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U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
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11555 Rockville Pike
Rockville, MD 20852-2738

South Texas Project
Units 3 and 4
Docket Nos. 52-012 and 52-013
Response to Request for Additional Information

Attached is the Nuclear Innovation North America, LLC (NINA) response to the NRC staff question in Request for Additional Information (RAI) letter number 419, related to Combined License Application (COLA) Part 2, Tier 2, Section 8.2, "Offsite Power Systems." The attachment to this letter contains the response to the following RAI question:

08.02-25

When a change to the COLA is required, it will be incorporated into the next routine revision of the COLA following NRC acceptance of the RAI response.

There are no commitments in this letter.

If you have any questions, please contact me 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 1/3/13

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

rhb

Attachment: RAI 08.02-25

D091
NRO

STI 33640722

(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 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.
- 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.
- 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.

RESPONSE:

This response provides the results of analyses of the design that is provided in Combined License Application (COLA) revision 8, and does not propose or rely upon any design features not included in COLA revision 8. The protection scheme for the onsite power system is described primarily in Design Certification Document (DCD) Section 8.3, and is not changed significantly by the limited departures related to electric power system.

Item 1: Single Phase Open Circuit Discussion

The undervoltage protective circuitry will separate the Class 1E Safety buses from a connected failed offsite source due to a loss of voltage or a sustained degraded grid voltage with or without concurrent design basis accidents. In the COLA Part 2, Tier 2, , section 8.3.1 'AC Power Systems', the undervoltage schemes for detecting loss of voltage and degraded voltage are provided as follows:

> *'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 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.)'

The loss of voltage and degraded voltage schemes are required to be operable as required by the Technical Specifications:

LCO 3.3.1.4 *The ESF Actuation Instrumentation for each Function in Table 3.3.1.4-1 shall be OPERABLE. (Requires all phase sensor channel functions to be Operable in all 5 Modes).*
Diesel Generator Actuation (Table 3.3.1.4-1) requires:
5.a, Division I, II, & III Loss of Voltage –4.16 kV, and
5.b, Division I, II, & III Degraded Voltage –4.16 kV

Based on the above, the loss of voltage and degraded relay schemes on each of the Class 1E Safety buses results in a design that will detect and respond to the postulated loss of phase scenarios. It should be noted that the Class 1E Safety buses are normally aligned to offsite sources through multiple paths. Refer to Item 2 below for the normal Class 1E bus lineups. (Refer to the attachment to this response for additional technical analysis and see COLA Part 2, Tier 2, Figure 8.3-1, for plant transformer configuration and transformer ratings.)

Main Transformer Back Feed Alignment Single-Phase Open Circuit Event

For a single-phase open circuit event on the grid side of the Main Transformer, the feed from the Main Transformer and each of the associated Unit Auxiliary Transformers (UAT) does not affect the safety-related or non-safety related loads since the wye-delta configuration of the Main Transformer regenerates the lost phase (open-circuited phase). Also, the Main Transformer can carry the increased load on the remaining two phases because the MVA capacity of the Main Transformer is large relative to the combined safety-related and non-safety related loads on the UATs. Therefore, the important to safety loads fed by the Main Transformer and associated UATs are not affected by a single-phase open circuit event on the grid side of the Main Transformer. A single-phase open circuit without ground fault or short circuit on the plant side of the Main Transformer and UAT cannot occur without also initiating a ground fault or short circuit, because the conductors are enclosed isolated phase bus, enclosed non-segregated bus, or enclosed medium voltage cables in tray, duct bank, or conduit. Conductor failures in these circuits are expected to result in a fault that would be immediately cleared by installed protective relaying.

Reserve Auxiliary Transformer Single-Phase Open Circuit Event

For a single-phase open circuit event on the grid side of a Reserve Auxiliary Transformer, the feeds from the Reserve Auxiliary Transformers are affected because of the wye-wye configuration of the Reserve Auxiliary Transformers. As stated above, the 4.16 kV Class 1E Safety buses have both loss-of-voltage and degraded voltage relays. These loss-of-voltage and degraded voltage relays monitor all three phases and are connected to 2 out of 3 coincidence logic to separate the Class 1E Safety buses from offsite power and realign them to the diesel generators upon detection of an unacceptable undervoltage or degraded voltage condition. 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.

High Impedance Ground Discussion:

The offsite power circuits have been reviewed with regard to high impedance grounds. The effect of a high impedance ground has been analyzed to be dependent on where the high impedance ground is located and the magnitude of current flowing to the high impedance ground.

If a high impedance ground were located on the low side of a large power transformer that provides offsite power to the Class 1E Safety loads (Unit Auxiliary Transformers and Reserve Auxiliary Transformers) and the magnitude of ground current is above the ground protection relay setpoint, then the ground protection relaying would actuate and lockout the transformer tripping all of the powered buses including the offsite power source feed to the associated 4.16 kV Class 1E Safety bus(es). Consequently, the affected 4.16 kV Class 1E Safety bus(es) would then be powered by its associated Emergency Diesel Generator.

The design of the power distribution system allows the system to stay operational if a single phase high impedance ground occurs. See COLA Part 2, Tier 2, Figure 8.3-1. To achieve this feature, neutral grounding resistors are installed on the low side of each transformer winding to limit the ground fault current (reference COLA Part 2, Tier 2, section 8.3.1.0.6.2 'Grounding Methods').

If a high impedance ground were located on the low side of any of the aforementioned large power transformers and the magnitude of ground current is below the ground protection relay setpoint, then the ground protection relays would not actuate. However, this very low magnitude current high impedance ground would not be expected to prevent Class 1E Safety loads from performing their design function while staying connected to their associated offsite power source, because the magnitude of the current to the ground fault is ultimately limited to an acceptable value by the neutral grounding resistor at the source transformer.

If a high impedance ground were located on the high side of the UATs or Reserve Auxiliary transformers, the high impedance ground 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 LOPP for the affected Class 1E Safety bus(es) which would then automatically realign to the Diesel Generator(s).

Below is a listing of the offsite power transformer winding and grounding configurations based on information from COLA Part 2, Tier 2, Figure 8.3-1.

Offsite Power Transformer Winding and Grounding Configurations

Transformer	**Winding Configuration (High Side / Low Side)**	**Grounding Configuration (High Side / Low Side)**
Main Transformer	Wye / Delta	Solidly Grounded / Ungrounded
Two of the Unit Auxiliary Transformers	Delta / Wye – Wye	Ungrounded / Low Resistance Grounded – Low Resistance Grounded
Third Unit Auxiliary Transformer	Delta / Wye	Ungrounded / Low Resistance Grounded
Reserve Auxiliary Transformers A & B	Wye / Wye – Wye	Solidly Grounded / Low Resistance Grounded – Low Resistance Grounded

Item 2: Offsite Power Sources During at Power Conditions

The Class 1E Safety buses at South Texas Project are normally powered by offsite power sources. Note 9 on COLA Part 2, Tier 2, Figure 8.3-1, sheet 1 states "During normal plant operations all of the non-class 1E buses and two of the Class 1E buses are supplied with power from the main turbine generator through the unit auxiliary transformers. The remaining Class 1E bus is supplied from RAT (B). This division is immediately available without a bus transfer if the NPP is lost to the other two divisions." Figure 8.3-1 sheet 1 also shows that there is a generator circuit breaker between the main generator and the main and auxiliary transformers. This allows an automatic back feed through the main transformers on trip of the main turbine generator.

Item 3: Plant Operating Procedures

Plant operating and off-normal procedures for onsite electrical distribution will be developed after the detailed design is complete and the equipment, including monitoring instrumentation, is procured and installed. A combination of monitoring instrumentation, procedural requirements, and operator training will be used to provide a high degree of assurance that required voltage is maintained on all three phases and that off normal conditions, including failures affecting a single phase, are detected promptly.

Attachment fot the Response to RAI 08.02-25

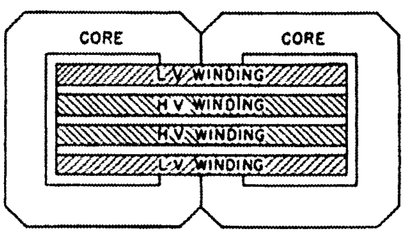
Byron Event Technical Analysis for Impact at the South Texas Project

Unit Main Transformer:

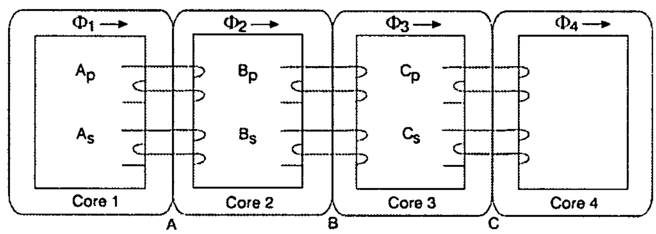
For the Main transformer, the construction type does not matter since the connection from the switchyard to the generator bus is connected wye-ground/delta as explained below. The following is an example of typical transformer construction for the reader's reference.

Shell-form construction for single-phase transformers consists of all windings formed into a single ring, with magnetic punchings assembled so as to encircle each side of the winding ring as shown below. The mean length of turn is usually longer than for a comparable core-form design, while the iron path is shorter.

Shell Type Transformer Construction



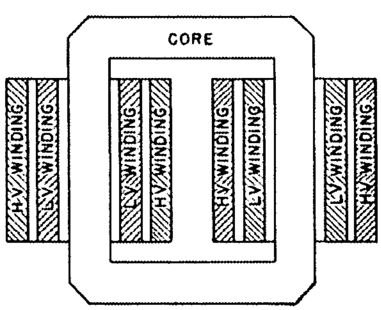
Single Phase



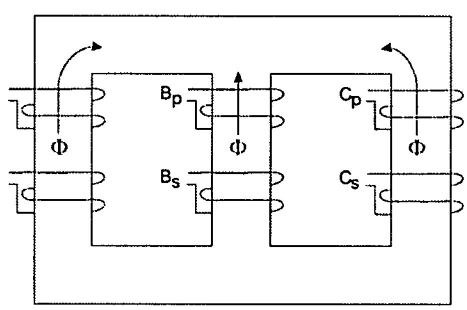
Three Phase

Core-form construction for a single-phase transformer consists of magnetic steel punchings arranged to provide a single-path magnetic circuit. High- and low-voltage coils are grouped together on each main or vertical leg of the core, as shown below. In general, the mean length of turn for the winding is comparatively short in the core form design, while the magnetic path is long.

Core-form Transformer Construction



Single Phase

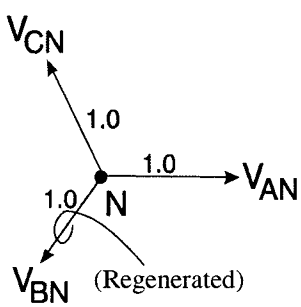


Three Phase

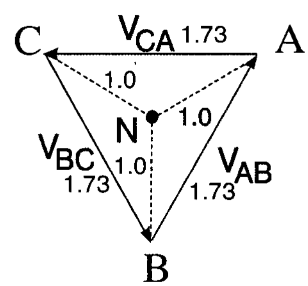
The Main transformer is comprised of 3 single phase, 537.5 MVA 345/26kV transformers that are connected wye-ground/delta. The wye side is connected to the 345kV switchyard and the delta side is connected to the 26kV main generator and three (3) Unit Auxiliary transformers. See COLA Part 2, Tier 2, Figure 8.3-1.

Based on Reference 1, a lost phase on a wye-grounded / delta transformer does not impact voltages on the secondary of the transformer. This is because the lost phase voltage is regenerated in the delta windings of the transformer. The three phase load on the secondary of the transformer will only be carried by the two connected phases on the high side of the transformer. This is within the capability of the Main transformer, which has a combined rating of about 1612 MVA, because the load on the Unit Auxiliary transformers is about 90 MVA with all the BOP motors running.

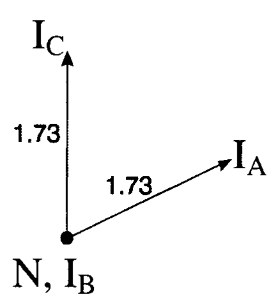
The following phasor diagrams represent the voltages and currents for the loss of "B" phase (Reference 1).



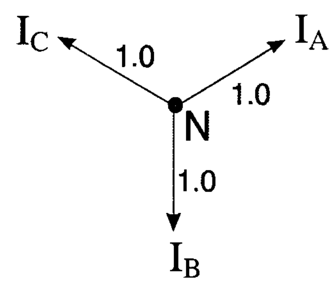
Primary Voltage



Secondary Voltage



Primary Currents



Secondary Currents

As can be seen, the lost phase voltage (B phase) on the primary is regenerated and the secondary voltage is equivalent to the expected phase to phase voltage. It should also be noted that the primary current of the remaining high side phases of the main transformers is the √3 (1.73) larger.

Unit Auxiliary Transformers:

Two of the Unit Auxiliary transformers are three winding transformers, 26/13.8/4.16 kV and are connected delta/wye-ground (with resistor) - wye-ground (with resistor). The third Unit Auxiliary transformer is a two winding transformer, 26/4.16 kV and is connected delta/wye-ground (with resistor). The Unit Auxiliary transformers are fed by the Unit Main or the Main Generator. Based on the ability of the Unit Main transformer to regenerate a lost phase, the Unit Auxiliary transformer would have all phase voltages present. The loss of a phase on the generator would cause a trip of the generator. See COLA Part 2, Tier 2, Figure 8.3-1.

Reserve Auxiliary Transformers:

The Reserve Auxiliary transformers (RATs) are three winding transformers 345/13.8/4.16 kV and are connected wye-ground/wye-ground (with resistor) - wye-ground (with resistor) and are expected to be shell type construction. Based on Reference 1, the lost phase will not be completely regenerated in the secondary wye windings like they are for a wye-ground/delta transformer on a loaded or unloaded transformer.

The following table provides the results of an analysis from Reference 1 and shows the resultant voltages for lost phases. The first table is for a transformer without any load on it.

Wye-G/Wye-G, 5 Legged Shell Form Xfmr, completely opened phase (No load), primary and secondary voltages					
B phase lost (middle phase)					
V_{AN}	1.00 $\angle$0	V_{AB}	~0.764 $\angle$19.1	$V_{0,LN}$	0.167 $\angle$60
V_{BN}	~0.5 $\angle$-120	V_{BC}	~0.764 $\angle$-79.1	$V_{1,LN}$	0.833 $\angle$30
V_{CN}	1.00 $\angle$120	V_{CA}	1.000 $\angle$150	$V_{2,LN}$	0.167 $\angle$-60
C phase lost (outside phase)					
V_{AN}	1.00 $\angle$0	V_{AB}	1.000 $\angle$30	$V_{0,LN}$	0.193 $\angle$-30
V_{BN}	1.00 $\angle$-120	V_{BC}	0.882 $\angle$-109	$V_{1,LN}$	0.839 $\angle$-6.6
V_{CN}	0.577 $\angle$90	V_{CA}	0.666 $\angle$150	$V_{2,LN}$	0.193 $\angle$90

The following table shows the expected resulting voltages of the Reserve Auxiliary transformer with the loss of one phase and some phase to neutral loading.

Wye-G/Wye-G, 5 Legged Shell Form Xfmr, opened phase, some Ph-N loading					
B phase lost (middle phase)					
V_{AN}	1.00 $\angle$0	V_{AB}	1.000 $\angle$30	$V_{0,LN}$	0.333 $\angle$-60
V_{BN}	~0	V_{BC}	0.578 $\angle$-120	$V_{1,LN}$	0.667 $\angle$0
V_{CN}	1.00 $\angle$120	V_{CA}	0.578 $\angle$180	$V_{2,LN}$	0.333 $\angle$60
C phase lost (outside phase)					
V_{AN}	1.00 $\angle$0	V_{AB}	1.000 $\angle$30	$V_{0,LN}$	0.333 $\angle$-60
V_{BN}	1.00 $\angle$-120	V_{BC}	0.578 $\angle$-120	$V_{1,LN}$	0.667 $\angle$0
V_{CN}	~0	V_{CA}	0.578 $\angle$180	$V_{2,LN}$	0.333 $\angle$60

The following table shows the expected resulting voltages of the Reserve Auxiliary transformer with the loss of one phase and phase to phase loading.

Wye-G/Wye-G, 5 Legged Shell Form Xfmr (similar to 3 single phase transformers based on analysis), opened phase, Ph-Ph load back-feed to lost phase; primary and secondary voltages					
B phase lost (middle phase)					
V_{AN}	1.00 $\angle 0$	V_{AB}	<0.500 $\angle$ -30	$V_{0,LN}$	0.500 $\angle 60$
V_{BN}	< 0.5 $\angle 60$	V_{BC}	<0.500 $\angle$ -30	$V_{1,LN}$	0.500 $\angle 0$
V_{CN}	< 1.00 $\angle 120$	V_{CA}	1.000 $\angle 150$	$V_{2,LN}$	0.500 $\angle$ -60

The loss of voltage and degraded voltage relays are fed from bus PTs that are connected phase to phase in a delta configuration. The output of the relays use a 2 out 3 logic to initiate circuitry for transferring power from offsite power to the onsite diesel generator. As shown in the table, if one phase is lost, two of the secondary voltages will be below the degraded voltage relay settings, and the degraded voltage relays drop out. The degraded voltage relay setting is nominally 90% (reference COLA Part 2, Tier 2, section 8.3.1.1.7 (8)).

Conclusions:

Unlike Byron, the STP 3 & 4 electrical auxiliary system is configured and operated such that a failure or problem with one offsite source will not impact all three divisions of safety related equipment. At least one division will be available and able to shutdown the unit and mitigate a design basis event.

For a single-open phase event on the grid side of the main power transformer, the safety related or non-safety related loads are not affected since the wye-ground/delta connection of the main transformer regenerates the lost phase. Also, the Main transformer can carry the increased load on the remaining two phases because of its MVA capacity relative to the combined safety and non-safety loads. Thus, a single-open phase on the high side of the main transformer will not result in the loss of accident mitigating functions of the associated Class 1E Safety buses.

For a single-open phase event on the grid side of the Reserve Auxiliary transformer, the feeds from the Reserve Auxiliary transformers are affected by the single-open phase. Based on the analysis from Reference 1, the loss of a single phase will drop the voltage on two phases of the transformer's secondary. This drop in secondary voltage will be detected by the degraded undervoltage relaying on the Class 1E Safety buses.

Reference

"A Practical Guide for Detecting Single-Phasing on a Three-Phase Power System" by John Horak and Gerald F. Johnson (Basler)