RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**259-8335**
SRP Section:	**08.03.01 – AC Power Systems (Onsite)**
Application Section:	**8.3.1**
Date of RAI Issue:	**10/19/2015**

Question No. 08.03.01-21

By letter dated July 29, 2015, the applicant provided a response to RAI 32-7946, Question 08.03.01-1. The response addresses the staff questions on automatic bus transfer of the Class 1E Medium Voltage switchgear buses to alternate preferred power source. The staff has the below follow-up questions to assess if the automatic bus transfer is capable of a voltage decay transfer (residual voltage transfer).

1. The applicant indicated that “If the fast transfer is blocked by the synchro-check relay output, a residual transfer will be performed automatically when the condition is met.” The applicant also indicated that bus transfer or reclosing will follow the guidance of ANSI/NEMA C50.41.

   According to ANSI/NEMA C50.41, for fast transfer or reclosing, calculations and/or tests should be performed to determine the expected vectorial Volts/Hertz. Please provide a summary of the calculation to ensure a residual transfer is achieved without any impact or damage to the Class 1E motors or any important to safety motors. The NRC staff recognizes that the studies need detailed knowledge of the motors, driven equipment and the power supply. Therefore, also provide the assumptions made for such calculations.

   The staff is also concerned about the possible causes of failure of bus transfer schemes. Please discuss that what measures would be taken to prevent such interruption of bus transfer. Typical examples of incomplete bus transfer could be due to the loss of motors because of inability to reaccelerate, out-of-phase transfer by setpoint error of under-voltage relays, motor contacts drop out, and current transformer saturation due to inrush current when SAT is loaded.

2. Discuss the protection relay selection and setting criteria for the bus transfer scheme.

3. In DCD Tier 1, Section 2.6, Table 2.6.1-3, Design Commitment item 8, discusses automatic bus transfer only. Please revise the DCD accordingly to reflect fast and residual bus transfer.

Response

The following provides KHNP's answers to each of the staff's requests:

Residual voltage transfer analysis

Residual voltage transfer is implemented if a fast transfer of a switchgear bus is blocked by the fast transfer scheme in order to avoid impact or damage to the connected motors. During the residual voltage transfer, the resultant V/Hz between a bus residual V/Hz and incoming source V/Hz is limited to 1.33 pu V/Hz at the instant the transfer is completed, according to ANSI/NEMA C50.41, Section 14.2.

In the APR1400 design, a residual voltage transfer is performed after the coast down voltage of a bus falls to less than the setting level (e.g., 0.3 pu) with a time delay (e.g., 200 ms). According to KHNP's analyses performed for the reference plants, the typical setting values ensure that in no case does the resultant V/Hz exceed 1.33 pu (aproximately 1 pu V/Hz).

The final setpoint of the undervoltage relay for residual voltage transfer (27R) will be determined based on the bus transfer study, which will be performed using the following input data:

- Voltage phase difference between two off-site sources
- Bus transfer initiation scenario
- Fault clearing time
- Dead bus time
- Dynamic modeling of motor loads
- Protective relay characteristics

Since some of the data and information above will be obtained from manufacturers or are site specific and the data will significantly affect the analysis result, the bus transfer study is to be performed by the COL applicant. KHNP will add a COL item, COL 8.3(14), to address performance of the bus transfer study by the COL applicant.

Discussion of bus transfer schemes

IEEE Std. 741 provides a discussion of the protection concerns related to automatic bus transfer. The concerns of incomplete bus transfer discussed in IEEE Std. 741 are adequately addressed in the APR1400 design by the following:

- Reacceleration of motors

  Upon receipt of a residual voltage signal, the feeder circuit breakers (CBs) of the non-Class 1E medium voltage (MV) motors are tripped automatically before the residual voltage

transfer. This load shedding scheme prevents the potential for motor reacceleration failure due to simultaneous starts of the non-Class 1E MV motors. After the CBs of the non-Class 1E MV motors are tripped, the switchgear bus is automatically transferred to the alternate power source which allows the operator to manually start the individual motors.

Unlike the non-Class 1E MV motors, the Class 1E MV motors remain connected during the residual transfer process. Reacceleration of the Class 1E motors will be analyzed by simulating simultaneous starts of the Class 1E motors at the instant the residual voltage transfer is completed. If the simultaneous starting of the Class 1E motors cannot be substantiated by the analysis, load shedding scheme will be considered to avoid reacceleration failure of the Class 1E motors.

- Setpoint error of undervoltage relay

  The undervoltage relay for residual voltage transfer (27R) needs to be adequate to measure voltage and operate correctly at low frequencies. When the COL applicant is selecting the type and model of the undervoltage relay, measuring tolerance at the low-frequency band will be verified.

- Motor contactors drop out

  The magnetic contactors of the motor control centers (MCCs) receive latching (close or open) signals from the component control system (CCS) so that the magnetic contactors, which were in the closed position before a residual voltage transfer, will be picked up again as soon as the MCC voltage is recovered after the bus transfer.

- Current transformer saturation due to the inrush current

  The current transformers (CTs) for the protective relays are designed not to be saturated by transformer magnetizing inrush current and also inrush current caused by a bus transfer. The turn ratio of the CTs has margin against the full-load current of the standby auxiliary transformers (SATs) and the turn ratio of CTs at the SATs is much higher (e.g., five times higher) than the full-load current of the SATs. These CT characteristics preclude undesirable operation of the associated protective relays.

Protection relay selection and setting criteria

Based on the results of the bus transfer study, selection and setting of the synchronism-check relay (25F) and undervoltage relay (27R) used for fast transfer and residual voltage transfer will also be developed by the COL applicant, as specified in the newly added COL 8.3(14), based on the following criteria:

- Synchronism-check relay

  The synchronism-check relay for fast transfer (25F) is to supervise that the voltages on both sides of the bus and the alternate source are in proper phase and voltage for bus transfer, thereby ensuring that the fast transfer is performed without excessive impact or damage on the connected motors in accordance with guidance in ANSI/NEMA C50.41, Section 14.3.

The synchronism-check relay should be accurate and a fast acting type to ensure proper implementation of the fast transfer.

The synchronism-check relay is set to adequately permit or block a fast transfer. The synchronism-check relay permits a fast transfer if voltage and phase angle differences between the bus and alternate source are within the predetermined value for each bus, which will be determined through the bus transfer study. The setpoints of the relay should consider an increase of the phase angle and resultant V/Hz differences during the relay operation and breaker closing time.

- Undervoltage relay

  As described above, the undervoltage relay for residual voltage transfer (27R) needs to be accurate enough to measure voltage and operate correctly at low frequencies.

  The undervoltage relay (27R) is set to provide reasonable assurance that the resultant V/Hz does not exceed 1.33 pu. A time delay is provided to preclude unintended operation of the undervoltage relay during the fault clearing time or fast transfer.

ITAAC for automatic bus transfer

The automatic bus transfer includes both the fast transfer and residual voltage transfer. DCD Tier 1, Table 2.6.1-3, ITAAC item 8 will be revised to clarify the automatic bus transfer includes both the fast transfer and residual voltage transfer.

Impact on DCD

DCD Tier 1, Table 2.6.1-3 and DCD Tier 2, Table 1.8-2 and Subsections 8.3.1.1 and 8.3.3 will be revised as shown in the attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

RAI 259-8335 - Question 08.03.01-21

Table 2.6.1-3 (3 of 6)

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
7.a The MG, UATs, MT, and GCB power feeders are separated from the SATs power feeders.	7.a Inspection and analysis of the as-built MG, UATs, MT, GCB, and SATs power feeders will be performed.	7.a The as-built MG, UATs, MT, and GCB power feeders are separated from the SATs power feeders by 3-hour-rated fire barriers.
7.b The MG, UAT, MT, and GCB instrumentation and control circuits are separated from the SATs instrumentation and control circuits.	7.b Inspection and analysis of the as-built MG, UATs, MT, GCB, and SATs instrumentation and control circuits will be performed.	7.b The as-built MG, UATs, MT, and GCB instrumentation and control circuits are separated from the SATs instrumentation and control circuits by 3-hour-rated fire barriers.
8. If the normal preferred offsite power supply is not available, Class 1E 4.16 kV medium voltage buses are automatically transferred to the alternate preferred offsite power supply.	8. Tests will be performed to verify that as-built Class 1E 4.16 kV medium voltage buses are automatically transferred to the alternate preferred offsite power supply.	8. Each as-built Class 1E 4.16 kV medium voltage buses are automatically transferred to the alternate preferred offsite power supply- when normal preferred offsite power supply is not available and alternate preferred power supply is available.
9. Instrumentation and control power for Class 1E medium voltage switchgear and load centers is supplied from the Class 1E dc power system in the same train.	9. Inspection of the as-built Class 1E medium voltage switchgear and load centers will be performed.	9. Instrumentation and control power for the as-built Class 1E switchgear and load centers of each train are supplied control power from their respective Class 1E trains.
10.a Independence is provided between each of the four trains of Class 1E distribution equipment and circuits.	10.a Tests will be performed on the as-built Class 1E distribution equipment and circuits by providing a test signal in only one train at a time.	10.a The test signal is present in the as-built Class 1E train under test.
10.b Independence is provided between Class 1E distribution equipment and circuits and non-Class 1E distribution equipment and circuits.	10.b Tests will be performed on the as-built Class 1E and non-Class 1E distribution equipment and circuits by providing a test signal in only one train for Class 1E or one division for non-Class 1E at a time.	10.b The test signal is present in the as-built Class 1E train or non-Class 1E division under test.

Add

through the fast transfer and residual voltage transfer schemes

Add

, through the fast transfer and residual voltage transfer schemes,

Table 1.8-2 (11 of 29)

RAI 259-8335 - Question 08.03.01-21

Item No.	Description
COL 8.3(1)	The COL applicant is to provide and to design a mobile generator and its support equipment.
COL 8.3(2)	The COL applicant is to describe and provide detailed ground grid and lightning protection.
COL 8.3(3)	The COL applicant is to provide testing, inspection, and monitoring programs for detecting insulation degradation of underground and inaccessible power cables within the scope of 10 CFR 50.65.
COL 8.3(4)	The COL applicant is to provide protective device coordination.
COL 8.3(5)	The COL applicant is to provide insulation coordination of surge and lightning protection.
COL 8.3(6)	The COL applicant is to develop the maintenance program to optimize the life and performance of the batteries.
COL 8.3(7)	The COL applicant is to provide short circuit analysis of onsite dc power system with actual data.
COL 8.3(8)	The COL applicant is to describe any special features of the design that would permit online replacement of an individual cell, group of cells, or entire battery.
COL 8.4(1)	The COL applicant is to identify local power sources and transmission paths that could be made available to resupply power to the plant following the loss of a grid or the SBO.
COL 8.4(2)	The COL applicant is to develop detailed procedures for manually aligning the alternate AC power supply when two (Trains A and B) of the four diesel generators are unavailable during a loss of offsite power event.
COL 9.1(1)	The COL applicant is to provide operational procedures and maintenance program as related to leak detection and contamination control.
COL 9.1(2)	The COL applicant is to maintain complete documentation of system design, construction, design modifications, field changes, and operations.
COL 9.1(3)	The COL applicant is to address the load-handling procedures. Load-handling procedures are established for component handling procedures and plant operating procedures in accordance with ASME B30.2. ASME B30.2 requires establishing component handling procedures that include (1) a safe load path for lifting heavy loads to perform special handling component inspections, (2) acceptance criteria prior to lift, and (3) use of steps and proper sequence in handling the load. ASME B30.2 requires plant operating procedure guidelines that include appropriate crane operator training and crane inspections. ASME B30.2 also requires that the load-handling procedures include preparing operating procedures for preoperational load testing and checkouts of interlocks, brakes, hoisting cables, control circuitry, and lubrication of OHLHS equipment.
COL 8.3(14)	The COL applicant is to provide a bus transfer study of the onsite power system. Based on the bus transfer study, the COL applicant is also to provide final relay selection and settings for the bus transfer (COL 8.3(14)).

Add

RAI 32-7946 - Question 08.03.01-1

RAI 259-8335 - Question 08.03.01-21

8.3 Onsite Power Systems

8.3.1 AC Power Systems

The COL applicant is to provide a bus transfer study of the onsite power system. Based on the bus transfer study, the COL applicant is also to provide final relay selection and settings for the bus transfer (COL 8.3(14)).

8.3.1.1 Description

The onsite ac power system includes standby power sources, distribution systems, and auxiliary supporting systems that are provided to supply power to safety-related equipment or equipment important to safety for all normal operating and accident conditions. There are four Class 1E emergency diesel generators (EDGs) and one non-Class 1E gas turbine generator (GTG). The alternate alternating current (AAC) source is used as a standby power source for the onsite ac power system. The four Class 1E EDGs provide backup power to the Class 1E 4.16 kV buses in the event of a loss of offsite power (LOOP). One Class 1E EDG is dedicated to the respective Class 1E 4.16 kV bus. The non-Class 1E AAC GTG provides backup power to the permanent non-safety (PNS) buses during a LOOP and the dedicated Class 1E 4.16 kV bus during a station blackout (SBO).

The Class 1E ac power system is supplied power from one of the two mobile generators in case of a beyond-design-basis external event. The connection box provided for the connection of a cable between the mobile generator and the 4.16 kV Class 1E bus is watertight. The connection box is installed in the entry and exit of the auxiliary building where the connection boxes are readily accessible to the mobile generator. The COL applicant is to provide and to design a mobile generator and its support equipment (COL 8.3(1)). In addition, Class 1E switchgear rooms are also designed with watertight exterior barriers and doors to prevent the inflow of floodwater.

The onsite power system consists of the Class 1E power system and the non-Class 1E power system. The onsite power system is normally powered from two unit auxiliary transformers (UATs). ~~In case the power is unavailable from the UATs, the power source for the connected onsite power system Class 1E and non-Class 1E buses is automatically transferred to the standby auxiliary transformers (SATs).~~

Add

If the normal preferred power source from UATs is unavailable, all Class 1E and non-Class 1E buses are automatically transferred to the alternate preferred power source from standby auxiliary transformers (SATs) by the fast and residual transfer scheme. For the automatic fast transfer, the synchro-check relay for each bus is used to supervise the voltage difference between the switchgear bus and upstream of the alternate feed incoming breaker and to provide a permissive for closing of the alternate feed incoming breaker to preclude unintended bus transfer. In case the fast transfer is not successful, residual transfer is performed automatically. The fast and residual transfer on each bus are permitted only when the alternate preferred power source from the SATs is available and the protection relay for the bus is not tripped.

Add

RAI 259-8335 - Question 08.03.01-21

The ground detector has an alarm in the MCR to monitor constant grounding and recording. The ground detector has high sensitivity.

8.3.3 Combined License Information

COL 8.3(1) The COL applicant is to provide and to design a mobile generator and its support equipment.

COL 8.3(2) The COL applicant is to describe and provide detailed ground grid and lightning protection.

COL 8.3(3) The COL applicant is to provide testing, inspection, and monitoring programs for detecting insulation degradation of underground and inaccessible power cables within the scope of 10 CFR 50.65.

COL 8.3(4) The COL applicant is to provide protective device coordination.

COL 8.3(5) The COL applicant is to provide insulation coordination of surge and lightning protection.

COL 8.3(6) The COL applicant is to develop the maintenance program to optimize the life and performance of the batteries.

COL 8.3(7) The COL applicant is to provide a short-circuit analysis of the onsite dc power system with actual data.

COL 8.3 (8) The COL applicant is to describe any special features of the design that would permit online replacement of an individual cell, group of cells, or entire battery.

8.3.4 References

1. IEEE Std. 141-1993, “IEEE Recommended Practice for Electric Power Distribution for Industrial Plants,” Institute of Electrical and Electronics Engineers, 1993.

Add

COL 8.3(14) The COL applicant is to provide a bus transfer study of the onsite power system. Based on the bus transfer study, the COL applicant is also to provide final relay selection and settings for the bus transfer (COL 8.3(14)).