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U7-C-NINA-NRC-140017

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
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Rockville, MD 20852-2738

South Texas Project
Units 3 and 4
Docket No. 52-012 and 52-013
Response to Request for Additional Information

References:

1. Letter, Michael Eudy to Scott Head, "Request for Additional Information Letter No. 419 Related to SRP Section 8.2 for Nuclear Innovation North America, LLC (NINA) Combined License Application", November 5, 2012 (ML12307A265)

2. Letter, David Misenhimer to Scott Head, "Request for Additional Information Letter No. 438 Related to SRP Section 8.2 for Nuclear Innovation North America, LLC (NINA) Combined License Application," November 21, 2013 (ML13325A905)

Attached are the Nuclear Innovation North America, LLC (NINA) revised responses to the NRC staff questions in the references. The attachment to this letter contains the responses to the following RAI questions:

RAI 08.02-25
RAI 08.02-26

The revised responses to the RAI questions supersede all previous responses to these RAI questions in their entirety.

The COLA changes documented in this submittal will be implemented in the next routine revision of the COLA.

There are no commitments in this letter.

D091
NRO

STI 33856851

If you have any questions, please contact Scott Head at (979) 316-3011, or Bill Mookhoek at (979) 316-3014.

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

Executed on 6/25/14

Scott Head
Manager, Regulatory Affairs
NINA STP Units 3 & 4

Attachment:

RAI 08.02-25 and 08.02-26

cc: w/o attachment except*
(paper copy)

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RAI 08.02-25:

QUESTION:

On July 27, 2012, the NRC issued Bulletin 2012-01, "Design Vulnerability in Electric Power System," (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12074A115) to all holders of operating licenses and combined licenses for nuclear power reactors requesting information about the facilities' electric power system designs, in light of the recent operating experience that involved the loss of one of the three phases of the offsite power circuit (single-phase open circuit condition) at Byron Station, Unit 2 to verify compliance with applicable regulations and to determine if further regulatory action is warranted.

In order to verify the applicants of new reactors have addressed the design vulnerability identified at Byron in accordance with the requirements specified in General Design Criterion (GDC) 17,"Electric Power Systems," in Appendix A, "General Design Criteria for Nuclear Power Plants," and the design criteria for protection systems under 10 CFR 50.55a(h)(3), please provide the following information:

- Describe the protection scheme design for important to safety busses (non-safety or safety related) to detect and automatically respond to a single-phase open circuit condition or high impedance ground fault condition on credited offsite power circuits.
- If the important to safety busses are not powered by offsite power sources during at power condition, explain how the surveillance tests are performed to verify that a single-phase open circuit condition or high impedance ground fault condition on an off-site power circuit is detected.
- Describe the plant operating procedures, including off-normal operating procedures, that specifically call for verification of the voltages on all three phases of the Class 1E Safety busses.

RAI 08.02-26:

QUESTION:

In the revised response to Request for Additional Information 08.02-25 dated September 4, 2013, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13256A154), Nuclear Innovation North America, LLC (NINA), the applicant, discussed its response to NRC issued Bulletin 2012-01, "Design Vulnerability in Electric Power System," (ADAMS Accession No. ML12074A115) on the electric power system design, and recent operating experience that involved the loss of one of the three phases of the offsite power circuit (single-phase open circuit condition) at Byron Station.

1) The applicant states that in the scenario where a single-phase open circuit event on the grid side of the Main Transformer (MT), the feed from the MT and each of the associated UATs does not affect the safety-related or non-safety related loads since:

- The wye-delta configuration of the MT regenerates the lost phase (open-circuited phase), and
- The MT can carry the increased load on the remaining two phases because the MVA capacity of the MT is large relative to the combined safety-related and non-safety related loads on the UATs.

Based on the statements above, address the following:

a. Unbalanced operation is among the potential hazards to motor loads that result from abnormal conditions such as a system-induced loss of phase. The current produces flux in the motor air-gap rotating in the opposite direction to the actual motor direction which is essentially a double-frequency current in the rotor. The skin effect results in higher resistance which compounds with the already increased total current (resulting from both the positive and negative-sequence current components) creating a heating effect. In the case of a loss of phase where the lost phase is induced in the secondary side of the transformer, increasing currents will be observed on the secondary upstream of the loads:

   i. Provide an analysis that shows that none of the safety-related or non-safety related loads will exceed their current ratings that would cause physical damage to motor windings, and other inductive elements.

   ii. Clarify how the phase angle change, as well as the presence of negative sequence currents, will be detected to preclude damage on inductive loads.

   iii. Provide your evaluation and analysis to show that sensitive instrumentation and control and protection circuits that are dependent on ac power quality are not adversely impacted by an unbalanced power system.

   iv. Provide supporting documentation from equipment vendors validating the capability of their equipment to function with current and voltage variations addressed in the above questions.

2) If the secondary side of the MT is regenerating the lost phase, there will be no change in voltage magnitude that would actuate the degraded voltage relays. However, there will be a change in the phase angle and the current on the secondary side of the transformer.

   a. Provide a means of detecting a loss of phase given the assumptions stated above since the degraded voltage relays will be incapable of detecting the loss of phase as a function of phase angle.

   b. Provide an ITAAC that demonstrates by testing that the selected means of protection will actuate and withstand the higher currents during the loss of phase condition.

   c. Provide a Technical Specifications (TS) Surveillance Requirements (SRs) that will provide assurance that the protective measures for a loss of phase condition are reliable and functional and able to preclude damage to safety related equipment.

d. Provide details on any tests that will be performed on the plant electrical system to validate the analytical results for a loss of phase on high voltage side of transformers and successful operation of worst case plant loading for an extended duration without adverse effects.

3) If no plant design changes are planned to automatically detect and isolate the open phase condition (degraded offsite power sources) and transfer the important to safety buses to alternate power source(s), provide the applicant and/or the grid operator's evaluation to show that availability and reliability of offsite power system (capacity and capability) is maintained in accordance with transmission system protocols and in accordance with 10 CFR 50 Appendix A, GDC 17 requirements.

4) The applicant states the following in the RAI response:

This response provides the results of analyses of the design that is provided in COLA revision 9, and does not propose or rely upon any design features that are not included in COLA revision 9. The protection scheme for the onsite power system is described primarily in DCD Section 8.3, and is not changed significantly by the limited departures related to electric power system...

Loss of a single phase on a Class 1E bus is specifically addressed in the certified ABWR design. As a result of loss of a single phase, the undervoltage protective circuitry will separate the Class 1E Safety buses from a connected failed offsite source due to loss of voltage or sustained degraded grid voltage with or without concurrent design basis accidents...

Based on the above, the loss of voltage and degraded voltage relay schemes on each of the Class 1E Safety buses detect and respond to the postulated loss of phase scenarios on a Class 1E Safety bus that could prevent the Class 1E bus from performing its required safety function. The loss of voltage and degraded voltage functions start the EDGs, disconnect the affected Class 1E bus from the degraded offsite source and connect the EDG to the affected Class 1E bus...

For a single-phase open circuit event on the grid side of the MT, the feed from the MT and each of the associated UATs does not affect the safety-related or non-safety related loads since the wye-delta configuration of the MT regenerates the lost phase (open-circuited phase). Also, the MT can carry the increased load on the remaining two phases because the MVA capacity of the MT is large relative to the combined safety-related and non-safety related loads on the UATs...

For a single-phase open circuit event on the grid side of a RAT, the feeds from the RATs are affected because of the wye-wye configuration of the RATs...The loss of a single phase on the high side of the transformer will drop voltage low enough for the degraded undervoltage relays to detect and trip the feed...

If a ground fault were located on the high side of the UATs or RATs, the ground fault would be expected to either burn off and clear or rapidly propagate to a ground fault that would actuate the protective relaying and disconnect the transformer from offsite power. This would result in a Loss of Preferred Power (LOPP) for the affected Class 1E Safety bus(es) which would then automatically realign to the EDG(s)...

Licensing Strategy: As described in this response, NINA has demonstrated that loss of a single phase in an offsite circuit either has no effect on STP 3 & 4 Class 1E electrical bus safety functions or will be detected by existing Technical Specification undervoltage and/or degraded voltage functions which will disconnect the affected offsite circuit and power affected Class 1E buses from an EDG. This conclusion will be confirmed for the 'as-built' plant by the ITAAC proposed below... To ensure that the 'as-built' design of the STP 3 & 4 Electrical Power Distributions (EPD) System is appropriately protected for a lost phase, with or without a ground fault, on credited offsite power circuits supplying the MT and RATs, NINA will revise COLA, Part 9, Section 3.0, Site-specific ITAAC

Based on the above statements the staff notes the following:

a. The design features described in COLA revision 9, DCD Section 8.3, is for addressing loss of voltage and degraded voltage conditions for a balanced 3-phase offsite power system.

b. The certified ABWR design mentioned in the above documents is referring to a loss of a single phase at the 4.16 kV bus level and not the loss of a single phase condition with and without a high impedance ground condition, on the high voltage side of a transformer connecting a credited GDC-17 offsite power circuit to the transmission system.

c. A single-phase open phase event on the grid side of a RAT cannot be detected for all operating configurations and design basis loading conditions by the existing degraded voltage protection scheme because the voltage response is dependent on transformer loading conditions. Refer to the various Bulletin responses provided to the NRC by the operating fleets.

d. As stated earlier, the existing scheme (loss of voltage instrumentation) does not automatically detect the open phase condition (Unbalanced AC power system condition) and therefore cannot take protective actions to enable proper functioning of important-to-safety structures, systems and components. The design vulnerability needs to be addressed to meet the ABWR certified design requirements specified in 10 CFR Part 52, Appendix A.

Therefore, the applicant is requested to provide sufficient analyses in the final safety analysis report (Sections 8.2 and 8.3 of Chapter 8) and ITAAC information (COLA, Part 9, Section 3.0, Site-Specific ITAAC) offsite power system) in accordance with § 52.79, "Contents of applications; technical information," and § 52.80, "Contents of applications; additional technical information," and 10 CFR 50.55a(h)(3) for the staff to determine whether the NINA COLA meets the requirements of 10 CFR Part 50, Appendix A, GDC 17 "Electric power systems," regarding the offsite power circuit and onsite electrical power distribution system to provide adequate capacity and capability in view of the design vulnerability identified in NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System." The information should include, as a minimum, design and analyses and ITAAC information to automatically detect and take protective actions for a single phase open phase condition with and without a high impedance ground condition, on the high voltage side of a transformer connecting credited GDC-17 offsite power circuits to the transmission system (high voltage side MTs and RATs).

5) In the RAI revised response the applicant states that it will evaluate Nuclear Strategic Issues Advisory Committee (NSIAC) initiatives to ensure that STP 3 & 4 design and procedures remain consistent with industry accepted practices. The staff requests the applicant to provide a license

condition to reflect this statement and also the proposed changes to the plant TS in terms of limiting conditions of operation and SRs.

6) Based on the Forsmark Operating Experience, address Questions 1 thru 5 for a loss of two phases condition with and without a high impedance ground condition on the high voltage side of a transformer connecting a credited GDC 17 offsite power circuits to the transmission high voltage side MTs and RATs.

REVISED RESPONSE TO RAI 08.02-25 and 08.02-26:

This response completely supersedes all previous responses to RAI 08.02-25 and RAI 08.02-26 and provides our comprehensive approach to resolving the open phase condition issue identified in NRC Bulletin 2012-01. Changes are being made as a result of two NRC audits conducted on June 2nd and 3rd and June 17th and 18th of this year. Changes from the previous response on May 16, 2014 are indicated by revision bars. COLA changes are indicated by gray shading.

This response is organized as follows:

- STP 3&4 Electrical Distribution System
- Overview of Open Phase Protection Approach
- Negative Sequence Voltage Protection
- Simulation of Open Phase Scenarios
- Final Safety Analysis Report Markup
- Technical Specification Markup
- Inspections, Tests, Analyses, and Acceptance Criteria Markup
- Probabilistic Risk Assessment
- Response to each question in RAI 08.02-25
- Response to each question in RAI 08.02-26

Detailed markups are provided for the Final Safety Analysis Report (FSAR), the Technical Specifications, and Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC).

STP 3&4 ELECTRICAL DISTRIBUTION SYSTEM

The STP 3&4 onsite and offsite electrical power system is shown in Figure 1. The electrical design includes three separate offsite power supplies for each unit. The three offsite power supplies are connected to the onsite power distribution system via three transformers - a Main Power Transformer (MPT) and two Reserve Auxiliary Transformers, RAT-A and RAT-B. During power operation the main generator output is sent to the offsite grid via the MPT and a portion of the output supplies three unit auxiliary transformers (UATs) which in turn supply two Class 1E 4.16 kV busses. Since each unit has a main generator circuit breaker, on a main generator trip, the UATs and the two Class 1E 4.16 kV busses are automatically back fed from the offsite grid via the MPT. The third Class 1E 4.16 kV bus is normally supplied by RAT-B. RAT-A is connected to the offsite grid in a standby mode and can be readily aligned from the Main Control Room to supply all three of the Class 1E 4.16 kV busses. The STP 3&4 electrical distribution system does not utilize any automatic bus transfer schemes.

The STP 3&4 Technical Specifications require two qualified offsite circuits between the offsite transmission network and the onsite Class 1E Distribution System to be operable at all times, with one of the two sources required to be the MPT. Each offsite circuit consists of all breakers, transformers, switches, interrupting devices, cabling, controls, and control power supplies required to transmit power to the onsite Class 1E 4.16 kV busses.

Each of the Class 1E 4.16 kV busses has its own Emergency Diesel Generator (EDG). In addition, the STP 3&4 design also includes a Combustion Turbine Generator (CTG) that can supply any two of the three Class 1E 4.16 kV busses. The combination of three offsite power sources, three dedicated EDGs, and a CTG provide a very robust electrical distribution system. For example, with the generator shut down and the MPT unavailable, standby transformer RAT-A can be aligned from the control room to power the two Class 1E 4.16 kV busses normally supplied by the MPT. Similarly, if RAT-B is unavailable, RAT-A can be aligned to provide the power for the third Class 1E 4.16 kV bus. These re-alignments are relatively simple to perform and can be done from the Main Control Room in a matter of minutes. In the STP 3&4 design, all three sources of offsite power, all three diesels, and the CTG would have to fail before a unit would lose the ability to power at least one of the Class 1E 4.16 kV busses.

OVERVIEW OF OPEN PHASE PROTECTION APPROACH

In order to address the issues in these RAIs in a timely manner consistent with the current licensing schedule for STP 3&4, Nuclear Innovation North America (NINA) proposes the following:

(1) Detection of open phase conditions on the high-voltage side of the MPT and of both RATs with an associated alarm in the Main Control Room

(2) Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) that will confirm the open phase detection and alarm functions work properly prior to initial unit operation,

(3) Monitoring of the three Class 1E 4.16 kV busses for negative sequence voltage and automatic isolation of the bus from offsite power if a setpoint and time delay are exceeded. This isolation will result in an automatic transfer to the EDG on undervoltage (UV).

(4) Inclusion of the Class 1E 4.16 kV negative sequence voltage monitoring and protection system instrumentation in Technical Specification 3.3.1.4,

(5) Revision of FSAR Sections 8.2, 8.3, and 16.3 to describe these features.

The detection and Main Control Room alarm for an open phase on the high voltage side of the MPT and RATs will be accompanied by plant procedures and training to guide the operator response to an open phase condition.

This approach addresses the potential safety issues raised by Bulletin 2012-01 and the RAIs by assuring that an open phase condition will be detected and corrected promptly, and also by providing Class 1E instrumentation, controlled by the Technical Specifications, to protect the Class 1E 4.16 kV busses and their associated safety-related loads.

NEGATIVE SEQUENCE VOLTAGE PROTECTION

Class 1E negative sequence voltage relays on the Class 1E 4.16kV busses will be used to protect safety related motor loads from heat damage due to voltage imbalance and the resulting negative sequence currents. These Class 1E relays will monitor for negative sequence voltage and initiate actions that will transfer the affected bus to an EDG if necessary.

Each negative sequence voltage relay compares all three phase voltages as a vector summation to determine the negative sequence voltage. If the setpoint and time delay are exceeded, a signal is generated to open the supply circuit breakers from the Unit Auxiliary Transformers (UAT), Reserve Auxiliary Transformers (RAT), and Combustion Turbine Generator (CTG) to the affected Class 1E 4.16 kV bus. When the circuit breakers are opened, the affected bus will lose power and automatically transfer to the EDG on undervoltage. A total of three devices are used to perform this function for each Class 1E 4.16 kV bus. The devices are configured in a two-out-of-three logic to prevent spurious trips and allow operation if a single relay fails.

The negative sequence voltage level at which the relays actuate is selected such that all motors or loads on the Class 1E 4.16 kV busses can withstand operation at or below this level on a continuous basis without damage or a significant loss of motor life. The negative sequence voltage relay setting is designed so that normal disturbances on the busses do not create nuisance trips during short duration transient conditions resulting from normal system operations. The relays that will be used on STP 3&4 will have a negative sequence voltage setpoint of 4.5%.

The relays will actuate after the setpoint is exceeded for 2.5 seconds. The time delay is selected to be short enough to ensure that motors do not trip on overcurrent should a running motor stall or if one tries to start and long enough to prevent inadvertent actuations due to normal bus disturbances. If the negative sequence voltage remains above the setpoint on 2 out of 3 sensors for 2.5 seconds, actuation occurs.

The calculation to determine the negative sequence voltage relay setpoint and time delay is performed in Reference 1.

SIMULATION OF OPEN PHASE SCENARIOS

In order to ensure that the proposed approach using negative sequence voltage relays on the Class 1E 4.16 kV busses provides the necessary protection for an open phase condition, a series of computer simulations were performed to demonstrate how the STP 3&4 electrical system would respond and to determine the expected safety bus trips, alarms and operator actions. These simulations were performed using the Electrical Transient Analysis Program (ETAP) Version 12.5.

A wide range of simulations were performed for various open phase scenarios. These analyses are documented in detail in Reference 2. The following scenarios were studied:

- Open phase on the high side of the Main Power Transformer (MPT), Reserve Auxiliary Transformer RAT-A, or Reserve Auxiliary Transformer RAT-B
- Open phase with the Main Generator online and offline
- Open phase with heavily and lightly loaded Class 1E 4.16 kV busses

A summary description of some of the key scenarios from Reference 2, including the operator response and the results of the ETAP calculated voltages, is provided below.

Generator On-line – Power Operation

Open Phase on MPT

When the plant is at power, the main generator normally supplies two of the Class 1E 4.16 kV busses (Divisions I and II) via the unit auxiliary transformers, and RAT-B supplies the third Class 1E bus (Division III) from the offsite grid. RAT-A is connected to the offsite grid but is unloaded in a standby mode. In this configuration, the MPT is transmitting power to the offsite grid. When an open phase occurs on the high side of the MPT, the Division I and II busses supplied by the main generator will experience a negative sequence voltage greater than 4.5%. The negative sequence relay actuation will initiate action that will result in a transfer of the busses to their respective EDG. The Class 1E 4.16 kV bus being supplied by RAT-B will experience a small negative sequence voltage because the generator is trying to transmit the power through two phases. This negative sequence voltage will be less than the setpoint, and the bus will continue to be powered from its offsite source. All three busses remain powered by an offsite circuit or an EDG throughout the event.

Two cases were analyzed using ETAP, one case for lightly loaded Class 1E 4.16 kV busses and one for heavily loaded busses. In this context, a heavily loaded bus is greater than 5 MW (typical of accident loads) and a lightly loaded bus is less than 0.5 MW. In performing these simulations, the open phase is always simulated on Phase A. Note that in the following tables V_{AB} is the phase-to-phase voltage between phases A and B, which is the voltage seen by the relay. It should also be noted that prior to the open phase, the negative sequence voltage for each bus is 0% and divisional phase-to-phase voltages for all three divisions are 100.00%. The negative sequence voltage is the vector summation of the phase-to-phase voltages V_{AB}, V_{BC}, and V_{CA}. In both simulation cases, the Division I and II busses actuate on negative sequence voltage. The negative sequence voltages are greater than 7.5% compared to the relay setpoint of 4.5%. The negative sequence voltage is greater than 4.5% for several minutes until the main generator trips. The Division III bus does not actuate, with a maximum negative sequence voltage of 2.0%. The UV relays do not actuate in these scenarios until the negative sequence relay actuates and opens the bus feeder breaker.

The automatic actions, operator actions and the ETAP results are shown in the following tables.

Generator On-line – Power Operation **Open Phase on MPT**
Automatic Actions
Open phase on the high voltage side of the MPT (Phase A)
Open phase alarms in Main Control Room
Division I and II Class 1E 4.16 kV busses experience a negative sequence voltage > 4.5%
After a 2.5 second time delay, the negative sequence relay opens the feeder breakers to the Division I and II 4.16 kV busses
Division I and II busses reach undervoltage (UV) setpoint
After a 3 second time delay, EDGs on Division I and II start
When EDGs reach full speed, the Loss Of Off-site Power (LOOP) sequencer connects the appropriate Division I and II loads onto their EDG
Operator Actions
Based on the open phase alarm, operators start to implement their response procedure
Once the open phase alarm is confirmed, the operators enter TS 3.8, Electrical Power Systems
The procedure guides operators to transfer the Class 1E 4.16 kV busses to an unaffected source of offsite power
Once the transfer is successful, the EDGs are secured and TS 3.8 Limiting Condition for Operation (LCO) is exited
Troubleshooting and maintenance take place on the MPT open phase

Generator On-line – Power Operation Open Phase on MPT		
Case	1	2
Loading of 4.16 kV busses affected by open phase	Light	Heavy
Div 1 Negative Sequence Voltage [%]	8.7	7.7
Div 1 Bus V_{AB} [%]	99.2	99.3
Div 1 Bus V_{BC} [%]	113.0	111.7
Div 1 Bus V_{CA} [%]	101.8	101.9
Div 2 Negative Sequence Voltage [%]	9.4	7.8
Div 2 Bus V_{AB} [%]	98.5	99.5
Div 2 Bus V_{BC} [%]	113.5	112.1
Div 2 Bus V_{CA} [%]	101.3	102.1
Div 3 Negative Sequence Voltage [%]	2.0	2.0
Div 3 Bus V_{AB} [%]	98.5	98.5
Div 3 Bus V_{BC} [%]	100.5	100.5
Div 3 Bus V_{CA} [%]	102.0	102.0

Generator Online – Power Operation

Open Phase on RAT-A or RAT-B

If an open phase condition occurs on RAT-B (normal plant lineup) while the plant is at power, the negative sequence relay on Division III would actuate and initiate actions that will result in a transfer of the Division III bus to the EDG. There is no significant impact on Divisions I and II which will continue to be supplied by the main generator.

If the open phase occurs on the high side of RAT-A, there is no immediate impact because this transformer is not normally aligned to supply any of the Class 1E 4.16 kV busses and is unloaded. However, the open phase detection system on RAT-A would detect and alarm in the Main Control Room and operators would dispatch maintenance to address this inoperable offsite power supply. Since there are two operable offsite sources, there would be no actions required by the Technical Specifications.

If RAT-A is aligned to the Division III Class 1E 4.16 kV bus and experiences an open phase, the response results would be identical to the system response described for RAT-B above.

The automatic actions, operator actions and the ETAP results are shown in the following tables for an open phase on RAT-B. The results are provided for a heavily and lightly loaded Division III Class 1E 4.16 kV bus.

Generator Online – Power Operation Open Phase on RAT-B
Automatic Actions
Open phase on the high voltage side of the RAT-B (Phase A)
Open phase alarms in Main Control Room
Division III Class 1E 4.16 kV bus experiences a negative sequence voltage > 4.5%
After a 2.5 second time delay, the feeder breaker to the Division III bus is opened
Division III bus reaches UV setpoint
After a 3 second time delay, EDG on Division III starts
When the EDG reaches full speed, the Loss Of Off-site Power (LOOP) sequencer connects the appropriate loads to the EDG
Operator Actions
Based on the open phase alarm, operators start to implement their response procedure
Once the open phase alarm is confirmed, the operators enter TS 3.8, Electrical Power Systems
Procedure guides operators to transfer the offsite power source to RAT-A
Once transfer is successful, the EDG is secured and TS 3.8 LCO is exited
Troubleshooting and maintenance take place on the RAT-B open phase

Generator On-line – Power Operation Open Phase on RAT-B		
Case	3	4
Loading of 4.16 kV bus affected by open phase	Light	Heavy
Div 1 Negative Sequence Voltage [%]	0.0	0.0
Div 1 Bus V_{AB} [%]	100.1	100.1
Div 1 Bus V_{BC} [%]	100.1	100.1
Div 1 Bus V_{CA} [%]	100.1	100.1
Div 2 Negative Sequence Voltage [%]	0.0	0.0
Div 2 Bus V_{AB} [%]	100.4	100.4
Div 2 Bus V_{BC} [%]	100.4	100.4
Div 2 Bus V_{CA} [%]	100.4	100.4
Div 3 Negative Sequence Voltage [%]	28.0	17.3
Div 3 Bus V_{AB} [%]	57.5	66.6
Div 3 Bus V_{BC} [%]	100.0	95.9
Div 3 Bus V_{CA} [%]	69.3	90.4

Generator Offline, Backfeeding via MPT

Open Phase on MPT

When the main generator is offline, the Division I and II Class 1E 4.16 kV busses are back fed from the offsite grid via the MPT and UATs. If an open phase condition occurs on the high voltage side of the MPT, the two busses fed by this transformer would experience negative sequence voltages, but they would be less than the setpoint. For example, the maximum negative sequence voltage would be 2.2%, compared to a setpoint of 4.5%. The phase-to-phase voltages would remain between 94% and 101%. The Division III Class 1E 4.16 kV bus supplied by RAT-B would experience a very small negative sequence voltage (<0.1%). None of the three busses would transfer to their EDG because the negative sequence voltage on the busses is less than the setpoint of the negative sequence voltage relay. After receiving the Main Control Room alarm due to the open phase on the MPT, the operators would transfer the offsite power supply for Division I and II Class 1E 4.16 kV busses to another source of offsite power, RAT-A, and the appropriate TS would be applied. The actions necessary to perform this transfer can all be performed from the Main Control Room.

The results of the simulations for an open phase on the MPT with the plant shutdown are provided for a heavily and lightly loaded Division I and II Class 1E 4.16 kV busses. The automatic actions, operator actions and the ETAP results are shown in the following tables.

Generator Offline – Backfeeding via MPT Open Phase on MPT
Automatic Actions
Open phase on the high voltage side of the MPT
Open phase alarms in Main Control Room
Operator Actions
Based on the open phase alarm, operators start to implement their response procedure
Once the open phase alarm is confirmed, the operators enter TS 3.8, Electrical Power Systems
Division I and II Class 1E 4.16 kV busses are transferred from the MPT to RAT-A and TS 3.8 LCO is exited
Troubleshooting and maintenance take place on the MPT open phase

Generator Offline – Backfeeding via MPT Open Phase on MPT		
Case	5	6
Loading of 4.16 kV busses affected by open phase	Heavy	Light
Div 1 Negative Sequence Voltage [%]	2.1	0.7
Div 1 Bus V_{AB} [%]	97.9	99.8
Div 1 Bus V_{BC} [%]	95.0	99.1
Div 1 Bus V_{CA} [%]	98.5	100.2
Div 2 Negative Sequence Voltage [%]	2.2	0.7
Div 2 Bus V_{AB} [%]	97.7	99.8
Div 2 Bus V_{BC} [%]	94.7	99.1
Div 2 Bus V_{CA} [%]	98.2	100.3
Div 3 Negative Sequence Voltage [%]	0.0	0.0
Div 3 Bus V_{AB} [%]	100.4	100.3
Div 3 Bus V_{BC} [%]	100.3	100.3
Div 3 Bus V_{CA} [%]	100.3	100.3

Generator Offline, Backfeeding via MPT

Open Phase on RAT-A or RAT-B

In these cases, the open phase occurs on either RAT-B or RAT-A when the transformer is supplying the Class 1E 4.16 kV bus associated with Division III. Scenarios with lightly and heavily loaded busses are analyzed. The Division I and II Class 1E busses supplied from the MPT are not significantly affected, with negative sequence voltages < 0.1% and voltages between 99% and 100%. The Division III Class 1E bus supplied by RAT-A or RAT-B will actuate on negative sequence voltage resulting in a transfer to the EDG. The open phase on RAT-A or RAT-B would alarm in the Main Control Room and the operator would switch to the transformer without the open phase. After transferring to an offsite source without an open phase, the EDG would then be secured.

Simulations are performed where the Class 1E 4.16 kV bus being supplied by the transformer with the open phase is lightly or heavily loaded. The automatic actions, operator actions and the ETAP results are shown in the following tables.

Generator Offline – Backfeeding via MPT **Open Phase on RAT-A or RAT-B**
Automatic Actions
Open Phase on the high voltage side of RAT-A or RAT-B (Phase A)
Open Phase alarms in Main Control Room
Division III Class 1E 4.16 kV bus experiences a negative sequence voltage > 4.5%
After 2.5 second time delay, the feeder breaker to the Division III bus is opened
Division III bus reaches UV setpoint
After a 3 second time delay, EDG on Division III starts
When the EDG reaches full speed, the Loss Of Off-site Power (LOOP) sequencer connects the appropriate loads to the EDG
Operator Actions
Based on the open phase alarm, operators start to implement their response procedure
When the open phase alarm is confirmed, the operators enter TS 3.8, Electrical Power Systems
The procedure guides operators to transfer the offsite power source to an unaffected source of offsite power
Once transfer is successful, the EDG is secured and TS 3.8 LCO is exited
Troubleshooting and maintenance take place on the transformer with the open phase

Generator Offline – Backfeeding via MPT Open Phase on RATs				
Case	7	8	9	10
Transformer with open phase	RAT-A	RAT-A	RAT-B	RAT-B
Loading of 4.16 kV bus affected by open phase	Heavy	Light	Heavy	Light
Div 1 Negative Sequence Voltage [%]	0.0	0.0	0.0	0.0
Div 1 Bus V_{AB} [%]	99.6	99.6	99.3	99.3
Div 1 Bus V_{BC} [%]	99.6	99.6	99.3	99.3
Div 1 Bus V_{CA} [%]	99.6	99.6	99.3	99.3
Div 2 Negative Sequence Voltage [%]	0.0	0.0	0.0	0.0
Div 2 Bus V_{AB} [%]	99.3	99.3	99.5	99.5
Div 2 Bus V_{BC} [%]	99.3	99.3	99.5	99.5
Div 2 Bus V_{CA} [%]	99.3	99.3	99.5	99.5
Div 3 Negative Sequence Voltage [%]	17.2	26.9	17.3	28.0
Div 3 Bus V_{AB} [%]	66.9	58.2	66.6	57.5
Div 3 Bus V_{BC} [%]	96.0	100.0	95.9	100.0
Div 3 Bus V_{CA} [%]	90.7	71.2	90.3	69.3

Summary of ETAP Simulations

For at-power scenarios with the generator on-line, an open phase on the high side of the MPT or a RAT that is feeding a Class 1E 4.16 kV bus (es) will result in an actuation of the negative sequence voltage relays on the bus that is being fed and a transfer of the bus or busses to the EDG.

For scenarios where the generator is offline and back feeding from offsite via the MPT, an open phase on the high side of the MPT will not result in an actuation because the negative sequence voltages on all three Class 1E 4.16 kV busses remain less than the setpoint. If the open phase occurs on RAT-A or RAT-B while feeding a Class 1E 4.16 kV bus, actuation will occur on the Class 1E 4.16 kV bus. The Class 1E 4.16 kV busses fed by the MPT are not significantly affected.

There are no scenarios that rely on operator action to protect the Class 1E 4.16 kV busses from adverse negative sequence voltages. The operators will follow their procedures to address the open phase alarm and ensure that an OPERABLE offsite power supply is restored in a timely manner. The ETAP simulations demonstrate that the negative sequence voltage relays will provide protection for the Class 1E 4.16 kV busses and ensure their availability in all plant modes.

FINAL SAFETY ANALYSIS REPORT MARKUP

Markups are provided to Sections 8.2, Offsite Power Systems, and Section 8.3, Onsite Power System. These markups describe the open phase detection and alarm system on the high voltage side of the MPT and RATs and the negative sequence relay protection on the Class 1E 4.16 kV busses. A markup of Section 16.3 is also provided to reflect the addition of the Technical Specification for the negative sequence voltage relays. The Technical Specification for these relays was modeled after the undervoltage and degraded voltage relay technical specifications.

Section 8.2 describes the monitoring of all three phases of the MPT and both RATs for open phases using the specific transformer protective relay. When an open phase is detected in one or more phases of a MPT or RAT, the relay will generate an alarm in the Main Control Room.

Section 8.3 describes the negative sequence voltage relay protection on each of the Class 1E 4.16 kV busses. These negative sequence voltage relays ensure that the motors on the 1E busses are not subjected to unbalanced currents and voltages. Each Class 1E 4.16kV bus has three (3) negative sequence voltage relays configured such that a two-out-of-three trip state will initiate circuitry that will result in the transfer of power from the offsite power supply to the EDG after a time delay. Each negative sequence relay monitors all three bus phases using the bus instrument potential transformers.

TECHNICAL SPECIFICATION MARKUP

The revised Technical Specifications (TS) are provided as a markup to FSAR Section 16.3. The negative sequence voltage relays are added as a new item (f) to TS 3.3.1.4, ESF Actuation Instrumentation. The format for the added TS is based on the TS for the UV relays. In the next routine revision of the COLA, a clean version of the Technical Specifications will be provided in COLA Part 4. Note that the TS refer to the Class 1E 4.16 kV busses as the 4.16 kV ESF busses.

INSPECTIONS, TESTS, ANALYSES, AND ACCEPTANCE CRITERIA MARKUP

A markup of Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) is provided to ensure that the open phase detection system can detect one or more open phases on the high voltage side of the MPT and RATs and that an alarm actuates in the Main Control Room. These ITAAC must be completed prior to initial operation.

PROBABILISTIC RISK ASSESSMENT

A probabilistic risk assessment (PRA) was performed to determine the Conditional Core Damage Probability (CCDP) and Core Damage Frequency (CDF) for an open phase condition and to determine whether the addition of negative sequence relays for the Class 1E 4.16 kV busses requires a change to the STP 3&4 PRA Model or to Chapter 19 of the FSAR. The CCDP represents the core damage likelihood given that the event has actually occurred. The assessment was based on the Unit 3&4 PRA model described in Chapter 19 of the FSAR. Modifications to the model and new scenarios were created to capture the effects of the postulated event. The PRA for an open phase condition is documented in Reference 3.

The following three cases were considered in the PRA assessment. The initial case considers an open phase condition on the high voltage side of the MPT and assumes the plant operators do not diagnose the presence of the open phase and take action. This case also assumes the two Class 1E 4.16 kV busses fed by the MPT are degraded and that the voltages are not recreated on the low voltage side of the MPT as NINA believes they would be. This case assumes no actions are taken in response to Bulletin 2012-01 and the open phase detection and negative sequence protection has not been added to the design.

The second case considers an open phase condition on one offsite power supply feeding the MPT and the plant operates as-designed, with the MPT capable of back feeding the electrical distribution system and recreating the lost phase on the low voltage side of the MPT. In this scenario, RAT-B, with no open phase condition, is not affected, and continues to feed the Div. III 4.16 kV bus. This case assumes the open phase detection and negative sequence protection has not been added to the design. This case addresses the open phase without any action in response to Bulletin 2012-01, but does credit the results of NINA's associated ETAP simulations.

The final case analyzes the risk from an open phase condition with the open phase detection on the MPT and RATs and the negative sequence voltage relay protection on the 4.16 kV busses added to the design. This case addresses the open phase after the actions in response to Bulletin 2012-01 described above.

The results are provided in the Table below. For all cases, the CCDP for an open phase condition is well below 1.0×10^{-5}. The annual CDF for open phase events is well below this value by two orders of magnitude. Both of these risk numbers are well within industry acceptable risk standards. These results demonstrate the robust nature of the STP 3&4 design.

Specifically, the key design features that contribute to these low risk numbers are:

- Three incoming power connections from offsite with one feeding plant operating loads and Division I and II Class 1E 4.16 kV busses, one feeding the Division (III) Class 1E 4.16 kV bus, and a reserve feed that is in standby that can supply all three buses.

- The Division III bus has two systems to assure core cooling, High Pressure Core Flooder or depressurization and the Residual Heat Removal (RHR) system.

- Reactor Core Isolation Cooling (RCIC) is an AC independent high pressure steam driven system available and capable of providing core cooling

- Depressurization is highly reliable by either manual control or Automatic Depressurization System (ADS).
- Power can be restored to the Class 1E 4.16 kV busses by cross connection from the other unit OR use of the Combustion Turbine Generator.
- Undervoltage detection is available on the three Class 1E 4.16 kV busses which will result in an automatic start of the EDG and transfer of the bus.
- An additional AC independent means of injecting cooling is available through AC Independent Water Addition (ACIWA)

In summary, the event postulated has been analyzed and determined to have a very low impact on the base PRA results in Chapter 19 which includes consideration of the frequency of an off-site power loss from the switchyard and grid. As a result of the fact that the changes in Case 3 are less than 1% of the current CDF for STP 3&4, the changes screen out and no changes are necessary to Chapter 19 or the STP 3&4 PRA model.

Open Phase Cases	CCDP	CDF
No operator action to diagnose presence of open phase	9.4×10^{-7}	9.4×10^{-9}
MPT recreates voltages	1.1×10^{-8}	1.1×10^{-10}
Open phase detection and negative sequence protection added to design	1.7×10^{-7}	1.7×10^{-9}

RESPONSE TO EACH QUESTION IN RAI 08.02-25

The NRC question being responded to is shown in ***bold italics***.

- ***Describe the protection scheme design for important to safety buses (non-safety or safety- related) to detect and automatically respond to a single-phase open circuit condition or high impedance ground fault condition on credited offsite power circuits.***

The overall protection scheme for open phase conditions is comprised of detection and alarm for open phases on the high voltage side of the MPT and RATs, and automatic protective actuation for a negative sequence voltage on any of the three Class 1E 4.16 kV busses. This actuation will open the breakers to the Class 1E 4.16 kV bus resulting in a transfer to the associated emergency diesel generator.

- ***If the important to safety buses are not powered by offsite power sources during at power condition, explain how the surveillance tests are performed to verify that a single-phase open circuit condition or high impedance ground fault condition on an off-site power circuit is detected.***

The Class 1E 4.16 kV safety busses at STP 3&4 are normally powered by offsite power sources during at power conditions. As shown in Figure 1, two of the Class 1E 4.16 kV busses are supplied with power from the main generator through the unit auxiliary transformers. The third Class 1E 4.16 kV bus is supplied from RAT-B. RAT-A is normally unloaded and in a standby mode. Open phase detection and alarm is provided for all three transformers (MPT, RAT-A, RAT-B) that are connected to the offsite grid.

- ***Describe the plant operating procedures, including off-normal operating procedures, that specifically call for verification of the voltages on all three phases of the Class 1E Safety buses.***

Plant operating and off-normal procedures for onsite electrical distribution will be developed after the detailed design is complete and the equipment, including monitoring and protective instrumentation, is procured and installed. Negative sequence voltage relays on each of the Class 1E 4.16 kV busses will ensure that voltages on each of the three phases of the Class 1E busses remain within required values.

RESPONSE TO EACH QUESTION IN RAI 08.02-26

The NRC question being responded to is shown in ***bold italics***.

Item 1) a: Unbalanced Operation Discussion

i. ***Provide an analysis that shows that none of the safety-related or non-safety related loads will exceed their current ratings that would cause physical damage to motor windings, and other inductive elements.***

As discussed in this RAI response, negative sequence voltage relays on each of the Class 1E 4.16 kV busses will actuate in the presence of an unbalanced voltage and initiate transfer to the associated emergency diesel (EDG) if the relay setpoint and time delay are exceeded. See the discussion in the Negative Sequence Voltage Protection section of this RAI response. The setpoint and time delay of the Class 1E negative sequence voltage relays are specifically designed to preclude damage to motor windings and other inductive elements.

ii. ***Clarify how the phase angle change, as well as the presence of negative sequence currents, will be detected to preclude damage on inductive loads.***

The negative sequence voltage relays will detect the presence of negative sequence voltages and initiate transfer of the bus to the associated EDG if the relay setpoint and time delay are exceeded. The relays are specifically designed to preclude damage to inductive loads.

iii. ***Provide your evaluation and analysis that sensitive instrumentation and control and protection circuits that are dependent on ac power quality are not adversely impacted by an unbalanced power system.***

I&C equipment for reactor protection is supplied by regulated power from constant voltage, constant frequency equipment or inverters. The added negative sequence voltage protection system is designed to operate on unbalanced voltages and phase angles and will separate the affected busses should unbalanced voltages be detected.

iv. ***Provide supporting documentation from equipment vendors validating the capability of their equipment to function with current and voltage variations addressed in the above questions.***

The negative sequence voltage relays will monitor and detect the presence of negative sequence voltages and initiate transfer the bus to its associated EDG if the relay setpoint and time delay are exceeded. These negative sequence voltage relays are specifically designed to preclude damage to motors and other inductive loads.

Item 2) Phase Angle Discussion

a. ***Provide a means of detecting a loss of phase given the assumptions stated above since the degraded voltage relays will be incapable of detecting the loss of phase as a function of phase angle.***

Relays to detect open phase conditions on the high voltage side of the MPT and RATs are being added. These relays are separate from and do not rely on the degraded voltage relays to detect the loss of phase.

b. ***Provide an ITAAC that demonstrates by testing that the selected means of protection will actuate and withstand the higher currents during the loss of phase condition.***

The negative sequence voltage relays that are being added to the Class 1E 4.16 kV busses to provide the actuation function are specifically designed to preclude damage to motors and other inductive loads. Inspection, Test, Analyses, and Acceptance Criteria (ITAAC) that demonstrate by testing that the selected means of protection will actuate are not needed for the negative sequence relays because this instrumentation is being placed in the Technical Specifications, which must be complied with at the time of initial and during subsequent plant operation. See the detailed Technical Specification markup in the Markup section of this response.

An ITAAC is being added for the open phase detection on the MPT and RATs as previously discussed.

c. ***Provide a Technical Specifications (TS) Surveillance Requirements (SRs) that will provide assurance that the protective measures for a loss of phase condition are reliable and functional and able to preclude damage to safety related equipment.***

The negative sequence voltage relays on the Class 1E 4.16 kV busses will be included in TS 3.3.1.4, ESF Actuation Instrumentation. This will provide assurance that the protective measures for loss of phase conditions are reliable and functional and able to preclude damage to safety related equipment. See the detailed TS markup in the Markup section of this response.

d. ***Provide details on any tests that will be performed on the plant electrical system to validate the analytical results for a loss of phase on high voltage side of transformers and successful operation of worst case plant loading for an extended duration without adverse effects.***

Because the STP 3&4 design will include open phase detection and control room alarm, automatic protective actuation for unbalanced voltages on the Class 1E 4.16 kV busses, there will be no extended duration operation with an open phase condition.

Item 3) Grid Availability and Reliability Discussion

If no plant design changes are planned to automatically detect and isolate the open phase condition (degraded offsite power sources) and transfer the important to safety buses to alternate power source(s), provide the applicant and/or the grid operator's evaluation to show that availability and reliability of offsite power system (capacity and capability) is maintained in accordance with transmission system protocols and in accordance with 10 CFR 50 Appendix A, GDC 17 requirements.

Design features are being added to automatically detect open phases and isolate them from the important to safety busses. Open phase conditions on the MPT and RATs will be detected and alarmed in the Main Control Room. In addition, the Class 1E 4.16 kV busses will be transferred to the EDG if there is a negative sequence voltage that is of sufficient magnitude to adversely affect the motors.

Item 4) Additional FSAR Information Discussion

Therefore, the applicant is requested to provide sufficient analyses in the final safety analysis report (Sections 8.2 and 8.3 of Chapter 8) and ITAAC information (COLA, Part 9, Section 3.0, Site-Specific ITAAC) offsite power system) in accordance with § 52.79, "Contents of applications; technical information," and § 52.80, "Contents of applications; additional technical information," and 10 CFR 50.55a(h)(3) for the staff to determine whether the NINA COLA meets the requirements of 10 CFR Part 50, Appendix A, GDC 17 "Electric power systems," regarding the offsite power circuit and onsite electrical power distribution system to provide adequate capacity and capability in view of the design vulnerability identified in NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System." The information should include, as a minimum, design and analyses and ITAAC information to automatically detect and take protective actions for a single phase open phase condition with and without a high impedance ground condition, on the high voltage side of a transformer connecting credited GDC-17 offsite power circuits to the transmission system (high voltage side MTs and RATs).

See the FSAR and ITAAC markups provided as part of this RAI response.

Item 5) Nuclear Strategic Issues Advisory Committee Discussion

In the RAI revised response the applicant states that it will evaluate Nuclear Strategic Issues Advisory Committee (NSIAC) initiatives to ensure that STP 3 & 4 design and procedures remain consistent with industry accepted practices. The staff requests the applicant to provide a license condition to reflect this statement and also the proposed changes to the plant TS in terms of limiting conditions of operation and SRs.

STP 3&4 will continue to follow the development of industry guidance for open phase conditions. Given that NINA is adding detection, alarm, protective actuation, Technical

Specifications, and an ITAAC in response to Bulletin 2012-01 for open phase conditions, NINA does not believe that a license condition is warranted.

<u>Item 6) Forsmark Operating Experience Discussion</u>

Based on the Forsmark Operating Experience, address Questions 1 thru 5 for a loss of two phases condition with and without a high impedance ground condition on the high voltage side of a transformer connecting a credited GDC 17 offsite power circuits to the transmission high voltage side MTs and RATs.

The open phase Detection and alarm will be capable of detecting and alarming one or more open phases on the high voltage side of the MPT and both RATs with or without a high impedance ground condition. The negative sequence voltage relays on each Class 1E 4.16 kV bus will provide their protective function based on the negative sequence voltages detected on the bus.

References

1. "Negative Sequence Relay Setting Calculation," Calculation No. STP-EC-14001 Rev. 1, Hurst Technologies Corporation, May 13, 2014.

2. "ETAP Studies for STP 3&4," DP Engineering Ltd. Inc., May 14, 2014.

3. "Open Phase Condition Risk Analysis for STP 3&4," Rev. 2, Report 1014STP.OP.003,ETRANCO Incorporated, June 21, 2014.

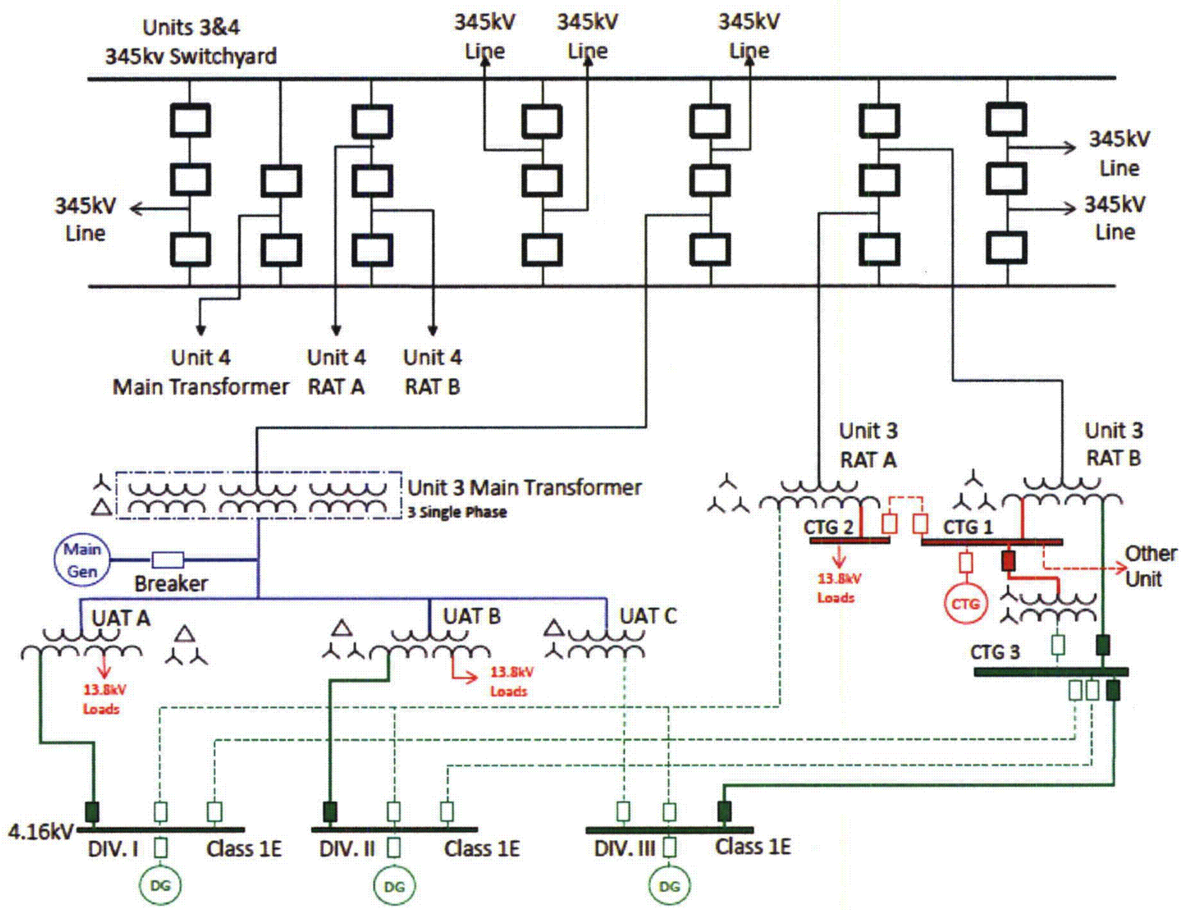

Figure 1

STP 3&4 Electrical Distribution System

MARKUPS

FSAR Markup

The following changes are made to Chapters 8 and 16 to describe the changes to protect against Open Phase conditions. The changes to the current FSAR are shown in the gray shading.

8.2.1.2.4 Monitoring of Main Power and Reserve Auxiliary Transformers

Standard Supplement - NRC Bulletin 2012-01

NRC Bulletin 2012-01 discusses the possibility that an open phase condition, with or without accompanying ground faults, located on the high-voltage side of a transformer connecting a GDC 17 offsite power circuit to the plant electrical system could, result in a degraded condition in the onsite power system (see Reference 8.2-7). To address this issue, protection of the Class 1E busses is provided as described in subsection 8.3.1, and monitoring of the normal and alternate preferred power supply feeds through the MPT and RATs is provided as described below.

All three phases of the MPT and RATs are monitored by specific transformer relays for open phase, and ground faults in any combination of one or more phases. The specific relays initiate alarms in the Main Control Room when an open phase or ground fault is detected. If required, operators will complete manual actions to address the alarms. Testing of the monitoring system is performed per Section 8.2.4.1 of this chapter to verify proper functionality.

Maintenance and testing procedures, including calibration and troubleshooting procedures, associated with the monitoring system are in accordance with Subsection 13.5. Control room operator and maintenance technician training associated with the operation and maintenance of the monitoring system is in accordance Section 13.2

8.2.6 References:

8.2-7 NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System," July 27, 2012.

8.3.1 AC Power Systems

STD DEP 8.3-1

Standard Supplement - NRC Bulletin 2012-01

The loss of voltage condition and the degraded voltage condition are sensed by independent sets of three undervoltage relays (one on each phase of the ~~6.9~~ 4.16 *kV bus) which are configured such that two-out-of-three trip states will initiate circuitry for transferring power from offsite power to the onsite diesel generator (after a time delay for the degraded voltage condition). The primary side of each of the instrument potential transformers (PTs) is* *connected phase-to-phase (i.e., a "delta" configuration) such that a loss of a single phase will cause two of the three undervoltage relays to trip, thus satisfying the two-out-of-three logic. (For more information on the degraded voltage condition and associated time delays, etc., see Subsection (8) of 8.3.1.1.7.)*

NRC Bulletin 2012-01 discusses the possibility that an open phase condition, with or without accompanying ground faults, located on the high-voltage side of a transformer connecting a GDC 17 offsite power circuit to the plant electrical system could, result in a degraded condition in the onsite power system (see Reference 8.2-7). To address this issue, monitoring of the normal and alternate preferred power supply feeds through the MPT and RATs is provided as described in subsection 8.2.1.2.4 and the Class 1E busses are provided with negative sequence voltage relays to ensure that the motors on the 1E busses are not subjected to unbalanced currents and voltages as described below.

Each of the Divisional Class 1E 4.16kV busses, has 3 negative sequence voltage relays configured such that a two-out-of-three trip state will initiate circuitry for transferring power from the offsite power supply to the onsite diesel generator after a time delay. Each negative sequence relay monitors all three bus phases using the bus instrument potential transformers. Should negative sequence voltage that would adversely affect the motors be present on a 4.16kV bus, the two-out-of-three logic will automatically actuate (see Subsection (10) of 8.3.1.1.7.).

Each ~~6.9~~ 4.16 kV Class 1E bus feeds its associated 480V unit substation power center *through a ~~6.9~~ 4.16 kV/ 480/277V power center transformer.*

8.3.1.1.6.3 Bus Protection

STD DEP 8.3-1

Standard Supplement - NRC Bulletin 2012-01

Bus protection is as follows:

(1) ~~*6.9 kV*~~ Medium voltage *bus incoming circuits have inverse time over-current, ground fault, bus differential ~~and,~~ under-voltage*, and negative sequence voltage *protection.*

8.3.1.1.7 Load Shedding and Sequencing on Class 1E Busses

STD DEP 8.3-1

Standard Supplement - NRC Bulletin 2012-01

This subsection addresses Class 1E Divisions I, II, and III. Load shedding, bus transfer and sequencing on a ~~6.9~~ 4.16 kV Class 1E bus is initiated on loss of bus voltage.

(1) ***Loss of Preferred Power (LOPP)****—The ~~6.9~~ 4.16 kV Class 1E busses are normally energized from the normal or alternate preferred power supplies. Should the bus voltage decay to ≤ 70% of its nominal rated value, a bus transfer is initiated and the signal will trip the supply breaker, and start the diesel generator. When the bus voltage decays to 30%, large pump motor breakers (~~6.9~~ 4.16 kV) are tripped.*

(2) ***Loss of Coolant Accident (LOCA)****—When a LOCA occurs, the standby diesel generator is started and remains in the standby mode (i.e. voltage and frequency are within normal limits and no lockout exists) unless a LOPP signal is also present as discussed in (3) and (4) below. In addition, with or without a LOPP, the load sequence timers are started if the ~~6.9~~ 4.16 kV emergency bus voltage is greater than 70%, and loads are applied to the bus at the end of preset times.*

Each load has an individual load sequence timer which will start if a LOCA occurs and the ~~6.9~~ 4.16 kV emergency bus voltage is greater than 70%, regardless of whether the bus voltage source is normal or alternate preferred power or the diesel generator.

(5) ***LOCA when diesel generator is parallel with preferred power source during test—*** *If a LOCA occurs when the diesel generator is paralleled with either the normal preferred power or the alternate preferred power source, the D/G will automatically be disconnected from the ~~6.9~~ 4.16 kV emergency bus regardless of whether the test is being conducted from the local control panel or the main control room.*

(8) ***Protection against degraded voltage****—For protection of the Division I, II and III electrical equipment against the effects of a sustained degraded voltage, the ~~6.9~~ 4.16 kV divisional bus voltages are monitored.*

(9) ***Station Blackout (SBO) considerations****—A station blackout event is defined as the total loss of all offsite (preferred) and onsite Class IE AC power supplies except Class IE AC power generated through inverters from the station batteries. In such an event, the combustion turbine generator (CTG) will automatically start and achieve rated speed and voltage ~~within two~~ in less than ten minutes. The CTG will then automatically assume pre-selected loads on the plant investment protection (PIP) buses. With the diesel generators unavailable, the reactor operator will manually shed PIP loads and connect the non-Class 1E CTG with the required shutdown loads within ten minutes of the event initiation. Specifically, the operator will energize one of the Class 1E distribution system buses by closing each of the two circuit breakers (via controls in the main control room) between the CTG unit and the Class 1E bus. The ~~circuit breaker closest to the CTG is non-Class 1E and the~~ circuit breaker closest to the Class 1E bus is Class 1E, and the other breakers are non-Class 1E. Later, the operator will energize other safety-related and non-safety-related loads, as appropriate, to complete the shutdown process. See Appendix 1C and Subsection 9.5.11 for further information on Station Blackout and the CTG, respectively.*

(10) **Negative Sequence Voltage**—For protection of the Division I, II and III electrical equipment against the effects of an unbalanced power supply, the Class 1E 4.16 kV divisional busses are monitored for negative sequence voltage. If the bus negative sequence voltage increases to 4.5%, and after a time delay (to prevent triggering by transients), the respective feeder breaker trips, which consequently starts the diesel generator on undervoltage before any of the Class 1E loads experience degraded conditions exceeding those for which the equipment is qualified. The time delay setting is defined to provide appropriate motor protection. This assures such loads will restart when the diesel generator assumes the degraded bus and sequences its loads. If the bus voltage recovers within the time delay period, the protective timer will automatically reset. Should a LOCA occur during the time delay, the feeder breaker with the negative sequence voltage will be tripped instantly. Subsequent bus transfer will be as described above.

8.3.5 References

Standard Supplement - NRC Bulletin 2012-01

8.2-7 NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System," July 27, 2012.

Technical Specification Markup

3.3 INSTRUMENTATION
3.3.1.4 ESF Actuation Instrumentation

The information in this section of the reference ABWR DCD, including all subsections, is incorporated by reference with the following departures and site-specific supplements. These site specific supplements partially address COL License Information Item 16.1.

STD DEP T1 2.4-2
STD DEP T1 2.4-3
STD DEP T1 3.4-1 (All)
STD DEP 8.3-1 (Table 3.3.1.4-1)
STD DEP 16.3-50
STD DEP 16.3-86
STD DEP 16.3-94
STD DEP 16.3-100
Standard Supplement - NRC Bulletin 2012-01

SURVEILLANCE REQUIREMENTS

---NOTE---
Refer to Table 3.3.1.4-1 to determine which SRs apply for each ESF Actuation Instrumentation Functions.

SURVEILLANCE		FREQUENCY
SR 3.3.1.4.1	Perform SENSOR CHANNEL CHECK.	12 hours
SR 3.3.1.4.2	Perform OUTPUT CHANNEL FUNCTIONAL TEST.	18 months
SR 3.3.1.4.3	Perform DIVISION FUNCTIONAL TEST in accordance with TS 5.5.2.11, Setpoint Control Program.	31 days
SR 3.3.1.4.4	Perform COMPREHENSIVE FUNCTIONAL TEST.	18 months
SR 3.3.1.4.5	Perform ECCS RESPONSE TIME TEST.	18 months
SR 3.3.1.4.6	Perform SENSOR CHANNEL CALIBRATION in accordance with TS 5.5.2.11, Setpoint Control	18 months

SURVEILLANCE		FREQUENCY
	Program.	
SR 3.3.1.4.7	Perform CHANNEL FUNCTIONAL TEST.	18 months
SR 3.3.1.4.8	Perform DIVISION FUNCTIONAL TEST.	31 days
SR 3.3.1.4.9	Perform SENSOR CHANNEL CALIBRATION. The Allowable Value shall be ≤4.5%. The time delay shall be 2.5 seconds.	18 months

Table 3.3.1.4-1 (Page 4 of 7)
ESF Actuation Instrumentation

	FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS	APPLICABLE CONDITIONS	SURVEILLANCE REQUIREMENTS
5.a	Division I, II, & III Loss of Voltage – 4.16 kV	1,2,3, 4[(h)],5[(h)]	1 per phase[(a)]	C	SR 3.3.1.4.1 SR 3.3.1.4.2 SR 3.3.1.4.3 SR 3.3.1.4.4 SR 3.3.1.4.5 SR 3.3.1.4.6
5.b	Division I, II, & III Degraded Voltage – 4.16 kV	1,2,3, 4[(h)],5[(h)]	1 per phase[(a)]	C	SR 3.3.1.4.1 SR 3.3.1.4.2 SR 3.3.1.4.3 SR 3.3.1.4.4 SR 3.3.1.4.5 SR 3.3.1.4.6
5.c	DG System Initiation	1,2,3, 4[(h)],5[(h)]	1 per DG[(b)]	B	SR 3.3.1.4.3 SR 3.3.1.4.4 SR 3.3.1.4.5
5.d	DG Device Actuation	1,2,3, 4[(h)],5[(h)]	1 per actuated device[(c)]	D	SR 3.3.1.4.2 SR 3.3.1.4.4

5.e	DG Manual Initiation	1,2,3, 4[(h)],5[(h)]	1 per DG[(d)]	F	SR 3.3.1.4.3 SR 3.3.1.4.4 SR 3.3.1.4.7

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5.f	Division I, II, & III Negative Sequence Voltage – 4.16 kV	1,2,3, 4[(h)],5[(h)]	1 per bus[(a)]	C	SR 3.3.1.4.1 SR 3.3.1.4.2 SR 3.3.1.4.4 SR 3.3.1.4.5 SR 3.3.1.4.8 SR 3.3.1.4.9
6.	Standby Gas Treatment System Actuation	1,2,3 (i)(j)	1 per subsystem[(b)]	B	SR 3.3.1.4.3 SR 3.3.1.4.4
6.a	SGTS Initiation				

B 3.3 INSTRUMENTATION
B 3.3.1.4 Engineered Safety Features (ESF) Actuation Instrumentation

BASES

The information in this section of the reference ABWR DCD, including all subsections, is incorporated by reference with the following departures and site specific supplement. The site specific supplement partially addresses COL License Information Item 16.1.

STD DEP T1 2.4-2
STD DEP T1 2.4-3
STD DEP T1 3.4-1 (All)
STD DEP 7.3-17
STD DEP 8.3-1
STD DEP 16.3-87
STD DEP 16.3-99
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5.f Divisions I, II, & III Negative Sequence Voltage – 4.16kV

Each of the three 4.16 kV ESF busses is monitored to detect a high negative sequence voltage, indicative of a loss of an electrical phase. If negative sequence voltage of a sufficiently high level is detected, the bus supply breakers are tripped allowing the associated Emergency Diesel Generator (DG), provided as a backup to the offsite power source, to start via the bus undervoltage relaying. These SENSOR CHANNELS are provided to assure that there is sufficient power available to supply safety systems should they be needed.

The Negative Sequence Voltage Function is not assumed in any accident or transient analyses for the ABWR. However, the Function is added to the plant licensing basis in response to NRC Bulletin 2012-01.

The input signals for this Function are provided by the bus instrument potential transformers connected to each phase of the three 4.16 kV ESF busses. The required channel on a 4.16 kV ESF bus has three separate negative sequence voltage relays that monitor the voltage on all three bus phases, and each negative sequence relay will detect a negative sequence voltage on the three phases. The three separate negative sequence relay outputs are combined in a 2/3 logic to ensure actuation of the Function, even in the event of a single relay failure, while also preventing a spurious trip should a single relay fail. A time delay is provided to prevent breaker trips due to normal transient conditions on the bus.

The required channel of this Function, consisting of three relays, is required to be OPERABLE on each 4.16 kV ESF bus in order to trip the respective ESF bus offsite feeder breaker and allow other protective functions to actuate. The Function must be operable in MODES 1, 2, and 3 and in MODES 4 and 5 when any ECCS system is required to be OPERABLE as described in LCO 3.8.2, "AC Sources – Shutdown" and LCO 3.8.11, "AC Sources – Shutdown (Low Water Level)".

The Allowable Value is selected to be low enough to trip the respective ESF bus feeder breaker prior to potential equipment damage, but high enough to prevent normal voltage fluctuations from causing spurious initiations. A time delay assures that normal bus transients do not cause spurious trips of the 4.16kV ESF bus supply breaker.

STD DEP 8.3-1

STANDARD SUPPLEMENT – NRC Bulletin 2012-01

ACTIONS

C.1

This Condition is provided to assure that appropriate action is taken for single or multiple inoperable SENSOR CHANNELS ~~*channels*~~ *that cause automatic or manual actuation of an ESF feature to become unavailable. However, automatic and manual initiation for redundant features are not affected.*

Action C.1 restores the intended plant protection capability. The 1 hour Completion Time for Action C.1 provides some amount of time to restore automatic or manual actuation before additional Required Actions are imposed.

This Action applies to

• ~~*- all LOGIC CHANNELS, except ADS*~~

• ~~*- isolation initiation manual channels*~~

• *Divisions I, II, & III Loss of Voltage -* ~~*6.9*~~ 4.16 *kV,* ~~*and*~~ *Degraded Voltage -* ~~*6.9*~~ 4.16 *kV, and Negative Sequence Voltage – 4.16 kV.*

STANDARD SUPPLEMENT – NRC Bulletin 2012-01

SR 3.3.1.4.3 and SR 3.3.1.4.8

A DIVISIONAL FUNCTIONAL TEST is performed on the LOGIC CHANNELS and SENSOR CHANNELS in each ESF division to provide confidence that the Functions will perform as intended. The test is performed by replacing the normal signal with a test signal as far upstream in the channel as possible within the constraints of the instrumentation design and the need to perform the surveillance without disrupting plant operations. See Section 1.1, "Definitions" for additional information on the scope of the test.

The devices used to implement the Functions are specified to be of high reliability and have a high degree of redundancy. Therefore, the [~~92~~ 31] *day frequency provides confidence that device actuation will occur when needed. This test overlaps or is performed in conjunction with the DIVISIONAL FUNCTIONAL TESTS performed under LCO 3.3.1.1, "SSLC Sensor Instrumentation" to provide testing up to the final actuating device.*

STANDARD SUPPLEMENT – NRC Bulletin 2012-01

SR 3.3.1.4.6 and SR 3.3.1.4.9

A SENSOR CHANNEL CALIBRATION is a complete check of the instrument loop and the sensor. This test verifies a SENSOR CHANNEL responds to the measured parameter within the necessary range and accuracy. SENSOR CHANNEL CALIBRATION leaves the channel adjusted to account for instrument drifts between successive calibrations. Measurement error historical determinations must be performed consistent with the plant specific setpoint methodology. The channel shall be left calibrated consistent with the assumptions of the setpoint methodology. As noted, the calibration includes calibration of all parameters used to establish derived setpoints and all parameters used to automatically bypass a trip function.

STD DEP 16.3-99

~~*If the as found trip point (fixed or variable) is not within its Allowable Value, the plant specific setpoint methodology may be revised, as appropriate, if the history and all other pertinent information indicate a need for the revision. Calibration shall be provided that is consistent with the assumptions of the current plant specific setpoint methodology.*~~

The 18 month frequency is based on the ABWR expected refueling interval and the need to perform this Surveillance under the conditions that apply during a plant outage. The Frequency is adequate based on the specified low drift of the devices used to implement the Functions covered by this LCO.

Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) Markup

The existing COLA Part 9, Table 3.0-29 is replaced with the following:

Table 3.0-29 Detection and Protection of Open Phase Events on the Main Power and Reserve Auxiliary Transformers

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
1. Continuous monitoring of the power feeds on the high voltage side of the Main Power Transformer (MPT) and Reserve Auxiliary Transformers (RAT) is provided to detect: a. An open phase with no transformer high-side ground. b. An open phase with a transformer high side ground between the open phase and the transformer. c. Two transformer high side open phases (simultaneously).	1. An analysis of the transformer relay scheme will be performed to verify the following: a. Relay current transformers have been correctly located. b. Relay set points can provide adequate detection.	1. An analysis demonstrates: The correct location of the current transformers for the MPT and RATs transformer relays. Relay set points ensure that the monitoring systems can adequately detect open phase conditions in any combination of three phases, with or without accompanying ground faults, on the high-voltage side of the MPT and RATs transformers.
2.The monitoring system provides a Main Control Room Alarm for: a. An open phase with no transformer high-side ground. b. An open phase with a transformer high side ground between the open phase and the transformer. c. Two transformer high side open phases (simultaneously).	2. A test will be performed of the as-built monitoring system, using simulated signals, to demonstrate that, at the designated relay set points, the MPT and RATs alarm in the Main Control Room.	2. Using simulated signals, at the designated relay set points in any combination of the three phases, the as-built MPT and RATs initiate an alarm in the Main Control Room.