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.:	**422-8536**
SRP Section:	**08.03.01 – AC Power System (Onsite)**
Application Section:	**8.3.1**
Date of RAI Issue:	**03/01/2016**

Question No. 08.03.01-24

The RAI Response 7984, Question 08.03.01-6, provided Degraded Voltage Relay (DVR) and Loss of Voltage Relay (LOV) setpoints and time delays. The staff requests response to the follow-up items below:

1. The response related to DVR time delay states that the first time delay duration is 60 Seconds and the second time delay is typically set at 4 minutes. The staff finds that these time delays are not consistent with the staff position B.1.b, described in Branch Technical Position BTP 8-6. The BTP requires “The subsequent occurrence of a safety injection signal (SIAS) should immediately separate the Class 1E distribution system from the offsite power system. In addition, the DVR logic should appropriately function during the occurrence of an SIAS followed by a degraded voltage condition.” The applicant is requested to provide justification as to how the time delays chosen will meet accident analysis assumptions if DVR occurs concurrent with a loss of coolant accident (LOCA).

2. Section 8.3.1.1.3.12 of the DCD states that the DVR and LOV protection schemes are designed in accordance with recommendation of IEEE Std. 741. NRC has not endorsed IEEE 741 and does not agree with the current version. Please confirm that the applicant meets all staff positions described in BTP 8-6 for DVR and LOV protection schemes.

3. Additionally, Section 8.3.1.1.3.12 of the DCD states that the drop-out for the second level undervoltage relays for the Class 1E distribution system is set at a level above the minimum voltage that allows proper operation of safety loads with the worst-case line-up and minimum switchyard voltage. The voltage studies for DVR typically are based on the minimum voltage requirements of equipment performed in conformance with BTP 8-6, Subsection B.1.a. Please clarify that this is the intent of the applicant’s selection of analytical voltage limits and time delays for DVR.

Please revise the DCD Section 8.3.1.1.3.12 accordingly.

Response

The answers provided below correspond to each of the staff's questions.

1. In the APR1400 design, two separate time delays are provided in the second level undervoltage relay, referred to as the degraded voltage relay (DVR), in accordance with Branch Technical Position (BTP) 8-6, Subsection B.1.b.

   The first time delay is selected to be long enough to ride through motor starting and acceleration time. The time delay duration is typically set at 60 seconds based on the total sequence loading time of the required Class 1E loads for accident mitigation, including relay operation time. In a degraded voltage condition, the DVR relay provides an alarm to the operator in the main control room (MCR) when the first time delay of DVR is exceeded. In the case of a safety injection actuation signal (SIAS) following the first DVR time delay, the Class 1E bus is immediately disconnected from the offsite power system by the DVR control scheme in accordance with BTP 8-6, Subsection B.1.b.i.

   The setpoint of the two DVR time delays will be based on the total sequence loading time and equipment characteristic that are to be established by the protective device coordination of the COL applicant as described in COL 8.3(4).

2. The Class 1E 4.16 kV bus degraded voltage relay scheme is designed to meet the requirements of BTP 8-6 as described in DCD Tier 2, Subsection 8.3.1.1.2.3. The design compliance of the APR1400 with the staff's positions for DVR and LOV protection schemes described in BTP 8-6 is provided in Table 1 of this response.

   DCD Tier 2, Subsections 8.3.1.1.3.12 and 8.3.1.3.4 will be revised to clarify that the degraded voltage and loss of voltage protection are designed in accordance with BTP 8-6.

3. The selection of the voltage limit and time delays of the DVR are determined from the voltage studies performed in conformance with BTP 8-6, Subsection B.3. The voltage studies consider the characteristics of the Class 1E equipment, circuit breakers, and thermal overload relays to determine the appropriate setpoints of the DVR time delay. The selection of the voltage limit and time delay setpoints of the DVR will be established and coordinated with other protective devices by the COL applicant as stated in COL 8.3(4).

   To maintain consistency between DCD chapters, DCD Tier 2, Table 1.9-2 (18 of 33 page) will be revised as shown in the attachment.

Table 1. Design Compliance of APR1400 with BTP 8-6 for DVR and LOV Protection Schemes

Branch Technical Position of BTP 8-6	APR1400 Design Compliance
1. In addition to the undervoltage scheme provided to detect LOOP at the Class 1E buses, a second level of undervoltage protection with time delay should be provided to protect the Class 1E equipment. This second level of undervoltage protection should satisfy the following criteria: a. The selection of undervoltage and time delay setpoints should be determined from an analysis of the voltage requirements of the Class 1E loads at all onsite system distribution levels.	The first-level undervoltage relays and second-level undervoltage relays are provided in each Class 1E bus to detect loss of voltage and degraded voltage condition of the Class 1E bus. To establish setpoints of the undervoltage and time delays for DVR, voltage studies are to be performed in conformance with BTP 8-6, Subsection B.3 as described in DCD Tier 2, Subsection 8.3.1.1.3.12.
b. Two separate time delays should be selected for the second level of undervoltage protection based on the following conditions: i. The first time delay should be long enough to establish the existence of a sustained degraded voltage condition (i.e., something longer than a motor-starting transient). Following this delay, an alarm in the control room should alert the operator to the degraded condition. The subsequent occurrence of a safety injection actuation signal (SIAS) should immediately separate the Class 1E distribution system from the offsite power system. In addition, the degraded voltage relay logic should appropriately function during the occurrence of an SIAS followed by a degraded voltage condition.	The first time delay for DVR is set to ride out power system transients and initiate action in a time that is consistent with the accident analysis as described in DCD Tier 2, Subsection 8.3.1.1.3.12. Following the first time delay of the DVR, a degraded voltage alarm in the MCR is annunciated. The Class 1E bus is disconnected automatically from the offsite power system if an SIAS occurs following the first time delay of DVR.
ii. The second time delay should be limited to prevent damage to the permanently connected Class 1E loads. Following this delay, if the operator has failed to restore adequate voltages, the Class 1E distribution system should be automatically separated from the offsite power system. The bases and justification for such an action must be provided in support of the actual delay chosen.	The second time delay for DVR is set to protect the connected Class 1E equipment from damage due to the sustained voltage degradation. After the second time delay of the DVR, the Class 1E bus is disconnected automatically from the offsite power system. The second time delay is established based on the characteristics of Class 1E equipment, circuit breaker, and thermal overload relay as described in item 1.b of the response to RAI 7984, Question 08.03.01-6 dated Sep. 8, 2015 (ADAMS Accession ML15251A245)

Branch Technical Position of BTP 8-6	APR1400 Design Compliance
c. The voltage sensors should be designed to satisfy the following applicable requirements derived from IEEE Std. 279 and/or IEEE Std. 603, as endorsed by RG 1.153: ii. An independent scheme should be provided for each division of the Class 1E power system. iii. The undervoltage protection should include coincidence logic on a per bus basis to preclude spurious trips of the offsite power source. iv. The voltage sensors should automatically initiate the disconnection of offsite power sources whenever the voltage setpoint and time delay limits (cited in item 1.b.2 above) have been exceeded. vi. Annunciation must be provided in the control room for any bypasses incorporated in the design.	Each Class 1E switchgear has independent detection schemes for the first-level undervoltage relay (LVR) and second-level undervoltage relay (DVR). The two-out-of-four coincidence logic is provided in each detection scheme to preclude nuisance tripping of the Class 1E bus due to any erroneous operation of any single LVR or DVR. When the voltage setpoint and time delay limit of the relays are exceeded, each LVR or DVR sends an individual detection signal to the component control system (CCS) to trip the incoming circuit breaker of the Class 1E switchgear. In case the Class 1E bus voltage drops below the voltage limit of LVR, the Class 1E bus is disconnected automatically from the offsite power system. During the degraded voltage condition on the Class 1E bus, after the first time delay of DVR, a degraded voltage alarm in the MCR is annunciated. The occurrence of an SIAS following the first time delay or after the second time delay of DVR, the Class 1E bus is disconnected from the offsite power system. The compliance with these requirements are provided in item 1.b of the response to RAI 7984, Question 08.03.01-6 dated Sep. 8, 2015 (ADAMS Accession ML15251A245).
2. The Class 1E bus load shedding scheme should automatically prevent shedding during sequencing of the emergency loads to the bus. The load shedding feature should, however, be reinstated upon completion of the load sequencing action.	The first time delay of DVR is typically set at 60 seconds. This value is based on the total sequence loading time of the Class 1E motor loads and the operation time of the undervoltage relay. The compliance with this requirement is provided in item 1.b of the response to RAI 7984, Question 08.03.01-6 dated Sep. 8, 2015 (ADAMS Accession ML15251A245).

Impact on DCD

DCD Tier 2, Table 1.9-2 and Subsections 8.3.1.1.3.12 and 8.3.1.3.4 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.

APR1400 DCD TIER 2

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Table 1.9-2 (18 of 33)

SRP Section/Title	Revision / Issue Date	Conformance or Summary Description of Deviation	DCD Tier 2 Section
BTP 8-5 – Supplemental Guidance for Bypass and Inoperable Status Indication for Engineered Safety Features Systems	Rev. 3 03/2007	The APR1400 conforms with this BTP.	8.1.3.3, ~~8.3.1.2.2,~~ delete ~~8.3.2.2.2~~ add 8.3.1.2.3 Table 8.1-2
BTP 8-6 – Adequacy of Station Electric Distribution System Voltages	Rev. 3 03/2007	The APR1400 conforms with this BTP ~~with the exception of B.1~~. ~~The Class 1E distribution system is separated from the offsite power system by the secondary undervoltage relay regardless of the occurrence of an SIAS.~~ delete	8.1.3.3, 8.2.2.3, 8.3.1.1.2.3, 8.3.1.1.3.12, Table 8.1-2 RAI 177-8166 - Question 08.01-10 add 8.3.1.3.4
BTP 8-7 – Criteria for Alarms and Indications Associated with Diesel-Generator Unit Bypassed and Inoperable Status	Rev. 3 03/2007	The APR1400 conforms with this BTP. 7.5.1.3, 8.1.3.3, 8.3.1.2.3, Table 8.1.2	~~8.1.3.3, 8.3.1.1.3 Table 8.1-2~~
BTP 8-8 – Onsite (Emergency Diesel Generators) and Offsite Power Sources Allowed Outage Time Extensions	02/2012	Not applicable RAI 177-8166 - Question 08.01-11	N/A
9.1.1 – Criticality Safety of Fresh and Spent Fuel Storage and Handling	Rev. 3 03/2007	The APR1400 conforms with this SRP.	9.1.1
9.1.2 – New and Spent Fuel Storage	Rev. 4 03/2007	The APR1400 conforms with this SRP.	9.1.2
9.1.3 – Spent Fuel Pool Cooling and Cleanup System	Rev. 2 03/2007	The APR1400 conforms with this SRP.	9.1.3
9.1.4 – Light Load Handling System and Refueling Cavity	Rev. 4 07/2014	The APR1400 conformance with acceptance criteria 5 is not applicable for the APR1400 design certification. (APR1400 is a single unit.)	9.1.4
9.1.5 – Overhead Heavy Load Handling Systems	Rev. 1 03/2007	The APR1400 conformance with exceptions. Criterion 5 is not applicable for the APR1400 design certification. (APR1400 is a single unit.)	9.1.5
add BTP 8-9 – Open Phase Conditions in Electric Power System	Rev. 0 07/2015	The APR1400 conforms with this BTP	8.1.3.1, 8.1.3.3, 8.2.1.3, 8.2.2.3, Table 8.1-2

RAI 178-8184 - Question 08.02-7

isolation devices that serve to remove from service any element of the onsite power system when that element is subjected to an abnormal condition that may prove detrimental to the effective operation or integrity of the unit.

Protective devices for the Class 1E ac power system are designed with the same as non-Class 1E ac power system described in Subsections 8.3.1.1.1.1, 8.3.1.1.1.2, and 8.3.1.1.1.3.

Protective device coordination studies are performed in accordance with IEEE Std. 141 and IEEE Std. 242 to verify that breakers closest to a fault open before upstream breakers. The protective relaying system for the Class 1E ac distribution system, dc distribution system, I&C system, electrical penetrations in the reactor containment building, and motor-operated valves (MOVs) is designed in accordance with IEEE Std. 741 (Reference 17) as endorsed by NRC RG 1.106 (Reference 18).

Class 1E buses are provided with separate bus voltage monitoring and protection schemes for degraded voltage and loss of voltage conditions, respectively. These schemes are designed in accordance with the recommendations of ~~IEEE Std. 741~~. Two separate time delays are selected for degraded voltage protection as recommended in IEEE Std. 741 Appendix A.

add

BTP 8-6

There are of four first-level undervoltage relays to detect loss of voltage and four second-level undervoltage relays to detect degraded voltage on each of the four Class 1E buses. These relays consist of a two-out-of-four coincidence logic in the component control system (CCS) that starts the EDG, trips the incoming breakers of the Class 1E 4.16 kV bus, sheds load, closes the EDG breaker on the switchgear, and begins sequencing.

The dropout for the first-level undervoltage relays for the Class 1E distribution system is set at a level below minimum voltage during motor starting. Its associated time delay is set to ride out power system transients and initiate action in a time that is consistent with the accident analysis.

The dropout for the second-level undervoltage relays for the Class 1E distribution system is set at a level above the minimum voltage that allows proper operation of safety loads with the worst-case line-up and minimum switchyard voltage. Its associated first time delay is

set to establish existence of a sustained undervoltage longer than motor starting. The second time delay is limited so that the connected Class 1E equipment is not damaged.

Voltage studies are to be performed in conformance with BTP 8-6, Subsection B.3. The results are to be verified by testing as described in BTP 8-6, Subsection B.4.

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Voltage studies are used to determine the relay pickup and time delays of all levels of the undervoltage protection described above. The capability to test and calibrate during power operation is provided and annunciation in the MCR and RSR is provided for any bypasses incorporated into the design.

Following the first time delay, an alarm is provided in the MCR. The subsequent occurrence of a safety injection actuation signal (SIAS) immediately separates the Class 1E bus from the offsite power system.

8.3.1.1.4 Electrical Equipment Layout

The locations of Class 1E and non-Class 1E electrical equipment rooms shown in Figure 8.2-1 are selected to minimize vulnerability to physical damage. The electrical equipment is located away from mechanical piping in order to minimize the damaging effects of pipe ruptures. Separation is achieved by locating equipment and circuits in separate rooms, maintaining distance, or use of barriers. The potential hazard of non-safety-related equipment failure on safety-related redundant equipment is considered in the choice of equipment location or protection.

The followings are the general features of the electrical equipment layout:

a. The Class 1E switchgears, load centers, and MCCs of the independent train are located in four separate rooms of the auxiliary building. Separate ventilation systems are used for each room powered from the corresponding train.

b. Class 1E batteries are located in the auxiliary building. Each battery is located in a separate room and each room is equipped with a separate ventilation system powered from the corresponding train.

c. Four separate and independent cable routes are provided for the four Class 1E trains A, B, C, and D in accordance with IEEE Std. 384.

Acceptance criteria for EDG loading are described in Subsection 8.3.1.1.3.6. Safety and non-safety motors, switchgears, load centers, MCCs, and distribution transformers are included in load flow and voltage regulation studies.

8.3.1.3.2 Short-Circuit Studies

Analysis is performed to demonstrate maximum short-circuit current by considering the bus fault in the onsite ac power system. ETAP, based on IEEE Std. C37 series, is used for short-circuit studies. Short-circuit current for each study case is less than the acceptance criteria, which are the applicable circuit breaker interrupting and close and latch ratings described in Table 8.3.1-6. Buses of switchgears and load centers are considered for maximum fault current analysis. Containment electrical penetration assemblies are protected by overload and short-circuit current in accordance with IEEE Std. 741.

8.3.1.3.3 Equipment Sizing Studies

add

and verified using ETAP analysis. The ratings of major electrical system components are not exceeded when load flow, short-circuit, and motor starting analysis are performed under normal and abnormal operation modes, including DBAs.

Electrical equipment sizing of the distribution system is performed using the spreadsheet load list. The medium-voltage switchgear loads are listed in Table 8.3.1-1. The Class 1E EDG loads are shown in Tables 8.3.1-2 and 8.3.1-3. The AAC GTG loads are shown in Tables 8.3.1-4 and 8.3.1-5.

8.3.1.3.4 Equipment Protection and Coordination Studies

The protective relaying coordination of onsite distribution system is performed so that the circuit breaker separates the faulted electrical equipment from service in sufficient time to minimize the extent of damage to the faulted equipment and to prevent damage to other electrical equipment. The degraded voltage and loss of voltage protection and time delay function are in accordance with ~~IEEE Std. 741~~. The COL applicant is to provide protective device coordination (COL 8.3(4)).

add BTP 8-6

8.3.1.3.5 Insulation Coordination (Surge and Lightning Protection)

Surge and lightning protection is provided for the security of equipment and personnel from transient overvoltage due to lightning and electrical faults. Electrical equipment protected from lightning includes the main transformer, unit auxiliary transformer, standby auxiliary