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.:	**437-8540**
SRP Section:	**08.01 – Electric Power - Introduction**
Application Section:	**8.1**
Date of RAI Issue:	**03/08/2016**

Question No. 08.01-16

In RAI 8166, Question 08.01-3, dated August 31, 2015, the staff stated in part that APR1400 DCD Table 8.1-2, “Criteria and Guidelines for Electric Power Systems,” and Table 1.9-2, “APR1400 Conformance with the Standard Review Plan,” states that BTP 8-8, “Onsite (Emergency Diesel Generators) and Offsite Power Sources Allowed Outage Time Extensions,” February 2012, is not applicable. Since BTP 8-8 is applicable to sections 8.2 and 8.3.1 according to the Standard Review Plan (SRP), NUREG-0800, the staff asked the applicant to clarify whether BTP 8-8 is applicable to the ARP1400 design for the Class 1E emergency diesel generators (EDGs) discussed in section 8.3.1.1. In response to RAI 8166, Question 08.01-3, dated December 18, 2015, ADAMS Accession ML15352A274, the applicant stated in part that BTP 8-8 is not required for the APR1400 design, and that KHNP does not consider Allowed Outage Time (AOT) for diesel generators (DGs) at this time. In addition, KHNP indicated that the limiting conditions for operation (LCO) for emergency diesel generators (EDGs) is consistent with RG 1.93 and is in TS 3.8.1. The applicant is not committing to BTP 8-8, which is part of the guidance of SRP 8.2 and 8.3, and BTP 8-8 is based on RG 1.93, “Availability of Electric Power Sources.” RG 1.93 pertains to the availability of both offsite and onsite power systems and provides an acceptable method for satisfying 10 CFR 50, Appendix A, GDC 17 and 10 CFR 50.36(c)(2). Therefore, the staff requests that the applicant include in the DCD a commitment to following the guidance in RG 1.93 or provide an alternate method to satisfy GDC 17.

Response

As noted, commitment to RG 1.93 is currently included in DCD Tier 2 in several locations, including: the references in Subsection 8.1.3.3 and the Bases for LCOs 3.8.1, 3.8.4, 3.8.7 and 3.8.9. However for clarity and consistency, KHNP will add commitment to RG 1.93 to DCD Sections 8.2 and 8.3.1 at a minimum.

Impact on DCD

DCD Tier 2, Table 8.1-2 (3 of 8), Subsection 8.1.3.3, 8.2.2, 8.3.1.2, 8.3.1.2.2, 8.3.2.2, and 8.3.2.2.2 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.

- NRC RG 1.212, "Sizing of Large Lead-Acid Storage Batteries," November 2008.

- NRC RG 1.218, "Condition-Monitoring Techniques for Electric Cables Used in Nuclear Power Plants," April 2012.

Branch Technical Positions

- BTP 8-1, "Requirements for Motor-Operated Valves in the ECCS Accumulator Lines," Rev. 3, March 2007.

- BTP 8-2, "Use of Diesel Generator Sets for Peaking," Rev. 3, March 2007.

- BTP 8-3, "Stability of Offsite Power Systems," Rev. 3, March 2007.

- BTP 8-4, "Application of Single Failure Criterion to Manually Controlled Electrically Operated Valves," Rev. 3, March 2007.

- BTP 8-5, "Supplemental Guidance for Bypass and Inoperable Status Indication for Engineered Safety Features Systems," Rev. 3, March 2007.

- BTP 8-6, "Adequacy of Station Electric Distribution System Voltages," Rev. 3, March 2007.

- BTP 8-7, "Criteria for Alarms and Indications Associated with Diesel Generator Unit Bypassed and Inoperable Status," Rev. 3, March 2007.

- ~~BTP 8-8, "Onsite (Emergency Diesel Generators) and Offsite Power Sources Allowed Outage Time Extensions," February 2012.~~

Deleted

Bulletin

- BL 2012-01, "Design Vulnerability in Electric Power System," July 2012.

Table 8.1-2 (3 of 8)

Criteria		DCD Section				Remarks
		8.2	8.3.1	8.3.2	8.4	
3. RG		Guidance				
RG 1.6	Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems		G	G		
RG 1.9	Application, and Testing of Safety-Related Diesel Generators in Nuclear Power Plants		G		G	
RG 1.32	Criteria for Power Systems for Nuclear Power Plants	G	G	G		
RG 1.47	Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems		G	G		
RG 1.53	Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems		G	G		
RG 1.63	Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants		G	G		
RG 1.75	Physical Independence of Electric Systems		G	G		
RG 1.81	Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants					Not applicable

(G) Guidance provided in the subject document is applied to the noted section.

ADD

RG 1.93	Availability of electric power sources	G	G	G		

The necessary electric power is provided for all the facility's operating modes, including transients and design basis accidents (DBAs), to meet these criteria. Conformance with these requirements is accomplished by meeting the requirements of GDC 17.

8.2.2.2 Conformance with NRC Regulatory Guides

NRC Regulatory Guide 1.32

NRC RG 1.32 (Reference 16) is related to the criteria for power systems for nuclear power plants.

The design, operation, and testing of offsite power system for the APR1400 meet the requirements of NRC RG 1.32.

NRC Regulatory Guide 1.155

NRC RG 1.155 (Reference 17) is related to an SBO.

NRC Regulatory Guide 1.93
NRC RG 1.93 is related to the LCO(Limiting Conditions for Operation) for availability of electric power sources. The LCO for availability of electric power sources is addressed in Technical Specification 3.8.1, 3.8.4, 3.8.7, and 3.8.9.

The APR1400 has an AAC power source of sufficient capacity, capability, and reliability for operation of all systems necessary for coping with an SBO. The offsite power sources are fully independent from the AAC power source. Conformance with NRC RG 1.155 is described in Section 8.4.

NRC Regulatory Guide 1.160

NRC RG 1.160 (Reference 18) is related to monitoring the effectiveness of maintenance at nuclear power plants.

NRC RG 1.160 endorses Revision 4A of NUMARC 93-01 (Reference 19), which provides methods for complying with the provisions of 10 CFR 50.65 (Reference 20) with some provisions and clarifications. Conformance with RG 1.160 is addressed in Section 1.9.

d. Control

e. Instrumentation

If the trays are stacked, the order from top to bottom is as shown above.

Cables of each train run in separate raceways are physically separated from cables of the other trains. Separation of trains is in accordance with IEEE Std. 384, as endorsed by NRC RG 1.75. Raceways for non-Class 1E are separated from each Class 1E train A, B, C, and D in accordance with IEEE Std. 384. The raceway in the cable spreading area, main control room, and other congested areas is designed in accordance with IEEE Std. 384. The power and control wiring in control boards or panels is separated in accordance with IEEE Std. 420 (Reference 40).

Medium-voltage power cables are routed in an open-top ladder-type cable tray in a single layer with maintained spacing. The distance between adjacent cables within a tray is one-quarter the diameter of the larger cable. The cable tray fill criterion for low-voltage power cables does not exceed 30 percent of the cross-sectional area of the open-top ladder-type tray. The cable tray fill criterion for control cable does not exceed 50 percent of the cross-sectional area of the open-top ladder-type tray. Solid-bottom and solid-cover type cable trays are used for routing instrumentation cables, with an allowable fill of 50 percent of tray cross-sectional area. Cable splicing in a raceway is prohibited.

8.3.1.2 Analysis

The APR1400 Class 1E ac power system is designed to meet the requirements of GDCs 2, 4, 5, 17, 18, 33, 34, 35, 38, 41, 44, 50, and the intent of NRC RGs 1.6, 1.9, 1.32, 1.47, 1.53, 1.63, 1.75, 1.81, 1.106, 1.118, 1.153, 1.155, 1.160, and 1.204. The criteria and guidelines are shown in Table 8.1-2 and include their applicability in the electrical system design.

1.93,

The EPAs in containment structures are designed to meet NRC RG 1.63 and IEEE Std. 317, which is endorsed by the NRC. Conformance with NRC RG 1.63 is addressed in Subsection 8.3.1.1.9.

NRC Regulatory Guide 1.75

NRC RG 1.75 is related to the criteria for independence of electrical safety systems.

The independence of the onsite power system is described in Subsection 8.3.1.1.2.3. The cable and raceway design related to NRC RG 1.75 is addressed in Subsection 8.3.1.1.10. The Class 1E onsite power system is designed to meet the requirements of NRC RG 1.75.

NRC Regulatory Guide 1.81

NRC RG 1.81 is related to the criteria for shared emergency and shutdown electric systems for multi-unit nuclear power plants.

The APR1400 is a single-unit plant. Therefore, NRC RG 1.81 is not applicable to the APR1400.

NRC Regulatory Guide 1.106

NRC RG 1.106 is related to the thermal overload protection for electric motors on motor-operated valves (MOVs).

NRC RG 1.106 provides criteria to provide reasonable assurance that safety-related MOVs, whose motors are equipped with thermal overload protection devices integral with the motor starter, perform their safety function. The thermal overload protection devices for safety-related MOVs conform with the requirements of NRC RG 1.106.

NRC Regulatory Guide 1.118

NRC RG 1.118 is related to the periodic testing of electric power and protection systems.

NRC Regulatory Guide 1.93

NRC RG 1.93 is related to the LCO(Limiting Conditions for Operation) for availability of electric power sources. The LCO for availability of electric power sources is addressed in Technical Specification 3.8.1, 3.8.4, 3.8.7, and 3.8.9.

The inverters that provide reliable I&C power have sufficient capacity and capability to perform their intended function. The Class 1E 120 Vac I&C power system loads are listed in Table 8.3.2-3 and the inverter rating is shown in Table 8.3.2-4.

A 125 Vdc control center is provided for each of the 125 Vdc power system load groups. Each control center supplies power to its assigned bus and equipment and is powered directly from its associated 125 Vdc battery and battery chargers irrespective of the condition of other control centers. The Class 1E dc control center supplies power to one dc distribution panel and one static inverter.

8.3.2.1.2.7 Class 1E 125 Vdc Power System and 120 Vac Instrumentation and Control Power System Status Information

The parameters or status that are monitored in the MCR for the 125 Vdc power system and 120 Vac I&C power system are listed in Table 8.3.2-5.

Ammeters provided to monitor battery current have the capability to monitor both charge and discharge currents. Voltmeters are supplied to monitor dc and ac voltage of the buses and inverter distribution panels. The indications and alarms in the dc control center, battery charger control panel, and inverter distribution panel are listed in Table 8.3.2-5.

Ground fault detectors and their corresponding ground monitoring alarms are provided with sufficient sensitivity.

8.3.2.2 Analysis

The APR1400 Class 1E 125 Vdc power system is designed to meet the requirements of GDCs 2, 4, 5, 17, 18, 33, 34, 35, 38, 41, 44, and 50 and the intent of NRC RGs 1.6, 1.32, 1.47, 1.53, 1.63, 1.75, 1.81, 1.106, 1.118, 1.128, 1.129, 1.153, 1.155, 1.160, and 1.212. Table 8.1-2 includes their applicability of the GDC and NRC RGs to the electrical system design.

1.93,

NRC Regulatory Guide 1.75

NRC RG 1.75 is related to the criteria for the independence of electrical safety systems.

The independence of the onsite power system is described in Subsection 8.3.2.1.2.5. The cable and raceway design related to NRC RG 1.75 is addressed in Subsection 8.3.1.1.10. The Class 1E 125 Vdc onsite power system is designed to meet the requirements of NRC RG 1.75. Redundant Class 1E batteries are placed in separate safety class structures as required in IEEE Std. 384, which is endorsed by NRC RG 1.75.

NRC Regulatory Guide 1.81

NRC RG 1.81 is related to the criteria for shared emergency and shutdown electric systems for multi-unit nuclear power plants.

The APR1400 is a single-unit plant. Therefore, NRC RG 1.81 is not applicable to the APR1400.

NRC Regulatory Guide 1.93
NRC RG 1.93 is related to the LCO(Limiting Conditions for Operation) for availability of electric power sources. The LCO for availability of electric power sources is addressed in Technical Specification 3.8.1, 3.8.4, 3.8.7, and 3.8.9.

NRC Regulatory Guide 1.106

NRC RG 1.106 is related to the thermal overload protection for electric motors on motor-operated valves (MOVs).

NRC RG 1.106 provides the criteria to ensure that safety-related MOVs whose motors are equipped with thermal overload protection devices integral to the motor starter perform their safety function. The thermal overload protection devices for safety-related MOVs are in conformance with the requirements of NRC RG 1.106.

NRC Regulatory Guide 1.118

NRC RG 1.118 is related to the periodic testing of electric power and protection systems.

Class 1E dc power systems are designed to be testable during operation of the nuclear power generating station as well as when the station is shut down. IEEE Std. 338, which is endorsed by NRC RG 1.118, provides design and operational criteria for the performance

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Application Section:	**8.1**
Date of RAI Issue:	**03/08/2016**

Question No. 08.01-18

In RAI 8166, Question 08.01-6, dated August 31, 2015, the staff stated that APR1400 DCD Table 8.1-2 listed the Commission Papers (SECY)-90-016 and SECY-91-078, but their applicability to the design was not discussed in DCD chapter 8 or other DCD sections. Therefore, the staff requested that the applicant provide a discussion on how the APR1400 design meets the guidance in SECY 90-016 and SECY 91-078. In response to RAI 8166, Question 08.01-6, dated December 18, 2015, ADAMS Accession ML15352A274, the applicant stated in part that station blackout rule (10 CFR 50.63) is the one that is applicable to the APR1400 electrical power system design and is applicable to SECY-90-016 and that the APR 1400 design meets the recommendation in SECY-90-016. The applicant also indicated that SECY-91-078 identifies the following two issues and provides recommendations on these issues, (1) Alternate Source of Power for Non-Safety Loads, (2) Connection of Safety Bus Offsite Power Sources through Non-safety Loads. The APR1400 design complies with the staff's position with regard to the second issue of SECY-91-078, and the response to RAI 16-7915 (Reference KHNP submittal MKD/NW-15- 0029L, dated June 22, 2015; ML15173A091) provides further discussion and clarification. However, the staff did not identify a statement or discussion in the DCD that provides specific mention to SECY-90-016 and SECY-91-078, and a review of referenced RAI 7915 did not provide a change in the DCD with a statement for SECY-91-078. Therefore, the staff requests that the applicant provide an explanation or statement in the DCD as to how the APR1400 design meets SECY-90-016 and SECY-91-078.

Response

DCD Tier 2, Subsections 8.2.1.3 and 8.4.1.1 will be revised to add the statements on design conformance with SECY-91-078 and SECY-90-016.

Impact on DCD

DCD Tier 2, Subsections 8.2.1.3, 8.2.4, 8.4.1.1, and 8.4.4 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.

b. When the normal preferred power supply is not available, the alternate preferred power supply maintains its availability.

c. The switchyard buses where the preferred power source circuits are connected are arranged as follows:

1) Any incoming or outgoing transmission line for one preferred power source circuit can be switched without affecting the other preferred power source circuit.

2) When a switchyard circuit breaker is isolated under maintenance condition, there is no disruption of service to either preferred power sources circuit.

8.2.1.3 Offsite Power System Components and Circuits

The offsite power system components consist of the MG, IPB, GCB, MT, two UATs, and two SATs. The MG is connected to the transmission network when the generator reaches rated speed and output voltage, and paralleling to the transmission network is accomplished automatically or manually by using the synchroscope and synchronizer. In the event that the MG is not in service, this system is used to supply power from the transmission network to the station auxiliaries.

The APR1400 design includes two offsite circuits to each independent safety train that is supplied directly from an offsite power source with no intervening non-safety buses, thereby permitting the offsite source to supply power to safety buses regardless of failure of non-safety buses. The preferred power supply system has provisions to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the MG or loss of power from the onsite electric power sources. Two physically independent circuits connect the switchyard to the APR1400.

Each preferred power source has the capacity and capability to permit functioning of structures, systems, and components important to safety and all other auxiliary systems under normal, abnormal, and accident conditions. The normal preferred power circuit is connected to the high-voltage side of the MT. During power operation mode, the GCB is

Add

This design feature complies with GDC 17 and the staff's position in SECY-91-078 (Reference 29).

This design feature satisfactorily addresses SECY-91-078. Add

closed and the MG is connected to the transmission system through the MT and also supplies power to the UATs. The alternate preferred circuit is connected to the high-voltage side of the SATs. In case the power supply is unavailable from the UATs, the power supply is maintained because the onsite non-safety-related and safety-related bus connections are transferred automatically from the UATs to the SATs. When the normal preferred power supply is restored, the transfer from the SATs to the UATs is accomplished manually. The UATs and SATs are three-winding transformers connected to the onsite non-safety-related and safety-related buses through their low-voltage side windings. Both non-safety-related and safety-related buses are normally supplied from the UATs.

The IPB is used to connect the MG to the GCB. The IPB provides the electrical connection among the GCB, the MT, and the two UATs. The MT is composed of three single-phase transformers that are connected to the two UATs through the IPB.

The GCB is used as a means of providing immediate access of the onsite ac power systems to the offsite power system by isolating the MG from the MT and the UATs and allowing backfeeding of offsite power to the onsite ac power system. The GCB is capable of interrupting normal load current and maximum fault current during transient and various fault conditions. The APR1400 is designed to follow the guidance in Appendix A of Standard Review Plan (SRP) Section 8.2 (Reference 6). After the MT is connected to the transmission network by closing the switchyard breakers with the GCB open, the UATs supply plant startup power to auxiliary and service loads of the APR1400. As part of the normal turbine-generator shutdown process, the GCB is opened to separate the MG from the switchyard when the MG output has been reduced to almost no-load condition. After the MG is disconnected from the switchyard by opening the GCB, the MT remains connected to the network system and backfeeds plant shutdown power to the APR1400 through the UATs during plant shutdown.

The COL applicant is to design the offsite power system to detect, alarm, and automatically clear a single-phase open circuit condition at the primary sides of MT or SATs in accordance with NRC BL-2012-01 (COL 8.2(7)) (Reference 7).

The COL applicant is to describe how testing is performed on the offsite power system components (COL 8.2(8)). The ratings of the MG, GCB, MT, UATs, SATs, and IPB are shown in Table 8.2-1.

22. IEEE Std. 665-1995, “IEEE Standard for Generating Station Grounding,” Institute of Electrical and Electronics Engineers, 1995.

23. IEEE Std. 666-1991, “IEEE Design Guide for Electric Power Service Systems for Generating Stations,” Institute of Electrical and Electronics Engineers, 1991.

24. IEEE Std. 1050-1996, “IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations,” Institute of Electrical and Electronics Engineers, 1996.

25. IEEE Std. C62.23-1995, “IEEE Application Guide for Surge Protection of Electric Generating Plants,” Institute of Electrical and Electronics Engineers, 1995.

26. NUREG-0800, Standard Review Plan, BTP 8-6, “Adequacy of Station Electric Distribution System Voltages,” Rev. 3, U.S. Nuclear Regulatory Commission, March 2007.

27. NUREG-0800, Standard Review Plan, BTP 8-3, “Stability of Offsite Power Systems,” Rev. 3, U.S. Nuclear Regulatory Commission, March 2007.

Add

29. SECY-91-078, "Chapter 11 of the Electric Power Research Institute's (EPRI's) Requirements Document and Additional Evolutionary Light Water Reactor (LWR) Certification Issues," U.S. Nuclear Regulatory Commission, March 25, 1991.

8.4 Station Blackout

8.4.1 System Description

Station blackout (SBO) is the complete loss of alternating current (ac) electric power to the Class 1E and non-Class 1E switchgear buses in the APR1400. The SBO involves the loss of offsite power (LOOP) concurrent with a turbine trip and failure of the onsite emergency ac power system, but it does not include the loss of available ac power to buses fed by station batteries through inverters or the loss of the power from the alternate ac (AAC) source.

8.4.1.1 Description

The offsite and onsite power systems are designed with sufficient independence, capacity, and capability to meet the requirements of General Design Criterion (GDC) 17 (Reference 1). The offsite and onsite systems are also designed to permit periodic inspection and testing in accordance with GDC 18 (Reference 2). The electrical connections between the offsite power system and onsite power systems are described in Section 8.2. The onsite power system is described in Section 8.3.

During an SBO, a non-Class 1E AAC gas turbine generator (GTG) with sufficient capacity, capability, and reliability provides power for the set of required shutdown loads (non-design-basis accident) to bring the plant to safe shutdown. The AAC GTG is started and manually connected to the ~~set of required~~ shutdown ~~equipment~~ within 10 minutes in accordance with Position C.3.2.5 of NRC RG 1.155 (Reference 3).

bus

RAI 24-7928-Question 08.04-2

Add

Training and procedures necessary to cope with an SBO for APR1400 plant operators are described in Section 13.2 and Section 13.5.

The application of the AAC GTG to cope with an SBO meets 10 CFR 50.63 (Reference 4) and SECY-90-016 (Reference 8).

8.4.1.2 Station Blackout Coping Duration

RAI 437-8540-Question 08.01-18

Delete

The SBO coping duration is determined by the ~~following~~ four design factors as specified in 10 CFR 50.63 ~~(Reference 4) and~~ NRC RG 1.155 Position C.3.1.

8.4.3 Combined License Information

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.

8.4.4 References

1. 10 CFR Part 50, Appendix A, General Design Criterion 17, “Electric Power Systems,” U.S. Nuclear Regulatory Commission.

2. 10 CFR Part 50, Appendix A, General Design Criterion 18, “Inspection and Testing of Electric Power Systems,” U.S. Nuclear Regulatory Commission.

3. Regulatory Guide 1.155, “Station Blackout,” U.S. Nuclear Regulatory Commission, August 1988.

4. 10 CFR 50.63, “Loss of All Alternating Current Power,” U.S. Nuclear Regulatory Commission.

5. Regulatory Guide 1.9, “Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants,” Rev. 4, U.S. Nuclear Regulatory Commission, March 2007.

6. NSAC-108, “Reliability of Emergency Diesel Generators at U.S. Nuclear Power Plants,” Electric Power Research Institute, September 1986.

7. NUMARC 87-00, “Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors,” Rev. 1, Nuclear Energy Institute, August 1991.

Add

8. SECY-90-016, "Evolutionary Light Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements," U.S. Nuclear Regulatory Commission, January 12, 1990.