CHAPTER 6

OUTDOOR LIGHTING

Section I--LIGHTING AND CIRCUIT TYPES

6-1. Outdoor lighting use.

Outdoor lighting includes public way, recreational, airfield, and security or protective lighting, whether installed on buildings or detached supports. The primary purpose of outdoor lighting is to provide lighting for exterior facilities, which require some degree of lighting during times of reduced visibility for safety or for observation. Poles which support outdoor lighting should be maintained as described in chapter 4, sections VII and VIII. Outside building-mounted lighting is considered interior lighting, if its sole purpose is to facilitate entrance into that building.

6-2. Types of lighting circuits.

Most lighting circuits will be of the multiple circuit type. Generally series circuits are used for only airfield lighting systems (except for very small airfields) to provide uniform brightness to all lights in a circuit. Some older streetlighting and protective lighting circuits may also be supplied from series circuits.

a. Multiple circuits. Multiple circuits use constant-voltage single-phase inputs, usually of *120, 208, 240, 277,* and 480 volts. The lights are connected in parallel. There are no code restrictions on the location of 120-volt lamps. When installed on buildings, circuits exceeding 120 volts, but not exceeding 277 volts to ground, need to meet NEC requirements for their distance from windows, platforms, and fire escapes. Circuits exceeding 277 volts to ground, but not exceeding 600 volts, need to meet NEC pole and structure mounting height requirements.

b. Series circuits. In a series circuit, all of the lamps are connected in series. The same current, therefore, flows through all the lamps and the voltage varies. The power is supplied through a constant-current transformer (regulator). These transformers are available to supply circuits rated 6.6, 15, or 20 amperes. The most common value of current used is 6.6 amperes and only 6.6 and 20 amperes are used for airfield lighting circuits. The lamps may be connected either directly to the series circuit or to insulating transformers connected to the series circuit. Most series airfield lighting circuits use insulating transformers. Series circuits may be installed as an open-loop, a closed-loop, or a combination of both. In the closed loop and combination systems the conductors are close together in numerous places so the circuit can be conveniently short-circuited when troubleshooting. Series circuit voltages range from 2,400 to 7,200 volts, in order to maintain the constant current. Therefore, series circuits must always be treated as medium-voltage circuits.

Section II-MULTIPLE TYPE LIGHTING

6-3. Multiple type lighting system components.

A multiple type lighting system consists of luminaires, mounting structures for luminaires, the control system to switch luminaires on and off, and the input circuit which provides the low voltage to operate the luminaires. Generally, some type of power transformer will provide input low voltage. Transformer requirements are provided in chapter 7.

6-4. Luminaires.

The basic, most visible part of an exterior lighting system, is the combination of luminaire and lamp or lamp/ballast. All gaseous conductor lamps require ballasts. A bare lamp at the end of a pair of wires will emit light, perhaps in large amounts, but only a part will be directed to where it will be useful and the rest is wasted. Luminaires are used to direct the light where it is wanted and, if necessary, to house the ballast.

6-5. lamp types.

There are two types of lights used in outdoor luminaires. These are filament types and gaseous conductive types. Filament lamps use the filament for conducting current. Gaseous conductive types use an ionized gas or vapor for the electron flow and are of the electric-discharge lamp type or fluorescent lamp type.

a. Filament lamps. The two types of filament lamps are the incandescent lamp and the tungsten-halogen lamp. The tungsten-halogen lamp adds a halogen regenerative cycle to deposit the filament's evaporated tungsten back on the filament, rather than on the lamp bulb, and thus provides a longer lamp life. Incandescent lamps are used mainly for

aviation lighting. Tungsten-halogen lamps are often used for recreational floodlighting, where good color rendition is necessary.

b. Electric-discharge lamps. Electric (or gaseous discharge lamps) include mercury-vapor, metal-halide, and high- and low-pressure sodium lamps. They differ in the gas or vapor used, which is either mercury, or mercury with halide salts, or sodium, at different pressures. Most outdoor public way lighting installations today use high-pressure sodium lamps. Most older mercury vapor luminaires are being replaced with high-pressure sodium luminaires because of the energy savings. Metal-halide lamps may be used for recreational and protective lighting systems, because their superior color rendition outweighs their lower lamp life and lumen output. Low-pressure sodium lamps, though they have a greater lumen output, also have a monochromatic color rendition and a lower lamp life and are rarely used for outdoor lighting installations on military facilities. All lamps require ballasts for correct operation.

c. Fluorescent lamps. A fluorescent lamp utilizes a mercury vapor, but the inside of the bulb has a thin coating of phosphor which glows or fluoresces when struck by the electrons flowing through the mercury vapor. The amount of light emitted is less than for electric discharge lamps, and only a limited control is possible because of their tubular shape. They may be used for lighted roadway, traffic, or airfield indication signs. All lamps require ballasts for correct operation, and some types require separate starters to provide the heat necessary for the electron emission to start.

6-6. Luminaire components.

In addition to lamp or lamp/ballast combination, the components of a luminaire include its optical controls, its component support assembly, and possibly, circuit controls.

a. Optical controls. Optical controls are used to provide the light distribution pattern most appropriate to the outdoor lighting requirement. One type of control is a reflector which uses a parabolic, ellipsoidal, or hyperbolic contoured surface with a specular, spread, diffuse, or compound finish to redirect light from a lamp into the desired pattern. Another type of control is a refractor which uses a different medium to bend the light. Refractors can provide a variety of light distributions, using prismatic or lens type refractors of glass or plastic. Other optical control methods use glass or plastic materials to scatter light or control brightness. Louvers or shields are used to mask a source or to absorb unwanted light. Any degradation of these items resulting from accumulated dirt or fixture damage will result in a less efficient lighting installation.

b. Component support assembly. The assembly provides the mechanical support for lampholders, sockets, ballasts, controls, reflectors, refractors, enclosures, mounting components, and other items needed to ensure the lamp provides the performance needed.

c. Circuit controls. Photo cells are the only circuit controls that are provided integrally with the luminaire. They are described in paragraph 6-8.

6-7. Luminaire maintenance.

Luminaire maintenance given herein is for high-pressure sodium (HPS) lamps which will most often be found in roadway and recreational lighting. Maintenance of other lamps should follow the same philosophy. Luminaire maintenance consists of cleaning, lamp replacement, and troubleshooting of components when other problems are indicated.

a. Frequency. The design footcandle level is generally the average illumination delivered at the design point when the illuminating source is at its lowest output and the luminaire is in its dirtiest condition. This requirement determines the maintenance frequency.

(1) *Lamp depreciation.* The lumen output of HPS lamps will decrease to 80 percent of its initial value at about 80 percent of its rated life. The lamp should then be replaced to maintain design footcandle levels. Rated lamp life is defined as approximately the time for half of the lamps to fail. Using a value of 24,000 hours for 80 percent of lamp life, and 4,000 hours of burning time per year, results in a theoretical 6-year life for half the lamps. On this basis, consider group replacement every 4 years. Premature outages can probably be held to approximately 10 percent if group replacement is made before the lamps approach the accelerated point on their mortality curve. The few lamps which do fail should be replaced promptly.

(2) *Luminaire depreciation.* Dirt on lamps, reflectors, and refractors is another cause of decreased lumen output. A cleaning schedule should be set up on an annual basis, that under normal operating conditions, dirt will not contribute more than 15 percent to the lighting depreciation. Cleaning recommendations for average dirt conditions range from every 2 to 3 months up to a 2-year schedule for inspection, cleaning, and washing.

b. Cleaning. Cleaning can be done from lift trucks using a one- or two-man crew. The crew

should be familiar with the necessary cleaning steps and the appropriate cleaning compounds for the application.

(1) *Procedure.* The cleaning sequence will vary dependent upon the type of luminaire, but typical methods for streetlights can be modified for other types of fixtures.

(a) Remove any removable shielding material and the lamp.

(b) Make the luminaire shock-free. Ensure that the electrical circuit is turned off or make the luminaire shock-free by covering sockets with tape or dummy lamp bases.

(c) Clean the basic unit. If required, heavy deposits of dirt can be removed first from the luminaire's top surface by wiping or brushing. Reflective or refractive surfaces are better off not wiped but only washed.

(d) Clean the shielding material and lamps. Plastic materials should be allowed to drip dry after rinsing or be damp dried with toweling or some other material. Dry wiping can cause the formation of electrostatic charges. New lamps should be dry wiped before installation.

(e) Replacement may require installing new shielding and new lamps.

(2) *Cleaning compounds.* Washing solutions should always be in accordance with the luminaire manufacturer's instructions. Strong alkaline or abrasive cleaners should be avoided. Most luminaire finishes can be cleaned using the following procedures.

(a) *Aluminum.* Very mild soaps and cleaners can be used on aluminum and will not affect the finish, if the material is thoroughly rinsed with clean water immediately after cleaning. Strong alkaline cleaners should never be used.

(b) Porcelain enamel. This finish is not injured by nonabrasive cleaners. Detergents and most automobile and glass cleaners do a good job under average conditions.

(c) Synthetic enamel. Some strong cleaners may injure this finish, particularly if the enamel is left to soak in the solution. Alcohol or abrasive cleaners should not be used. Detergents produce no harmful effects.

(d) Glass. As with porcelain enamel, most nonabrasive cleaners can be used satisfactorily on glass. Dry cleaners are usually preferred on clear glass panels, but not on etched or sand blasted surfaces. Most detergents will work well under average conditions.

(e) Plastics. Dust is very often attracted by the static charge developed on plastic. Most common detergents do not provide a high degree of permanence in their anti-static protection. In most areas, however, if the plastic is cleaned at least twice a year with a detergent, a satisfactory balance in regard to static dirt collection is obtained.

c. Troubleshooting. The main defects requiring maintenance are nonstart, cycle on and off, extra bright light output, and low light output. Some of these conditions result from normal end of lamp or ballast life. Other conditions result from loose wiring, ballasts, or lamps, or from incorrect lamp and ballast installations. Refer to the manufacturers' lamp, ballast, and luminaire troubleshooting guides and the IESNA's Lighting Handbook for methods of diagnosing and correcting problems. Ballast replacement and voltage and current measurements present the possibility of exposure to potentially hazardous voltages and should be performed only by qualified personnel.

d. Replacement. Consider replacing glass items with tougher materials such as acrylics if breakage (vandalism) becomes a problem. Replace incandescent lamps with discharge lamps (sodium preferred) whenever possible. Departmental policy should be complied with in changing lamp types.

6-8. Multiple type lighting controls.

Most control is provided by either a central control or an integral control. Central controls use a time switch with an astronomical dial, or a contactor controlled by a photo cell. Integral systems have a photo cell installed on each luminaire.

a. Time switches. Time switches used on lighting circuits should have an astronomical dial, which ideally has been adjusted at the factory for the particular locality in which it is used. If it is necessary to do so in the field, adjust as follows:

(1) See that the center dial screw is tight (finger-tight on models with knurled knobs).

(2) Turn the dial either by the manual reset knob or by the dial screws in the direction indicated by the arrow until the correct time of day is directly under the hour pointer. The black half-moon represents night periods.

(3) Turn the star wheel in either direction until the date pointer is directly over the correct day and month. On models that do not have every day indicated, 5- or 10-day periods are shown and the exact date may be obtained by turning the star wheel one point for each day from the known data points. Spring-driven mechanisms may gain or lose time because of temperature variations. Synchronous motor-driven clocks will lose time if there is an interruption to service. They should be checked monthly and reset and adjusted if necessary. The contacts should be checked about once a year. On clocks having contacts on the back of the panel, disconnect the 120-volt wires from the terminal

block and remove the panel. Contacts should be inspected and replaced if badly pitted. On contacts, other than silver-plated ones, a coating of nonoxide grease is desirable. When grease cups are provided for the front and rear motor bearings, the grease cups should be given a half turn every 3 months. The manufacturer's recommended grease should be used for refilling. The clock mechanism should be overhauled every 5 years by the manufacturer or a competent watchmaker.

b. Contactors. Contactors are described under chapter 11, section II.

c. Photo cells. Any dust or dirt on the windows of photo controls of any type will prevent proper operation. These windows must be kept clean.

(1) *Self-generating phototronic photo cell.* The self-generating phototronic cell has a normal clear day output of 1.5 to 6 milliamperes. It can operate the relay on 0.5 milliampere, so replacing the light collector is not necessary until its output tests below 0.5 milliampere. Any testing should be made on a cloudless day using a milliammeter with a range of 0 to 10 milliamperes. The check can be made most conveniently at the terminals on the relay box. When the output of the light collector tests less than 0.5 milliampere, it should be returned to the manufacturer for rehabilitation, or replaced with a photoconductive cell. The relay for a phototronic cell is very delicate because of the small amount of energy needed to operate it. Misoperation is most often the result of sticking contacts and damaged bearings. Sticking contacts should be carefully cleaned with crocus cloth. Damaged bearings are usually caused by severe continuous vibration or knocks. Any maintenance on the relay panel, other than the cleaning of contacts mentioned above, should be done by the manufacturer. Careful handling is essential.

(2) *Phototube photocell.* A periodic checkup should be made every 6 months. The windows should be cleaned and all tubes replaced. Replaced tubes should be checked by a competent tester and discarded if poor. Any extensive maintenance work should be considered justification for replacing with a solid-state type.

(3) *Solid-stat e photocell.* Failure of this type is denoted by lights being on during daylight. If cleaning the window does not correct the malfunction, the unit should be replaced. The high repair labor cost usually exceeds the replacement cost.

SECTION III--LIGHT DISTRIBUTION

6-9. Light distribution standards.

Industry standards regulate outdoor lighting design. Luminaires are designed to provide light distributions to meet the design standards by focusing the light into the patterns, beam spreads, or cutoffs as applicable.

6-10. Roadway lighting.

IESNA's Lighting Handbook lists five basic distributions. Figure 6-l and the distribution discussions following have been provided to simplify IESNA definitions. While many luminaires can be adjusted to produce more than one pattern, no luminaire is suitable for all patterns. Care must be used, especially in repair and replacement, to install the proper luminaire for the designed pattern, as specified in manufacturer's literature. Even when the proper luminaire is installed, care must be used to ensure all adjustments have been properly made to produce the desired results.

a. Type I. The distribution of *(a)* is intended for narrow roadways with a width about equal to lamp mounting height. The lamp should be near the center of the street. The variation of *(b)* is suitable for intersections of two such roadways with the lamp at the approximate center.

b. Type II. The distribution of (c) produces more spread than does type I. It is intended for roadways with a width of about 1.6 times the lamp mounting height, with the lamp located near one side. The variation of *(d)* is suitable for intersections of two such roadways, with the lamp not near the center of the intersection.

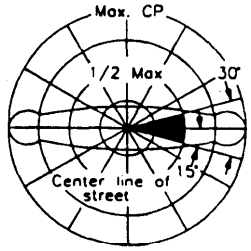
c. Type III. The distribution of (e) is intended for luminaires located near the side of the roadway with a width of not over 2.7 times the mounting height.

d. Type IV. The distribution of (f) is intended for side-of-road mounting on a roadway with a width up to 3.7 times the mounting height.

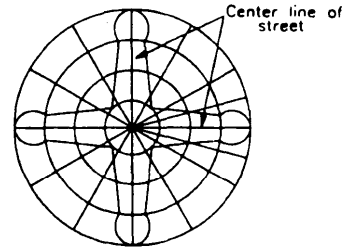
e. Type V. The distribution of (g) is circular and is suitable for areas and wide roadway intersections. Types III and IV can be staggered on opposite sides of the roadway for better uniformity in lighting level, or for use on wider roadways.

6-11. Floodlighting.

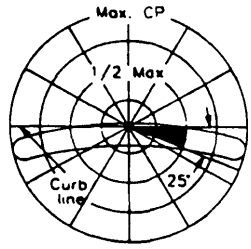
Floodlighting is used for recreational lighting and for area lighting. Floodlighting is defined by the NEMA field angle as indicated in table 6-l with projection distance given in feet (ft) and meters (m).



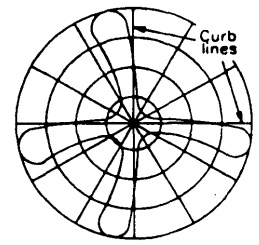
TYPE I
a



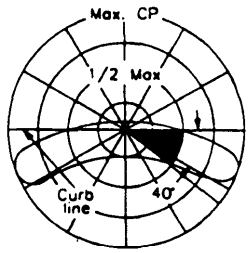
TYPE I
4 WAY
b



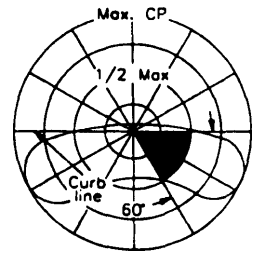
TYPE II
c



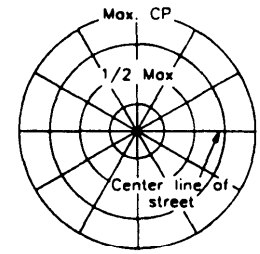
TYPE II
4 WAY
d



TYPE III
e



TYPE IV
f



TYPE V
g

Figure 6-l. Light distribution patterns for roadway lighting

Table 6-l. Floodlight beam descriptions[1]

Beam type	Beam spread degrees range	Projection distance
1	10 to *18*.	*240* ft and greater (73 m and greater)
2	*18* up to 29. ...	200 to 240 ft (61 to 73 m)
3	29 up to 46. ...	175 to 200 ft (53 to 61 m)
4	46 up to 70. ...	145 to 175 ft (44 to 53 m)
5	7oup to 100...	105 to 145 ft (32 to 44 m)
6	100 up to 130. .	80 to 105 ft (24 to 32 m)
7	130 and up	Under 80 ft (under 24 m)

[1]This table is reproduced by permission from IESNA Lighting Handbook, References and Application, Eighth Edition, 1993.

6-12. Airfield lighting.

Airfield lighting fixtures are covered by the Federal Aviation Administration's (FAA) advisory circulars. For many items there will be two or more specifications for qualified equipment which may not be identical in form, fit, and function. Care must be used in repair and replacement to install fixtures whose performance characteristics are compatible with the existing fixtures, particularly with respect to light output and aiming. Both the military and the FAA maintain qualified products listing (QPL) in the DOD Index of Specifications and Standards and the FAA checklist AC-00-2.8.

Section IV-SERIES TYPE AIRFIELD LIGHTING

6-13. Series type lighting system components.

A series-type lighting system for airfield lighting includes luminaires, mounting structures for the luminaires, the control system to switch luminaires on and off and the power system which provides the constant-current to operate the luminaires. Luminaires provide light distribution applicable to the type of airfield lighting involved. In general, series type streetlighting systems should be phased out in accordance with departmental policy.

6-14. Series type lighting controls and protection.

Low-voltage airfield lighting controls includes power sources, control panels, relay equipment, accessories, and circuits. Controls energize, de-energize, and select lamp brightness in accordance with operational requirements. Control will normally be provided only at the control tower and the airfield lighting vault. Medium-voltage controls, utilize the following devices.

a. Protective *relays.* Protective relays open the primary feed of constant-current regulators in case of an open circuit in the series lighting circuit.

b. Primary switches. A primary oil switch is usually a single-pole, solenoid-operated oil switch. Air switches, provided as an integral part of dry-type constant-current transformers, are also available.

c. Series plug cutouts. Cutouts are plug-type units used to disconnect a series light circuit or its constant current regulator. With the plug handle assembly removed and secured, maintenance personnel are ensured of protection.

d. Film cutouts. Film cutouts or film disks operate automatically and are inserted in older lamp sockets to bypass failed lamps. Some circuits that have more than one lamp on an insulating transformer will use film cutouts to bypass a burned-out lamp and keep the other lamps supplied from that transformer operating. Because of their size and shape, they are sometimes referred to as “dimes.” When current no longer flows because of lamp failure or removal, full circuit voltage exists across the cutout film, which then ruptures, allowing the series circuit to be completed. A new film cutout of proper rating must be used whenever a faulty lamp is replaced. It is good practice to replace the cutouts whenever lamps are replaced under a group replacement program. Always screw the lamp into the socket before inserting the socket into the receptacle. If the socket is replaced before putting the lamp in it, the film cutout will puncture. Never re-use a punctured film disk. Paper, cardboard, or other insulation should never be used as a substitute for the film cutout.

6-15. Series type lighting power supply equipment.

The main item of power supply equipment is the constant-current transformer to supply the series circuit power. The other item is the insulating transformer, whose main purpose is to isolate each luminaire to prevent an open circuit when a lamp burns out.

a. Constant-current transformers. The transformer (usually called a regulator) has a movable secondary winding that automatically changes position to provide a constant-current output for any varying load impedance, within its rating, when supplied from an approximately constant-voltage source. The balance point between coil weight and magnetic force may be adjusted to provide the desired output current. Most existing constant-current transformers are oil-insulated; but dry type units, which are not much larger, are available and should be considered for replacement of failed oil-insulated units whenever possible.

(1) *Loading.* Constant-current regulators should be loaded as near to 100 percent as possible. It is generally accepted that overheating will not be caused by any load between 50 percent and 100 percent of rated kW. Regulators, unlike transformers, are rated in kW, not kVA.

(2) *Operation.* A constant-current regulator must never be operated with an open-circuit secondary. However, a short circuit, even a bolted short, on a secondary will have no immediate adverse effects if a reasonable percentage of the load remains energized.

b. Insulating transformers. Insulating transformers isolate the medium-voltage of a series circuit from the wiring and fixtures. In addition, they are sometimes used to obtain higher or lower current for lamps having a different ampere rating, or constant voltage for multiple lamps connected to a series circuit. They are sometimes referred to as isolating transformers. Unless the case and one secondary conductor are grounded, the secondary must be treated as a medium-voltage circuit:

6-16. Maintenance and troubleshooting series type lighting.

Use the recommended guidelines for the maintenance of airport visual aid facilities given in FAA AC 150/5340-26 which covers the various types of lighting systems, the airfield lighting vault equipment, and associated control tower equipment. It also includes troubleshooting procedures for series lighting circuits.