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.: **164-8179**

SRP Section: **09.05.03 – Lighting Systems**

Application Section:

Date of RAI Issue: **08/20/2015**

Question No. 09.05.03-1

DCD Tier 2, Section 9.5.3.3 states: "The emergency AC [alternating current] lighting powered from the Class 1E sources is classified as non-Class 1E circuits. Lighting circuits are electrically isolated from Class 1E circuits by the use of isolation devices and separation distance as indicated in IEEE Std. [Standard] 384-1992." IEEE Std. 384-1992 "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits," is endorsed by NRC RG 1.75, "Criteria for Independence of Electrical Safety Systems." IEEE Std. 384 requires electrical isolation of power circuits to be achieved by Class 1E isolation devices that must meet certain criteria. NRC RG 1.75, Position (1) provides additional criteria (capability and periodic testing) for an acceptable breaker or fuse that is automatically opened by fault current.

a. Please provide additional information about the isolation devices such as class, type, and number of isolation devices, which will be used to electrically isolate the Class 1E circuits from the non-class 1E lighting circuits. Also, please discuss how the APR1400 design conforms with NRC RG 1.75 in regards to lighting systems.

b. Please provide an ITAAC for the isolation devices in DCD Tier 1, Section 2.6.8.1 to confirm recommendations of NRC RG 1.75. In addition, please provide reference to IEEE Std. 384-1992 and NRC RG 1.75 in DCD Tier 2, Section 9.5.11, "References," for completeness.

Response

The following provides a response to each item of the staff's request above.

a. In the APR1400 lighting system, molded case circuit breakers (MCCBs) complete with associated relay(s) and protective devices(s) are used as isolation devices between the Class 1E motor control centers (MCCs) and non-class 1E lighting circuits. As the Class 1E feeder circuit breakers for non-Class 1E lighting circuits are chosen as isolation devices, the cables feeding the emergency AC lighting circuits are non-Class 1E and

routed on the non-Class 1E raceways (e.g. trays, conduits, etc.). The minimum separation distance according to IEEE Std. 384 is maintained between the non-Class 1E cables feeding emergency AC lighting and the cables of Class 1E divisions, from the origin to the destination of the non-Class 1E cables.

In addition, the MCCBs being used as isolation devices between the Class 1E MCCs and the non-Class 1E lighting circuits have the proper capabilities according to RG 1.75 and IEEE Std. 384-1992. Periodic testing to demonstrate the capability of the isolation device will be performed in accordance with RG 1.75, Regulatory Position (1). DCD Tier 2, Subsection 8.3.1.1.2.3 will be revised to incorporate conformance with Regulatory Position (1) of RG 1.75.

b. The isolation devices between Class 1E buses and non-Class 1E loads are part of the Class 1E onsite electrical system and specified in DCD Tier 2, Subsection 8.3.1.1.2.3. The ITAAC for the isolation devices is described in DCD Tier 1, Table 2.6.1-3 as item No. 17, which covers all electrical isolation devices between Class 1E buses and non-Class 1E loads including the emergency AC lighting circuits.

   IEEE Std. 384-1992 and NRC RG 1.75 will be added in DCD Tier 2, Section 9.5.11, “Reference”.

Impact on DCD

DCD Tier 2, Subsections 8.3.1.1.2.3 and 9.5.11 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.

Following a LOOP, the associated Class 1E EDGs are started and the safety buses are isolated from offsite sources and fed solely from the associated EDG. The four load sequencers (one for each Class 1E bus) used for bus load shedding and load sequencing are independent from one another. The Class 1E 4.16 kV bus degraded voltage relay scheme is designed to meet the requirements of Branch Technical Position (BTP) 8-6 (Reference 8). The protective relay scheme is described in detail in Subsection 8.3.1.1.2.12.

The isolation devices meet Regulatory Position (1) of RG 1.75.

Non-Class 1E loads are connected to the Class 1E bus by Class 1E isolation devices. Pressurizer heater backup groups are provided power from the Class 1E 4.16 kV bus in accordance with 10 CFR 50.34 (Reference 9). Emergency ac lighting is powered from the Class 1E 480V MCC buses. Emergency lighting is described in Subsection 9.5.3.

The physical separation between the redundant equipment, including cables and raceways, is designed in accordance with IEEE Std. 384 as endorsed by NRC RG 1.75. The design criteria for the cable designs are described in Subsection 8.3.1.1.10. The identification of onsite power system components, including cables and raceways, is described in Subsection 8.3.1.1.10.

8.3.1.1.2.4 System Capacity and Capability

The Class 1E onsite power system has four independent trains. Each train is connected to one EDG. The selected two EDGs (trains A and C or trains B and D) are sufficient to meet the emergency load requirements for a safe shutdown during a LOOP concurrent with LOCA conditions.

The Class 1E EDG rating shown in Tables 8.3.1-2 and 8.3.1-3 is based on the characteristics of each load and the combined bus load demand connected to each diesel generator during the worst-case operating condition. Trains A and B EDGs are rated at 9,100 kW continuous rating and 10,010 kW short-time rating (2 hours), and trains C and D EDGs are rated at 7,500 kW continuous rating and 8,250 kW short-time rating.

Each EDG is designed to attain a rated voltage and frequency within 17 seconds after receipt of a start signal, supply power to its Class 1E 4.16 kV bus within 19 seconds, and begin to accept sequenced loads to meet the response times assumed in Chapter 15 analyses. The loading sequence and bases are shown in Tables 8.3.1-2 and 8.3.1-3.

79. Regulatory Guide 1.137, “Fuel Oil Systems for Nuclear Power Plant,” Rev. 3, U.S. Nuclear Regulatory Commission, June 2013.

80. Regulatory Guide 1.32, “Criteria for Power Systems for Nuclear Power Plant,” Rev. 3, U.S. Nuclear Regulatory Commission, March 2004.

81. NFPA 101, “Life Safety Code,” National Fire Protection Association, 2012.

82. IEEE 384-1992, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits," Institute of Electrical and Electronics Engineers, 1992.

83. Regulatory Guide 1.75, "Criteria for Independence of Electrical Safety Systems," Rev. 3, U.S. Nuclear Regulatory Commission, February 2005.

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SRP Section: **09.05.03 – Lighting Systems**

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Question No. 09.05.03-2

DCD Tier 2, Section 9.5.3.1 stated that the lighting systems provide adequate illumination levels as specified in NUREG 0700, “Human-System Interface Design Review Guidelines,” and IESNA lighting handbook in various areas of the plant during normal and off-normal conditions.

Please provide the illumination levels for normal lighting for: (1) various tasks and work areas as specified in NUREG-0700, Table 12.1, “Nominal illumination levels for various tasks and work areas,” (2) in-plant areas as specified in NUREG-0700, Table 12.10, “Range of recommended illuminances for inspection/assembly activities,” and (3) all other areas/rooms of the plant that are required for control and maintenance of equipment and plant access routes during normal plant operations.

Response

The illumination level for normal lighting in the APR 1400 standard design is provided as indicated in the attachment.

Impact on DCD

There is no impact on the DCD.

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.

Normal Illumination Levels (Including Essential)

Building	Area	Recommended Lux
Reactor Containment	- Operation Deck	300
	- Others	200
Auxiliary	- Main Control Room	
	a. Operator Console	300~1000[1]
	b. LDP Area	100~500[1]
	c. Safety Console & Auxiliary Control Panel	250~750[1]
	- Computer Room	700
	- TSC	700
	- I&C Equip. Room	300
	- Remote Shutdown Room	300~1000
	- Sample Room	700
	- Fuel Handling over Pools	300
	- Fuel Transfer Pit	400
	- Others	100~500

[1] Dimming Controlled.

Normal Illumination Levels (Including Essential)

Building	Area	Recommended Lux
Auxiliary (Cont.)	- Others	100~500
Turbine Generator	- Operation Deck	200
	- Other	200
Compound	- Laboratory, Instru. Repair Room	700
	- Secondary Sample Room	700
	- Office	500
	- OSC	700
	- Counting Room	700
	- Control Room	750
	- Drumming Area	200
	- Other	200
Others	- Battery Room	200

Normal Illumination Levels (Including Essential) (Cont.)

Building	Area	Recommended Lux
Others (Cont.)	- General Office	500
	- Chemical Storage Room	200
	- Wash Room, Locker Room	200
	- Corridors	100
	- Stairway	100
	- ESW BLDG. , CW Pump House	200
	- Radioactivity Pollute Area (Sump Pump Area)	200
	- Cable Spreading Room	50
	- Fire Pump & Water/ Wastewater Treatment Bldg.	200
	- Electrical Equipment Room such as Switchgear, MCC, LC, Relay, and Protection Panel	300

Normal Illumination Levels (Including Essential) (Cont.)

Building	Area	Recommended Lux
Others (Cont.)	- Machine Room such as HVAC, Pump, and Valve Room	200
	- Outdoor Switchyard Areas	10
	- Outdoor Transformer Areas	50
	- Tunnels	100
	- Road way	10
	- Lobby	200

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Question No. 09.05.03-3

DCD Tier 2, Section 9.5.3.2 states: "[The normal lighting system] is energized from non-Class 1E 480 VAC buses and permanent non–safety [PNS] buses as long as power is available from the standby auxiliary transformers or unit auxiliary transformers. […]. Emergency AC lighting system is energized from Class 1E 480 Volts AC (VAC) bus backed up by the Class 1E EDG and the non-

Class 1E AAC [alternate AC] source to provide reasonable assurance that the emergency lighting AC system is available during a LOOP [loss of offsite power]." However, as stated in DCD Tier 2, Section 8.4, the non-Class 1E AAC source provides backup power to the non-Class 1E PNS 4.16 Kilo Volts (KV) buses during a LOOP and to the dedicated Class 1E 4.16 KV bus during a station

blackout (SBO).

Please provide the backup power sources for the emergency AC lighting system during the following events: 1) a LOOP and 2) an SBO.

Response

The emergency AC lighting is energized by Class 1E 480 VAC bus backed up by the Class 1E EDG during a LOOP and the non-Class 1E AAC source during an SBO. DCD Tier 1 Subsection 2.6.8.1 and Tier 2 Subsection 9.5.3.2 will be revised accordingly.

Impact on DCD

DCD Tier 1 Subsection 2.6.8.1 and DCD Tier 2 Subsection 9.5.3.2 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.

2.6.8 Lighting Systems

2.6.8.1 Design Description

The plant lighting system is non-Class 1E and consists of two subsystems which are normal lighting and emergency lighting. Emergency lighting system is divided into emergency ac and dc lighting system.

1. The functional arrangement of the lighting system is as described in the Design Description of Subsection 2.6.8.1.

2. The normal lighting system provides normal levels of illumination throughout the plant and is powered from the non-Class 1E ac buses.

3. The emergency ac lighting system is powered from the Class 1E ac buses backed-up by the Class 1E emergency diesel generators.

4.a There are two configurations for lighting during a LOOP and the non-Class 1E AAC source during an SBO lighting system, lighting fixtures powered self-contained battery pack unit lighting fixtures.

4.b The emergency dc lighting fixtures equipped with self-contained rechargeable battery pack are powered from Class 1E or non-Class 1E ac in accordance with area designation. The emergency illumination level is at least 0.1 foot-candle at the floor level for 8 hours.

5. The emergency illumination levels in MCR and RSR are minimum 10 foot-candle for 8 hours.

2.6.8.2 Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.6.8-1 specifies the inspections, tests, analyses, and associated acceptance criteria for the lighting system.

The emergency lighting system is located in operating areas to perform emergency operations and provide safe personnel access and egress pathways when the normal lighting system is lost. The emergency lighting system is subdivided into 2 categories as follows.

1) Emergency ac lighting system

The emergency ac lighting system is always turned on and combines with the normal lighting to provide adequate illumination levels that support operation and maintenance activities during normal plant operation. The emergency ac lighting system is provided in the MCR, radwaste control room, emergency TSC, OSC, RSR, EDG room, Class 1E battery room, Class-1E SWGR room, and their access aisles for the safety-related equipment. Emergency ac lighting system is energized from Class 1E 480 Vac bus backed up by the Class 1E EDG and the non-Class 1E AAC source to provide reasonable assurance that the emergency lighting ac system is available during a LOOP. Emergency ac lighting provides more than 10 foot-candles of illumination at the above designated areas.

and an SBO respectively

2) Emergency dc lighting system

The emergency dc lighting consists of emergency dc lighting fixtures fed from 8 hour rated non-Class 1E 125 Vdc station batteries and self-contained battery pack lighting fixtures fed from receptacles for normal or emergency ac lighting.

The emergency dc lighting fixtures are powered by the non-Class 1E 125 Vdc station batteries upon loss of emergency ac lighting power and are provided to the areas where emergency ac lights are provided.

The emergency dc lighting powered from the station batteries provides more than 10 foot-candles of illumination.

The self-contained battery lighting fixtures are provided in areas needed for operation of safe-shutdown equipment and for access and egress route thereto.

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Question No. 09.05.03-4

DCD, Tier 2, Section 9.5.3.2 stated that the emergency direct current (DC) lighting system consists of DC lighting fixtures fed from non-Class 1E 125 VDC station batteries and self-contained battery pack lighting fixtures. Section 9.5.3.3 stated that the emergency DC lighting powered from the station battery or the individual self-contained battery provides adequate illumination for safe shutdown operations and for movement of personnel to the access and egress routes during LOOP, safe shutdown earthquake (SSE), and SBO.

Please clarify whether illumination during LOOP, SSE, and SBO is provided by the emergency DC lighting powered from both “the station battery and the individual self-contained battery” or from either “the station battery or the individual self-contained battery.” Also, please confirm that all safe-shutdown operations can be performed with the self-contained battery lighting if illumination after loss of AC power is provided by the self-contained battery lighting only.

Response

Illumination during LOOP, SSE, and SBO is provided by the emergency DC lighting powered from both the station battery and the individual self-contained battery. The self-contained battery fixtures are provided in sufficient quantity in areas to be needed for operation of safe shutdown and for access and egress route thereto. Where sufficient illumination for safe-shutdown operations can’t be provided only with self-contained battery pack lighting fixtures, DC lighting fixtures fed from non-Class 1E 125 VDC station batteries are provided to ensure required the illumination level in the area.

Impact on DCD

There is no impact on the DCD.

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.