		RBS-EE-17-00003	RBS Open Phase Detection Monitoring Period Report January 2015 - July 2017	0
		RBS-EE-18-00001	RBS Open Phase Detection Monitoring Period Report July 2017 - January 2018	00
	Miscellaneous	RBG-47430	Letter from River Bend Station Response to Request for Additional Information Regarding Response to Bulletin 2012-01, "Design Vulnerability In Electric Power System"	January 31, 2014
		RBG-47299	90-Day Response to Bulletin 2012-01, Design Vulnerability in Electric Power System River Bend Station – Unit 1	October 24, 2012
		AR 283793	Preventive Maintenance Change Request: RSS1 Open Phase Detection System Protection Relays and Current Transformers RSS2 Open Phase Detection System Protection Relays and Current Transformers	October 16, 2017

Inspection Procedure	Type	Designation	Description or Title	Revision/ Date
		AR 283795	Preventive Maintenance Change Request: RSS1 and RSS2 Open Phase Detection System	October 16, 2017
	Procedures	AOP-0064	Degraded Grid	010
		OSP-0028	Log Report - Normal Switchgear, Control, and Diesel Generator Buildings	107
		OSP-0028R107CN-E	Procedure Action Request Change Notice for Log Report - Normal Switchgear, Control, and Diesel Generator Buildings	
		OSP-0031	Log Report - Outside Area	093
		OSP-0031	Log Report - Outside Area	064
		ARP-680-09	P680-09 Alarm Response	033
		SOP-0055	Main and Station Transformers (SYS #311)	040
	Vendor Documents	P517-0109	PCS2000 Open Phase Detection System User Manual	0
	Work Orders	00365542	Install PCS2000 Relay on RTX-XSR1C for Open Phase Detection	April 11, 2017
		00365543	Install PCS2000 Relay on RTX-XSR1D for Open Phase Detection	September 15, 2015

Corrective Action Documents (CR-RBS-)		
2015-08755	2017-08510	2018-00893
2017-01281	2018-00360	2012-01000
2017-00493	2018-00396	2017-05750
2017-00501	2018-00495	2018-00892
2017-01217	2018-00857	
2017-02356	2018-00859	
2017-02770	2018-00894	
2017-03493	2018-00891	

Table 1 – Information Gathered for Temporary Instruction 2515/194

A	Open Phase Condition Detection and Alarm Scheme		Describe Observations/Comments
1	Are all credited offsite power sources specified in Updated Safety Analysis Report Chapters 8.1, 8.2, and 8.3 and plant Technical Specifications considered in the design of open phase condition detection and protection schemes?	☒ Yes ☐ No	Updated Safety Analysis Report Section 8.1 states that River Bend Station is provided power from the 230 kV bays of the Fancy Point substation via two physically and electrically independent lines. Each 230 kV line is terminated at a transformer yard. Transformer yard 1 includes preferred station service transformer RTX-XSR1C and yard 2A includes RTX-XSR1D. The Updated Safety Analysis Report section also states that standby 4160 V buses ENS-SWG1A and ENS-SWG1B are connected to preferred station service transformers RTX-XSR1C and RTX-XSR1D, respectively. The transformers in both transformer yards support the normal operation and safe shutdown operation of River Bend Station Drawings 0242.112-027-025 and 0242.112-027-026 show the inputs of the new open phase detection system being connected to the high side of preferred station service transformers RTX-XSR1C and 1D. References: Engineering Change 47357 Updated Safety Analysis Report Section 8.1 and 8.2 Drawings: 0242.112-027-025 and 0242.112-027-026
2	Are open phase condition detection scheme(s) installed to monitor the qualified offsite power paths to the engineered safety feature buses during all modes of operation?	☒ Yes ☐ No	The PCS2000 system overview and user manual states that the system is capable of detecting open phase conditions anywhere on the direct line between the source breaker and the power transformer while in standby mode and drawing excitation current, lightly loaded or fully loaded. This also includes the detection of an open phase and grounded condition, a double open phase and grounded condition, and an open phase with line charging current on the high side of a power transformer. The system has two modes of monitoring the power transformer for an open phase condition: no load excitation current mode and transformer load mode. Internal logic is used to measure the power transformer high side current levels and give alarming/tripping priority to either

			mode based on the power transformer current levels RTX-XSR1C and RTX-XSR1D provide preferred source of power for the engineered safety feature buses from Offsite sources. The licensee stated that Engineering Calculation G13.18.3.6*025 that performed the feasibility analysis at River Bend Station considered various open phase configurations for different station loading scenarios. The audit team did not review the feasibility studies.
3	What is the scope of open phase conditions considered by the licensee? Did the licensee exclude certain open phase conditions (e.g., high voltage or low voltage side of power transformers), operating and loading configurations in their analyses? If so, identify the technical justifications for any exclusion.	☒ Yes ☐ No	The scope of open phase condition scheme considered the high voltage side of the transformers only. Open phase conditions on the low voltage side are not expected to occur. The PCS system is capable of detecting open phase conditions anywhere on the direct line between the source breaker and the power transformer while in standby mode and drawing only excitation current, lightly loaded or fully loaded. This includes the detection of an open phase and grounded condition, a double open phase and grounded condition, and an open phase with line charging current on the high side of a power transformer. Preventive maintenances on switchgears include inspecting the bus for damaged components, loose parts, corrosion, etc. Thermography tests are performed on various safety-related components that include motor control centers, switchgears, transformers, and distribution panels. Safety-Related breakers are inspected and refurbished, motors are inspected and baker tested on a periodic basis through the preventive maintenance process. Apart from various maintenance activities that ensure expected operation, system engineering and operations perform frequent walkdowns to identify any system anomalies. Based on this, the requirement for a separate system that monitors for open phase condition on the plant side is not required.
4	Are the detection schemes capable to identify open phase conditions under all operating electrical system configurations and plant loading conditions?	☒ Yes ☐ No	The licensee indicated that Engineering Calculation G13.18.3.6*025 performed the feasibility analysis at River Bend Station and considered various open phase configurations for different station loading scenarios. Report No. RBS-EE-17-00002, Revision 1 for RTX-XSR1D open phase detection system provides monitoring data between March 2015 and January 2016. The report was revised to add more detail on plant specific events.

			Specifically, the report updated data for events which includes timestamps, sequence components, and calculations to estimate horsepower for each motor start event and load change event. A review of the revised report RBS-EE-17-00001, shows the systems response to motor starts at various estimated loads, different load changes and transformer energization. A review of the report indicates that the detection schemes are capable of identifying open phase conditions under all operating electrical system configurations and plant loading conditions.
5	If the licensee determined that open phase condition detection and alarm scheme was not needed, did the licensee provide adequate calculational bases or test data? Are all open phase conditions detected and alarmed in the main control room with the existing relays?	☒ Yes ☐ No ☒ Yes ☐ No	The licensee has determined that open phase condition detection and alarm scheme is needed at its facility. The alarms from the open phase detection system are tied into common alarms for transformer trouble and annunciated in a panel in the main control room. The alarms signify Preferred Station Service Transformer Trouble.
6	Are the detection and alarm circuits independent of actuation (protection) circuits? If the detection, alarm, and actuation circuits are non-Class 1E, was there any interface with Class 1E systems?	☒ Yes ☐ No ☐ Yes ☒ No	Relay contacts in each relay in the system provide trip/alarm signals which use circuits that are independent of each other. There are no interfaces with Class 1E systems.
7	Did the manufacturer provide any information/data for the capability of installed relays to detect conditions, such as unbalanced voltage and current, negative sequence current, subharmonic current, or other parameters used to detect open phase condition in the offsite power system? What are the analyses and criteria used by the licensee	☒ Yes ☐ No	The open phase detection system uses a combination of parameters to determine an open phase condition. These include specific differences between phase currents relating to magnitudes and phase angles, as well as comparisons of current sequence components. A variety of initial input data is used for each transformer: winding configuration, expected and actual nominal excitation current, mega volt amp and voltage, inrush delay, and time delays for trips. Monitoring data is used to update and adjust input data and typical levels of unbalance. A high-level description of the open phase condition detection circuit requires the

	to identify the power system unbalance due to open phase conditions; and loading and operating configurations considered for all loading conditions which involve plant trip followed by bus transfer condition? If certain conditions cannot be detected, did the licensee document the technical basis for its acceptability? Did the licensee perform functional testing to validate limitations specified by the manufacturer of the relays?	☒ Yes ☐ No ☒ Yes ☐ No	following conditions: 1. The current(s) drops in the phase this is open, drops below a low percentage setpoint of the nominal current. This includes both fundamental and root mean square components. 2. The current in the intact phase(s) stays above a high percentage setpoint of the nominal current. Certain restraint setpoints also need to be met such as the ratio of fundamental to root mean square current, ratios of sequence components, and holding these conditions for the required amount of time. River Bend Station performed calculations that evaluated various loading conditions in conjunction with the transmission system model for various open phase condition configurations. Failure modes and effects analysis was performed and used as an input into Engineering Change 47357 and testing procedures for the engineering change to ensure misoperation are minimized. Functional testing including Factory Acceptance and Site Acceptance testing were performed as part of Engineering Change 47357 prior to commissioning the system.
8	Do open phase condition detection circuit design features minimize spurious detections due to voltage perturbations observed during events which are normally expected in the transmission system? Identify whether the licensee considered alarm/trip settings coordination with other electric power system relays including transmission system protection features setup to avoid false indications or unnecessary alarms.	☒ Yes ☐ No	There are several restraints built into the detection logic to prevent spurious detections from normal transmission disturbances. These restraints with initial setpoints were created from PCS Lab testing, and were updated and expanded based on testing and data collected from installed systems: Entergy engaged an external consulting company (Sargent & Lundy) to develop test cases for the River Bend Station open phase condition detection scheme. The test cases considered different types of disturbances on the transmission system; monitoring data from the River Bend Station systems and from other site's open phase detection systems include multiple transmission faults and disturbances used to validate and tune restraint setpoints. Engineering Calculation G13.18.3.6*025 developed and documented the power system model for the station auxiliaries, and the transmission network near River Bend Station for system analyses using industry-approved software named electro magnetic transient program. The calculation provided inputs for testing a relaying scheme that is able to reliably detect an open

			phase event at the high voltage side of the preferred station service transformers being fed from offsite power circuits without false actuation due to various disturbances (e.g. transformer energization, motor starting, station faults, transmission system disturbances etc.). Alarm Circuits: As documented in Engineering Change 47357, several fuses were installed to provide adequate protection between the PCS2000 cabinets and the transformer control panels. Coordination plots of the fuses with the upstream protective devices are attached with Engineering Change 47357. The final alarm actuation setpoints will be developed after substantial monitoring periods. Trip Circuits: Protective coordination of the trip circuits with offsite and onsite protection system will be evaluated as part of the future engineering change that will be performed to enable trip functionality. Reference Documents: RBS-EE-17-00002, RBS-EE-17-00003, G13.18.3.6*025, and Engineering Change 47357
9	Identify how the alarm features provided in the main control room including setpoints are maintained, calibrated, and controlled.		Alarms from the open phase detection system sent to the main control room are managed in several ways. The monitoring period and data are used to adjust alarm setpoints, troubleshoot issues that arise, and give operating experience on alarms. The system has physical (test) switches that can be used to block specific alarms once they have been acknowledged, such as a device problem or loss of power (this allows the main control room alarm to be cleared and prevents masking of other alarms). The switches can also be used to prevent spurious main control room alarms during troubleshooting or when setpoints are updated (in addition to procedures being developed). The system cabinets are locked and the relays are (non-default) password protected. Setpoint control is also accomplished through as-found/as-left relay settings comparison procedures used in Entergy Transmission. North American Electric Reliability Council standards are utilized to perform preventive maintenance and calibration of relays. The

			relays and other digital components that are part of the open phase detection system were evaluated and are controlled by Entergy critical digital asset procedures.
10	Does the open phase condition detection scheme consider subharmonics in the supply power or offsite power system?	☒ Yes ☐ No	The open phase detection system considers both fundamental and root mean square components of each phase current as well as the ratio between fundamental and root mean square. The open phase detection system also considers instantaneous current magnitudes along with short- and long-term smoothed (averaged) magnitudes. The monitoring period will be used to establish the threshold for 'background' and transient subharmonics, and adjust trip or actuation setpoints above the threshold.
11	Are open phase condition detection and alarm circuit components scoped into the licensee's maintenance rule program?	☐ Yes ☒ No	The Engineering Change required to install the trip functionality is a work in progress. The maintenance rule program applicability/inclusion will be evaluated in the ongoing engineering change that enables the trip functionality. This is consistent with the process and procedures followed by Entergy. Condition Report CR-RBS-2018-00893 was initiated to document this question and ensure that the maintenance rule applicability is evaluated through the engineering change process. The components added through the open phase detection system are scoped into the preventive maintenance program. These action requests initiated preventive maintenances and calibrations for the open phase components. The actual preventive maintenance will be processed through the regular work management schedule. The licensee has currently implemented a modification that installed the open phase detection system in the monitoring and alarm mode. The system currently does not have the trip functionality enabled.
B	Open Phase Condition Protection Scheme	Yes/No	Describe Observations/Comments
1	Record location of the sensing of the protection scheme (e.g., high voltage or low voltage side of the transformer, engineered safety feature bus, etc.).		Location: High voltage side of preferred power station service transformers

2	Record the classification of the protection scheme, safety or non-safety. Did the licensee consider the interface requirements for non-safety with safety-related circuits?	 ☒ Yes ☐ No	Classification: Non-Safety There are no direct interfaces with safety-related systems
3	Record the type of the protection scheme, digital or non-digital. Are cyber security requirements specified for digital detection scheme?	 ☒ Yes ☐ No ☐ N/A	The protection scheme is digital. The open phase detection system utilizes microprocessor relays, computers, satellite synchronized clocks, and annunciators. The components are considered digital. The cyber security evaluation was performed as part of Engineering Change 47357. The components installed by this engineering change are considered Critical Digital Assets. The components installed by the engineering change have software equipped which were evaluated by the engineering change and classified as Level B software.
4	Did the licensee consider any design features to prevent protective functional failures for open phase condition protection system?	☒ Yes ☐ No	The engineering change evaluates the installation of the open phase system that has redundant circuits. To enhance reliability, the two systems communicate by fiber optic interface to exchange information. Separate output contacts are provided in redundant cabinets for the following functions: open phase detection, ground overcurrent detection, mode disagreements, and relay failure. The open phase detection system installed on the transformer follows a one out of two taken twice logic. This ensures that a single failure of a protective relay cannot affect the credited offsite power source.
5	Identify the number of channels provided per offsite power source, and if there is independence between channels and sensors.		Two independent sets of current transformers/sensors are provided per offsite power source. Each sensor provides input to its own set of relays that sense current imbalances. The relays are connected in such a manner that the system requires a one out of two taken twice logic.
6	What is the safety classification of power supply for the protection scheme?		The power supply for the protection scheme is non-safety related. This is consistent with the safety classification of the preferred station transformer and the open phase detection systems.

	Was a loss of power to the protection scheme considered?	☒ Yes ☐ No	The impacts of loss of power supply to the protection scheme have been evaluated in the failure modes and effects analysis performed as part of Engineering Change 47357. The loss of power supply is identified through a relay self-test and a system alarm is provided that would notify operations of a loss of power supply. Moreover, the system relays and other components are supplied by DC power that is fed from a non-safety battery system. Upon loss of charger, the battery is capable of supplying loads for a 2 hour period as credited in the system design. AC power is supplied to the panel's space heaters. Loss of AC power supply is considered in the failure modes and effects analysis.
7	Identify if the licensee considered the consequences of a failure or malfunction of a channel.		The PCS2000 system installed at River Bend Station is built with coincidence logic to add defense-in-depth and reduce spurious actuations. The open phase detection system follows a one out of two taken twice logic. The system has redundant panels that contain two Schweitzer Engineering Laboratories (SEL) 451 relays each, which take inputs from independent current sensors. To enhance reliability, the two panels will communicate by fiber optic interfaces to exchange information. The SEL relays that sense open phase conditions are digital microprocessor relays that have self-monitoring capabilities. A relay failure is detected through a relay self-test. A relay self-test failure is identified by a system alarm. In a one out of two taken twice logic, the failure of one relay does not have the potential to spuriously trip offsite power source. The second relay in the panel and the two relays on the redundant panel are relied upon to detect an open phase condition. The digital relays fail in 'as is' configuration and will not actuate a trip signal. It is unlikely that two out of four relays will fail in an 'actuated mode.' Therefore, failure of a single channel current sensor or the entire channel of an open phase detection system, the coincidence logic at River Bend Station (one out of two taken twice) prevents spurious misoperation/spurious trip of offsite power source.
8	Did the design consider the single failure criteria as	☐ Yes ☒ No	The open phase detection is a non-safety related system and may potentially fail during

	outlined in the general design criteria (GDC) or the principle design criteria specified in the Updated Safety Analysis Report?		postulated accidents or plant shutdown resulting from an external event. In the event of an open phase condition in power source related with one safety division, coupled with a single failure in the opposite (or redundant) train, the safe shutdown capability may be adversely impacted as both trains may not be available to power the safety-related busses. Since failures in non-safety systems are considered to occur when evaluating conformance to the single failure criterion (safety systems), the open phase condition scheme at River Bend Station does not conform to the single failure criteria as outlined in the GDC or the principle design criteria specified in the River Bend Station Updated Safety Analysis Report (i.e., for an open phase condition, a non-Class 1E circuit should not preclude the onsite electrical power system from being able to perform its safety function given a single failure of the onsite power system).
9	Did the licensee identify the industry standards and criteria to verify power quality issues caused by open phase conditions that affect redundant engineered safety feature buses? What industry standards were used to develop the acceptance criteria for open phase condition trip setpoint or analytical limit?	☒ Yes ☐ No	Based on the various loads and generating stations around River Bend Station, the power flow from and to the Fancy Point switchyard does not see much noise. Additionally, Engineering Calculation G13.18.3.6*025 modelled the transmission system near River Bend Station on EMTP and ran various loading scenarios for multiple open phase condition. The monitoring period at River Bend Station will also enable the site to monitor the offsite source for general disturbances and noise. The setpoints will be adjusted accordingly. The trip setpoints will be evaluated with the associated industry standards in a future engineering change that will enable the trip functionality. The licensee is proposing a trip setpoint of less than 5 seconds which will ensure any heating effects from unbalanced voltage conditions do not adversely impact plant motors.
10	What are the analytical limits or criteria used for setpoints of the actuation/protection scheme to provide adequate protection for motors and sensitive equipment?		The actual setpoints for the actuation circuits will be evaluated as part of the future engineering change that will enable the trip functionality. The licensee is proposing a trip setpoint of less than 5 seconds which will ensure any heating effects from unbalanced voltage conditions do not adversely impact plant motors.

11	What are the design features provided to preclude spurious trips of the offsite power source (e.g. coincidence logic)?		The PCS2000 system installed at River Bend Station is built with coincidence logic to add defense-in-depth and reduce spurious actuations. The open phase detection system follows a one out of two taken twice logic. The system has redundant panels that contain two SEL 451 relays each which take inputs from independent current sensors. To enhance reliability, the two panels will communicate by fiber optic interfaces to exchange information. The SEL relays that sense open phase conditions are digital microprocessor relays that have self-monitoring capabilities. A relay failure is detected through a relay self-test. A relay self-test failure is identified by a system alarm. In a one out of two taken twice logic, the failure of one relay does not have the potential to spuriously trip offsite power source. The second relay in the panel and the two relays on the redundant panel are relied upon to detect an open phase condition.
12	What analyses have been performed by the licensee which demonstrates that the open phase conditions do not adversely affect the function(s) of important-to-safety equipment required for safe shutdown during anticipated operational occurrences, design basis events, and accidents? If an analyses was not performed, what justification was provided? Are bus transfer schemes and associated time delays considered?	☒ Yes ☐ No	Engineering Calculation G13.18.3.6*026 was developed to determine the minimum amount of time an open phase event on the high side of the preferred transformer, occurring simultaneously with a loss-of-coolant accident, could persist before damage to or tripping of, medium voltage and low voltage auxiliary power system motors would result. Further analysis including time delays associated with bus transfer schemes will be evaluated by a future engineering change that will be performed to enable the trip functions of the open phase detection system.
13	Are open phase condition protection/actuation circuit components scoped, as appropriate, into the licensee's maintenance rule program?	☐ Yes ☒ No	The Engineering Change required to install the trip functionality is a work in progress. The maintenance rule program applicability/inclusion will be evaluated in the ongoing engineering change that enables the trip functionality. This is consistent with the process and procedures followed by Entergy. Condition Report

			CR-RBS-2018-00893 was initiated to document this question and ensure that the maintenance rule applicability is evaluated through the Engineering Change.
C	Updated Safety Analysis Report Updates to Reflect the Need to Protect Against	No	Describe Observations/Comments
	Open phase conditions: Using items 1 to 6 below as examples, identify whether the licensee has updated the Updated Safety Analysis Report (and supporting documents such as calculations of record, design change modifications, etc.) to ensure plant-specific licensing basis/requirements include discussions of the design features and analyses related to the effects of, and protection for, any open phase condition design vulnerability:		The open phase detection system is currently in monitoring phase and a future engineering will be performed to actuate the trip functionality. All Updated Safety Analysis Report /Licensing basis changes will be evaluated by the future engineering change. Condition Report CR-RBS-2018-00891 was created to track Updated Safety Analysis Report Changes.
1	The plant-specific analysis and documentation that established the resolution of the open phase condition design vulnerability, including the failure mode analysis performed.	N/A	
2	Description of open phase condition automatic detection scheme, including how offsite power system open phase conditions are detected from sensing to alarm devices (loss of one or two phases of the three phases of the offsite power circuit both with and without a high-impedance ground fault condition on the high-voltage side of all credited qualified offsite power sources under all		

	loading and operating configurations; and loss of one or two phases of three phases of switchyard breakers that feed offsite power circuits to transformers without ground).		
3	Detection circuit design features to minimize spurious indications for an operable offsite power source in the range of voltage perturbations, such as switching surges, transformer inrush currents, load or generation variations, and lightning strikes, normally expected in the transmission system.		
4	Alarm features provided in the main control room. Discuss the engineered safety feature bus alignment during normal plant operation and the operating procedures in place to address open phase conditions. If the plant auxiliaries are supplied from the main generator and the offsite power circuit to the engineered safety feature bus is configured as a standby power source, then open phase conditions should be alarmed in the main control room for operators to take corrective action within a reasonable time.		
5	Describe the automatic protection scheme provided for open phase conditions including applicable industry standards used for designing the scheme. Design features to minimize		

	spurious actuations for an operable offsite power source in the range of voltage perturbations, such as switching surges, transformer inrush currents, load or generation variations, and lightning strikes, normally expected in the transmission system should be described.		
6	Brief discussion of the licensee's analyses performed for accident condition concurrent open phase conditions which demonstrate that the actuation scheme will transfer engineered safety feature loads required to mitigate postulated accidents to an alternate source consistent with accident analyses assumptions to ensure that safety functions are preserved, as required by the licensing bases.		
D	Technical specification surveillance requirements and limiting condition for operation for equipment used for open phase condition mitigation		Describe Observations/Comments The open phase detection system is currently in monitoring phase and a future engineering will be performed to actuate the trip functionality. All Updated Safety Analysis Report / licensing basis changes will be evaluated by the future engineering change. Condition Report CR-RBS-2018-00891 was created to track Updated Safety Analysis Report Changes. The final design of the open phase detection scheme will trip the offsite source emanating from the 230 kV switchyard (Fancy Point) upon detecting an open phase condition independent of plant operating mode (start up, normal operation, or accident condition). The loss of one offsite source will require entry into appropriate technical specification related limiting condition for operation. Technical specification related surveillance requirements have not been developed yet.

	Are technical specifications surveillance requirements and limiting condition for operation for equipment used for the mitigation of open phase condition identified and implemented consistent with the operability requirements specified in the plant technical specifications? If the licensee determined that technical specifications are unaffected because open phase condition is being addressed by licensee-controlled programs, is the technical justification adequate?	☐ Yes ☒ No ☐ Yes ☐ No	The open phase detection system is currently in monitoring phase and a future engineering will be performed to actuate the trip functionality. All Updated Safety Analysis Report /Licensing basis changes will be evaluated by the future engineering change. Condition Report CR-RBS-2018-00891 was created to track Updated Safety Analysis Report Changes N/A – see above
E	<u>Provide a brief summary of the open phase condition plant modification performed under 10 CFR 50.59.</u>	Engineering Change 47357 involved the installation of an open phase detection system on the offsite power supply to preferred station service transformers 1RTX-XSR1C and 1RTX-XSR1D. This system will be capable of detecting open phase conditions – including an open-phase and grounded condition, a double open-phase and grounded condition, and an open phase with line charging – anywhere between the Fancy Point substation 230 kV buses and these transformers. The system will also be capable of detecting open phase conditions while the transformers are fully loaded, lightly loaded, or drawing only excitation current. Upon detection of an open phase condition, a control room alarm will be actuated. The initial phase of the activity included data collection and performance monitoring of the new system. The open phase detection system will be modified under a separate activity to trip preferred station service transformers 1RTX-XSR1C or 1RTX-XSR1D – which will result in an automatic start of the safety-related emergency diesel generator to supply the engineered safety feature buses. The scope of Engineering Change 47357 involves the installation of an open phase detection system on the offsite power supply to preferred station service transformers 1RTX-XSR1C and 1RTX-XSR1D, and includes:	

		• New bushing sensors and new neutral current transformers will be installed on the high side of the transformers • New open phase detection cabinets and associated structural components will be installed above the transformer oil containment pits • New cables to connect the new open phase detection equipment to existing plant equipment will be installed; AC power will be supplied from new 480/120V transformers located near the new open phase detection cabinets, and fed from NHS-MCC-18A and NHS-MCC-20A, while DC power will be supplied from battery 1BYS-PNL03B via 1CES-PNL1G and 2CESPNL1F • Upon detection of an open phase condition, the existing transformer alarm circuit will be actuated REFERENCE: River Bend Station Process Applicability Determination Engineering Change 47357

TI 2515/194 Inspection Documentation Request

Please provide the following documentation (Items 1 – 6) to the lead inspector prior to the onsite inspection date, preferably no later than January 22, 2018. Whenever practical, please provide copies electronically (IMS/CERTREC is preferred). Please provide an index of the requested documents which includes a brief description of the document and the numerical heading associated with the request (i.e., where it can be found in the list of documents requested).

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Arlington, TX 76011
817-200-1102
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1. Copies of any calculations, analyses, and/or test reports performed to support the implementation of your open phase condition (OPC) solution. If, in your implementation, OPCs are not detected and alarmed in the control room please include documentation that: a) demonstrates the OPC will not prevent functioning of important-to-safety SSCs; and b) detection of an OPC will occur within a short period of time (e.g., 24 hours).

2. Copies of any modification packages, including 10 CFR 50.59 evaluations if performed, used for or planned for the implementation of your OPC solution.

3. Copies of periodic maintenance, surveillance, setpoint calibration, and/or test procedures implemented or planned, for your OPC solution.

4. Copies of your licensing basis changes to Updated Final Safety Analysis Report (UFSAR) and/or Technical Specifications (TS), as applicable, which discuss the design features and analyses related to the effects of, and protection for, any open phase condition design vulnerability.

5. Copies of any procurement specifications and acceptance testing documents related to the installation of your OPC solution.

6. Copies of any site training the team will need to accomplish to gain access to areas with, or planned, major electrical equipment used in your OPC solution (i.e. switchyard).

Please provide the following documentation to the team when they arrive onsite. Whenever practical, please provide copies electronically, except for drawings. Drawings should be provided as paper copies of sufficient size (ANSI “C” or “D”) such that all details are legible.

7. A brief presentation describing your electric power system design and typical electrical transmission and distribution system alignments; OPC design schemes installed to detect, alarm and actuate; bus transfer schemes; and maintenance and surveillance requirements. This presentation should be a general overview of your system. Please schedule the overview shortly after the entrance meeting.

8. Plant layout and equipment drawings for areas that identify: (a) the physical plant locations of major electrical equipment used in your open phase condition solution; (b) the locations of detection and indication equipment used in the open phase condition sensing circuits.

9. If OPC actuation circuits are required, provide documentation that demonstrates continued coordination with the other protective devices in both the offsite electrical system (within River Bend Station area of responsibility) and the onsite electrical systems.

10. Access to locations in which open phase condition equipment is installed or planned (i.e. switchyard, transformer yard, etc.)

11. Copies of documentation or testing that demonstrates your OPC solution minimizes spurious actuation or misoperation in the range of voltage imbalance normally expected in the transmission system that could cause undesired separation from an operable off-site power source.

RIVER BEND STATION – NRC INSPECTION OF TEMPORARY INSTRUCTION 2515/194, INSPECTION OF THE LICENSEE'S IMPLEMENTATION OF INDUSTRY INITIATIVE ASSOCIATED WITH THE OPEN PHASE CONDITION DESIGN VULNERABILITIES IN ELECTRIC POWER SYSTEMS (NRC BULLETIN 2012-01) – INSPECTION REPORT 05000458/2018010 – MARCH 26, 2018

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