

9.5.3 Lighting System

The plant lighting system consists of normal lighting, emergency lighting, special emergency lighting, escape route lighting, and security lighting systems. These plant lighting systems maintain illumination levels throughout the plant during normal operation. Standby power is supplied to selected fixtures to make sure adequate lighting is available during abnormal operation.

9.5.3.1 Design Basis

Illumination levels provided by the lighting systems provide necessary lighting for normal plant operation, maintenance activities, and plant egress for safe evacuation of personnel from plant rooms and buildings when required.

Lighting fixtures are staggered so that loss of a distribution panel does not result in a complete loss of lighting in a given area.

The emergency lighting system and special emergency lighting system fixtures are normally energized and combined to provide main control room (MCR) and remote shutdown station (RSS) lighting during normal and emergency operation.

The special emergency lighting system fixtures are powered from the Class 1E uninterruptible power supply (EUPS), which maintains power to the fixtures for a minimum of two hours in the event of a station blackout. The two hours allow, if necessary, operators the ability to align the station blackout diesel generators (SBODG) to the Class 1E emergency power supply system (EPSS), restoring power to station blackout loads, which includes emergency and special emergency lighting.

The lighting circuits are non-Class 1E and the lighting system does not perform any safety-related functions. Isolation is provided for lighting systems powered from Class 1E sources by a Class 1E isolation device located at the motor control center (MCC) feed to the distribution panel.

No aluminum lighting fixtures are located in containment.

Mercury vapor lamps or switches are not used in fuel handling areas or containment.

Lighting system bulbs are not seismically qualified.

9.5.3.2 System Description

Lighting systems are powered by 480 Vac MCCs through transformers to obtain the correct voltage for the specific lighting application. The power is distributed to the individual lighting fixtures via a distribution panel.

9.5.3.2.1 Normal Lighting

The normal lighting system provides lighting in plant buildings and site areas to support normal operation and plant maintenance activities. The system lighting distribution panels are supplied from the non-Class 1E normal power supply system (NPSS). The NPSS provides a source of interruptible power during normal plant operation. In the event power is lost from the NPSS, normal lighting is lost until NPSS power is restored. The normal lighting fixtures are distributed with the emergency lighting system fixtures in areas served.

9.5.3.2.2 Emergency Lighting

The emergency lighting system provides lighting in plant areas primarily containing safety-related equipment. The system is supplied with interruptible power from the EPSS and the NPSS. EPSS supply to emergency lighting is emergency diesel generator (EDG) backed. SBODG alignment to EPSS buses will also restore emergency lighting. Emergency lighting fixtures powered from the EPSS are normally illuminated and provide lighting for normal operation, control and maintenance of safety-related equipment used for implementing plant safe shutdown, and fire fighting.

Emergency lighting fixtures powered by the NPSS provide SBODG backed lighting in the switchgear building to support station blackout operations.

The emergency lighting system combines with the normal lighting to provide illumination levels that support operation and maintenance activities during normal operation. The amount of lighting provided by the emergency lighting system is determined by the amount of safety-related equipment in the area being served, with a higher percentage of lighting being supplied by the emergency lighting system in areas that have safety-related equipment.

EPSS Division 2 and Division 3 power the emergency lighting system to provide approximately 67 percent of the MCR and RSS lighting. During abnormal conditions that result in a loss of offsite power to the EPSS buses, MCR lighting from the emergency lighting system is interrupted until power is restored by the EDGs or SBODGs.

Battery pack emergency lighting fixtures are fixed, self-contained sealed-beam units with eight hour battery packs. The batteries are charged from the NPSS during normal operation. Refer to Section 9.5.1 for use and location of emergency lighting for fire fighting and operator actions.

9.5.3.2.3 Special Emergency Lighting

EUPS Division 2 and Division 3 powers special emergency lighting to provide approximately 33 percent of the illumination in the MCR and RSS. The system

provides lighting during normal operation and sufficient lighting during abnormal operation.

The EUPS system provides an uninterruptible source of power to the special emergency lighting fixtures while the EDGs are starting and connecting to the EPSS buses. In the event of a sustained loss of power to the emergency lighting system, the EUPS system provides a two hour power supply.

9.5.3.2.4 Escape Route Lighting

Escape route lighting provides illumination for safe evacuation of personnel from plant rooms and buildings when normal lighting is lost.

The fixtures are self-contained battery-backed sealed beam units maintained in a charged condition by the NPSS. The battery-backup automatically provides power during power interruption for at least 90 minutes following loss of normal power. The fixtures are installed in plant traffic areas such as stairwells, corridors, and building exit ways.

9.5.3.2.5 Security Lighting

Security lighting requirements in support of the physical security plan are described in Section 13.6.

9.5.3.3 Safety Evaluation

The plant lighting system is non-safety related. However, emergency lighting and special emergency lighting provide illumination for operations during anticipated operational occurrences; egress lighting is provided by escape route lighting for the safe evacuation of plant personnel during conditions where normal lighting is de-energized. The special emergency lighting system powered from the EUPS system provides the minimum illumination levels, as indicated in NUREG-0700 (Reference 1) which is based on IESNA HB-9 (Reference 2), in the MCR and RSS for emergency operations. The two hour EUPS duration permits MCR operator response actions, including restoring normal offsite power, starting the EDGs, or aligning the SBODGs to the EPSS during station blackout conditions. EDG and SBODG supply to the EPSS restores emergency lighting in the MCR and plant areas containing safety-related equipment.

A single failure will not prevent the plant lighting systems from providing sufficient lighting throughout the plant areas. Table 9.5.3-1—Plant Lighting Failure Modes and Effects Analyses, demonstrates plant lighting capability during single component failure.

Lighting fixtures located in the MCR and RSS, and also those located within close proximity of safety-related systems or components outside of the MCR and RSS, are classified Seismic Category II.

Emergency lighting and special emergency lighting circuits to lighting fixtures in the MCR and RSS are routed through Seismic Category I cable raceways or conduits.

Normal, emergency, and special emergency lighting circuits are fed from their respective lighting panels and are physically separated from each other. Lighting circuits are electrically isolated from Class 1E circuits by the use of isolation devices and separation distance as indicated in IEEE Std 384-1992 (Reference 3). Where required when separation distances cannot be met, the circuits will be separated by a barrier. Additionally, where normal, emergency, and special emergency lighting circuits share common areas, lighting circuits are color coded so that the lighting circuits are readily distinguishable.

The MCR and RSS workstations are illuminated to at least 100 foot-candles and the safety-related panels (e.g., safety information and control system panels as described in Section 7.1.1.3.1) are illuminated to at least 50 foot-candles during normal operation when lighting is provided by the emergency lighting and special emergency lighting systems.

The special emergency lighting system provides at least 10 foot-candles illumination in the MCR and RSS workstations for two hours when powered from the EUPS.

9.5.3.4 Inspection and Testing Requirements

- Plant lighting fixtures are continuously energized and require no periodic testing. Visual inspections are periodically performed to detect and replace faulty lighting equipment.
- Escape route lighting and battery pack emergency lighting units are periodically inspected and tested to verify proper operation including battery capacity and integrity of the charging mechanism. Periodic testing of escape route lighting is in accordance with the guidance of NFPA 101-2006 (Reference 4) for periodic testing of emergency lighting equipment. Eight-hour battery pack emergency lighting fixtures are periodically tested to meet the guidance of RG 1.189.

9.5.3.5 References

1. NUREG-0700, "Human-System Interface Design Review Guidelines," Revision 2, U.S. Nuclear Regulatory Commission, May 2002.
2. IESNA HB-9, "Lighting Handbook Reference & Application – 9th Edition," Illuminating Engineering Society of North America, 2000.

3. IEEE Std 384-1992, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits," Institute of Electrical and Electronics Engineers, 1992.
4. NFPA 101-2006, "Life Safety Code – 2006 Edition," National Fire Protection Association, 2005.

Table 9.5.3-1—Plant Lighting Failure Modes and Effects Analyses

Component Identification	Function	Failure Mode	Effect on System Safety Function	Description
Offsite power	Normal power to NPSS and EPSS buses	Loss of voltage from switchyard to NPSS and EPSS	None, offsite power does not have a safety function	<ol style="list-style-type: none"> 1. Partial loss of lighting in Nuclear Island and Turbine Island areas. 2. EDGs restore power to the EPSS, which restores emergency lighting system fixtures. 3. MCR and RSS lighting is provided by special emergency lighting during EDG start sequence. 4. Escape route lighting provides illumination in stairways, corridors, and room exits. 5. SBODGs restore power to emergency lighting in the Turbine Island.
NPSS individual lighting distribution panels	Power supply to normal lighting system distribution panels and emergency lighting	Loss of voltage from one NPSS lighting distribution panel	None, system does not have a safety function	<ol style="list-style-type: none"> 1. Partial loss of lighting in areas served. 2. Normal lighting powered from separate lighting distribution panel or area emergency lighting maintains sufficient lighting in affected areas. 3. Escape route lighting provides illumination in stairways, corridors and room exits.
EPSS individual lighting distribution panels	Power supply to emergency lighting	Loss of voltage from one EPSS lighting distribution panel	None, system does not have a safety function	<ol style="list-style-type: none"> 1. Partial loss of lighting in areas served. 2. Normal lighting maintains sufficient lighting in affected areas. 3. Redundant emergency lighting division and special emergency lighting maintains sufficient lighting in the MCR and RSS.
EUPS special emergency lighting panels	Power supply to MCR and RSS special emergency lighting	Loss of voltage from one special emergency lighting distribution panel	None, system does not have a safety function	<ol style="list-style-type: none"> 1. Partial loss of in the MCR and RSS. 2. Emergency lighting is not affected and maintains sufficient MCR and RSS lighting. 3. Partial special emergency lighting is still provided in the MCR and RSS from the other division.