Chapter 12
Lighting and Receptacle Systems

12-1. Design

a. General. For the purposes of design and plan preparation, the lighting system is defined as beginning with the lighting transformers and extending to the fixtures. This facilitates design coordination of various features of the lighting system. For purposes of discussion, it also covers 480-V and 120-V convenience outlets and corresponding circuits. After the design is complete, the system may be broken down into separate categories as determined by how the equipment will be obtained and installed in the construction stage. One method of handling the division of work is outlined below. The lighting systems, including fixtures and receptacles, are normally furnished and installed by the powerhouse contractor.

b. Conduit and cable schedule. Supply cables and conduit to transformers and lighting panels should be listed in the conduit and cable schedule. Branch circuits are normally not included on the schedule.

c. Panels. Lighting panels should be designed for the job, using air circuit breakers to protect the branch circuits, and should be purchased and installed by the general contractor.

d. Distribution center. In designing the lighting distribution system, several schemes should be considered, and a scheme adopted which gives the lowest overall cost without sacrificing simplicity of design or efficiency of operation. Two general schemes are:

(1) Small plant. A centrally located lighting transformer supplying the entire plant, which may be either:

(a) A 480-120/240-V, single-phase transformer with 120/240-V feeders and branch circuits.

(b) A 480-120/208-V, 3-phase, 4-wire transformer with 120/208-V feeders and branch circuits.

(c) A 480-480Y/277-V, 3-phase, 4-wire transformer with 480Y/277-V feeders and branch circuits.

(2) Large plant. Transformers located near the load centers and fed by individual supply feeders from the station service switchgear to supply lighting for a local area, each transformer being either:

(a) A 480-120/240-V, single-phase transformer, feeding panels with 120/240-V branch circuits.

(b) A 480-120/208-V, 3-phase, 4-wire transformer, feeding panels with 120/208-V branch circuits.

(c) A 480-480Y/277-V, 3-phase, 4-wire transformer, feeding panels with 480Y/277-V branch circuits.

12-2. Illumination Requirements

a. Intensity level. The lighting system should be designed to give the maintained-in-service lighting intensities recommended by the IES Handbook (Kaufman 1984). A maintenance factor of 0.75 is considered appropriate for a well-maintained project.

b. Emergency lighting. Emergency lighting should be designed to light important working areas within the powerhouse and should be adequate to provide safe passage between such areas with a minimum load on the station battery. NFPA 101 provides guidance on areas requiring emergency lighting for personnel safety. Self-contained, battery-operated, emergency lighting systems should be considered to lower capacity requirements on the station battery. Self-contained, battery-operated systems should be employed in areas with minimal occupancy or personnel access following an event initiating use of the emergency lighting system. Emergency lighting for control rooms, unit control switchboard areas, station service switchgear areas, the emergency generator area, and interconnecting passageways between these areas should be powered by the station battery.

c. Exterior lighting. Exterior lighting should be provided for the switchyard, parking areas, passageways near the powerhouse, the draft tube deck, and for the upstream deck if there is one. Flood-lighting of the outside powerhouse walls should be included in the original design, with provisions made for extension of lighting circuits if the floodlights are not initially installed. Exterior doorways should be lighted either by flush soffit lights or by bracket lights. If bracket lights are used, they should be selected to enhance the architectural appearance of the doorways.

d. Specific conditions. For general areas, the zonal cavity method of illumination design (see IES Handbook) is considered satisfactory. For special conditions such as illumination (Kaufman 1984) of the vertical surfaces of switchboards, a careful check by the point-by-point method may be needed. Care should be taken to minimize reflected glare from the faces of switchboard instruments. To facilitate design review, the manufacturer's candlepower distribution curves should accompany the design drawings. If fixtures of unusual design are being specified, their use must be justified, with complete details of the fixtures submitted with the lighting design data.

e. Evaluation. Evaluation and choice of lighting systems should consider both energy and maintenance costs as well as initial cost of the fixtures.

12-3. Efficiency

a. General. Energy conservation is an important concern when designing lighting systems. In the powerhouse, use of high efficiency lighting has the potential for saving significant amounts of energy. An efficient lighting system is one in which the required amount of light reaches the area to be illuminated at the proper level and color, while using the minimum amount of energy. The well-designed lighting system should make maximum use of available natural light and consider the direction of light and the desired dispersion or focus. Encouraging efficient use requires provision of convenient control points, use of proximity detectors in unoccupied interior spaces, and consideration of two-level lighting in low-occupancy machinery areas.

b. Lighting source types. Efficient light sources should be considered. There are four common lighting source categories, as follows:

(1) Incandescent. In general, incandescent lamps provide the "whitest" light, but at a higher energy cost and relatively short life. Incandescent lamps are used where fluorescent fixtures are not practical for reasons of vapor, limited space, high lighting levels, or the need for superior color rendition.

(2) Fluorescent. Triphosphor fluorescent lamps are a good source of "white" light and are relatively long-lived, with energy efficiencies better than incandescent lamps. Most rooms and shops should be illuminated with energy-efficient, fluorescent fixtures, using T-8 high-efficiency lamps and electronic ballasts.

(3) High-intensity discharge (HID).

(a) HID mercury lamps are fairly efficient, have relatively long lives, but are not a good source of "white" light, covering only about 50 percent of the visible spectrum.

(b) HID metal halide lamps are a good source of "white" light, covering about 70 percent of the visible spectrum. They have good life and are very efficient. Their disadvantages are relatively long start and restart times.

(c) HID high pressure sodium lamps are very efficient, but are a poor source of "white" light, covering only about 21 percent of the available spectrum. They need about 3 or 4 min of start time, and about 1 min of restart time.

(4) Low-pressure sodium (LPS). LPS lamps are the most efficient lamps available, but produce almost no "white" light, so their use is extremely limited. They have long lives, short start times, and very short restart times.

c. Evaluation. When designing the lighting system, all of the above sources should be considered and the most efficient combination of sources used, appropriate with achieving design lighting levels and good lighting quality. Evaluation and choice should consider both energy and maintenance costs, as well as initial cost of the fixtures. EPRI TR-101710 provides guidance on achieving design lighting levels in an energy-efficient, cost-effective manner.

12-4. Conductor Types and Sizes

The voltage drop in panel supply circuits should be limited to 1 percent if possible, and the drop in branch circuits should be limited to 2 percent. If it is not possible to limit the voltage drop to these figures, a limit of 3 percent for the total voltage drop should be observed. In arriving at the voltage at the load, the impedance drop through the transformer should be considered, although this drop need not be considered in feeder or branch circuit design. Branch circuit and panel feeder design should be based on the considerations outlined in Chapter 15. Minimum conduit size should be 3/4 in. and the minimum conductor size should be No. 12 AWG.

12-5. Emergency Light Control

A system employing selected fixtures normally supplied from the AC source through an automatic transfer switch transferring the fixtures to the DC system on AC voltage failure should be provided. Fixtures sourced from the station battery should be minimized to reduce battery drain (see paragraph 12-2*b*). Return to the AC source should be automatic when the AC source is restored.

12-6. Control Room Lighting

a. General. Many different schemes have been used in attempting to develop “perfect” control room lighting. This emphasis is due to the difficult and continuous visual tasks that are performed in the control room. Task ambient lighting provides the most effective approach to achieving desired results. IES-RP-24 provides guidance on topics such as quality of illumination, luminance levels, and the visual comfort of room occupants, which must be evaluated in developing a control room lighting design.

b. VDTs and instrument faces. Plant control systems use visual display terminals (VDTs) which tend to “wash out” in high ambient lighting, and the VDT face reflects light from sources behind the operator that make the screen image unreadable. Switchboard instrument faces also reflect light, and such reflections obscure the instrument dial. Light fixtures or window areas should not be reflected by the instrument glass and VDT screen.

c. Switchboard lighting. Switchboards should be lighted so that the instrument major scale markings and pointers can be readily seen from the control console even though the actual numbers opposite these markings cannot be read. Sufficient vertical illumination on the fronts of the boards is only part of the answer. Illumination must be provided in a manner that does not produce glare from the instrument glass, or objectionable shadows on the instrument face from the instrument rims and control switches. It is also important that no light source be visible in the line of the operator’s vision when viewing the boards.

d. Lighting criteria. Extreme contrasts in lighted areas, such as a bright ceiling or wall visible above the switchboard, must be avoided, as they produce eye strain. The modern practice of using light-colored switchboards, and the latest design of indicating instrument dials have both helped to improve control room lighting. Good control room lighting will be obtained if the following criteria are observed:

(1) Adequate vertical illumination on vertical board surfaces.

(2) Brightness contrasts preferably within a ratio of 1 to 3. (No light sources in line of vision).

(3) No specular reflection from instrument, VDT screen, or other surfaces.

(4) No objectionable shadows on working surfaces.

e. Heat. The amount of heat from the lamps (of any type) in the control room must be given special consideration in designing the air-conditioning layout for the control room and adjacent areas.

12-7. Hazardous Area Lighting

Battery room and oil room fixtures should be vapor- and explosion-proof type, and local control switches should be mounted outside the door. Lighting switches of the standard variety may be used by placing them outside the room door. Convenience receptacles in the rooms should be avoided, or where necessary, be of the explosion-proof type.

12-8. Receptacles

The types and ratings of receptacles for convenience outlets should be clearly indicated on the fixture and device schedule sheet in the drawings, or in the bill of materials. Standardization of receptacles allows use of portable equipment throughout the project. The following receptacles are suggested as the appropriate quality and type:

a. 480-V receptacles. 3-wire, 4-pole, 30 A, grounded through extra pole and shell of plug type receptacles are recommended. The receptacles and plugs should meet the requirements of ANSI/UL 498 and should be weather resistant for use in wet and dry locations. For welding machines and other portable 480-V equipment, use two-gang-type cast boxes to ensure adequate room for No. 6 AWG feeders, except for the placement of 480-V receptacles at the end of conduit runs, which may be single-gang receptacles.

b. 120-/208-V receptacles. 4-wire, 5-pole, 30 A, grounded type receptacles, plugs, and fixtures meeting the requirements of ANSI/UL 498 and 514 are recommended. Typically, these fixtures are used to service supplemental lighting in work areas during overhauls.

c. 120-V receptacles. The choice between using a twist-lock receptacle or using a parallel-blade receptacle has never been standardized nationwide. There is a trend to employ parallel-blade receptacles on new construction projects. Parallel-blade receptacles are recommended unless there is a strong local preference for twist-lock receptacles based on existing local standardization. Ground fault protection should be provided for 120-V outlets in all wet locations or outdoors. Use appropriate ground fault interrupter circuit breakers in these locations.

(1) Twist-lock receptacles. For projects using twist-lock receptacles, 3-pole, 15-A, 125-V, grounding, duplex, twist-lock, NEMA L5-15R configuration for use with compatible twist-lock caps are recommended for dry locations within all powerhouse areas. For wet locations or outdoors, a similar single-gang receptacle in a cast box with twist-lock caps or plugs is recommended. For lunch rooms, office areas, lounges and restrooms, duplex combination, twist-lock, straight-blade receptacles, NEMA L5-15R configuration, are recommended.

(2) Straight-blade receptacles. For projects using straight-blade receptacles, 3-pole, 20-A, 120-277-V grounding, duplex, hospital grade, NEMA 5-20R configuration, are recommended for dry locations. For wet locations or outdoor use, single, hospital-grade receptacles in the same configuration, with weatherproof single-receptacle cover plates are recommended.