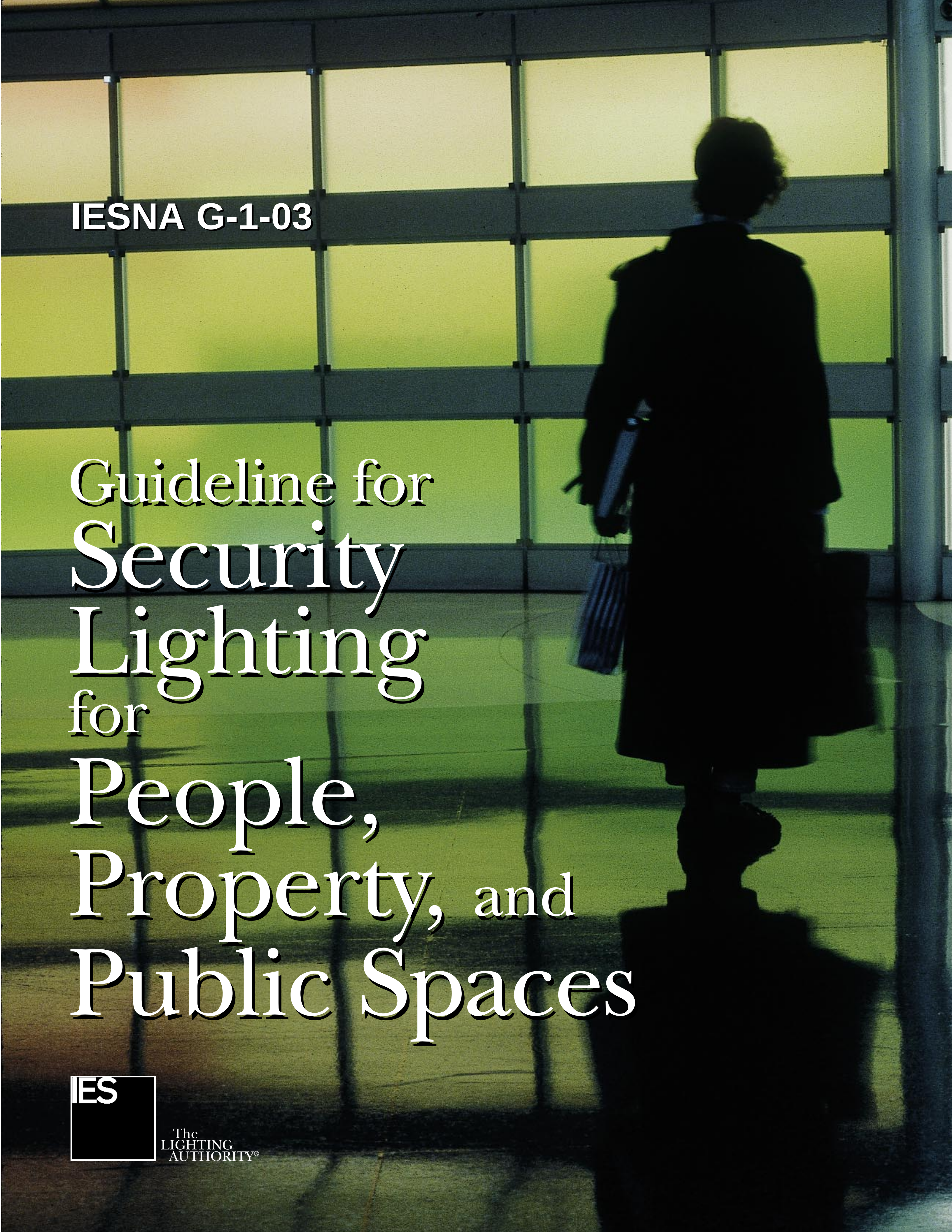

IESNA G-1-03

Guideline for Security Lighting for People, Property, and Public Spaces

IES

The LIGHTING AUTHORITY®

IESNA G-1-03

Guideline
for
Security Lighting
for
People, Property, and Public Spaces

Publication of this Committee
Report has been approved
by the IESNA. Suggestions for
revisions should be directed
to the IESNA.

Prepared by:
IESNA Security Lighting Committee

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IESNA G-1 Security Lighting for People, Property, and Public Spaces

Foreword and History

During World War I, the U.S. Government recognized the need for industry to increase exterior lighting at key production facilities, docks, assembly yards, high security facilities, and railway yards. These improvements had two purposes, to aid in production, and to deter sabotage. Although exterior protective lighting was widely increased, no standard was set.

- With the advent of World War II, at the request of the War Department, Military Intelligence, with assistance from the Insurance Committee for the Protection of American Industrial Plants, and the American Standards Association (ASA), initiated a project to develop a *standard* on outdoor protective lighting for industrial properties. The primary purpose of these efforts was to prevent theft and sabotage. Additionally, it was soon realized that "light discipline" was important to the war effort. Coastal facilities were darkened, and *stray light* was strictly controlled. North America was learning the importance of good security lighting and lighting discipline.

- During 1942, the ASA War Standards Procedure was applied, and a War Standards Committee prepared and published American Standard, A85-1942, Protective Lighting for Industrial Properties. This eventually became an ANSI Standard.

- In 1948, the ASA Safety Code Correlating Committee terminated *War Standards* and instituted a *revised standard* for peacetime use. The Illuminating Engineering Society was designated Administrative Sponsor for this effort.

- The IES Protective Lighting Committee developed the first draft of this revision, which the Sectional Committee used as a basis for an American National Standard Practice.

- In 1977, The Protective Lighting Committee, IES, sponsored, wrote, and published American National Standard Practice for Protective Lighting-RP-10. This standard was intended as a guide for outdoor protective lighting to those responsible for plant protection.[1]

- In 1994, a Security Lighting Committee was formed by the IESNA. Its first project was to write a modern guideline for security lighting for North America.

- During 1997-1998, the Security Lighting Committee developed material that was the basis for Chapter 29 of the IESNA Lighting Handbook, Ninth Edition.[2]

- During 1999, members of the Security Lighting Committee outlined the contents and approach for a guideline for peer review and comment before several professional groups. These groups included the American Society of Safety Engineers, and the American Society for Industrial Security.

- During 2000, additional presentations were made before professional security groups concerned with the safety and security of the public, including the International Conference on Shopping Centers and the American Society of Industrial Security.

1.0 INTRODUCTION

The Security Lighting Committee, previously known as The Protective Lighting Committee of the Illuminating Engineering Society of North America (IESNA), was established to generate and develop criteria for lighting to enhance the security of people and property, to recommend the integration and interaction of lighting as part of a total security system, and to write a publication.

1.1 Lighting and its Relationship to Crime

The possibility that lighting might have an impact on the incidence of crime was a topic of interest in the United States in the sixties. Municipalities across America improved their street lighting to combat crime and some encouraging results were reported, but on review there was no significant statistical evidence that improved street lighting influenced the *level* of street crime. There was, however, an indication that the improved street lighting decreased the *fear* of crime.

Twenty years later, in 1988, a before and after relighting study of a street in the outer city area of London, England, by K. Painter demonstrated a marked reduction in the incidence of crime and the fear of crime on the relighted street. (See **Annex A**.)

This lead to an outburst of similar studies in the UK by Painter (1989, 1991, 1994), Barr and Lawes (1991), Burden and Murphey (1991), Davidson and Goodey (1991), Herbert and More (1991), Glasgow Crime Team (1992, Nair (1993), Ditton and Nair (1994) and Cridland (1995). The results were mixed.

The most sophisticated study undertaken on the effect of lighting on the incidence of crime was in 1999 in Stoke-on-Trent in England by Painter and Farrington.

Three areas of housing were selected; one was the experimental area where the lighting was improved; one was designated the adjacent area; the third was the control area, which served as the baseline against which any changes in crime could be monitored. The lighting in the adjacent and control areas remained unchanged. One aspect of the study was to see if improved lighting in one area might lead to similar benefits of crime reduction in the adjacent area. There was a marked reduction in the prevalence of crimes such as theft and vandalism, vehicle crime, and personal crime in the experimental area after relighting. There was no significant change in the adjacent or control areas. A similar study in the town of Dudley, England, showed that the level of delinquency decreased more in the relighted area than in the control area.

The results of all these studies indicate that lighting has a place to play in crime prevention. A list of sources for further reading may be found in **Annex A**. While there are no guarantees that improved lighting will cause a decrease in crime, there are circumstances in which lighting can be an effective crime countermeasure, either alone or in combination with other measures.

Lighting can affect crime by two indirect mechanisms. The first is the obvious one of facilitating surveillance by the authorities and the community after dark. If such increased surveillance is perceived by criminals as increasing the effort and risk and decreasing the reward for a criminal activity, then the level of crime is likely to be reduced. Where increased surveillance is perceived by the criminally inclined not to matter, then better lighting will not be effective. The second mechanism by which an investment in better lighting might affect the level of crime is by enhancing community confidence and hence increasing the degree of informal social control. This mechanism can be effective both day and night but is subject to many influences other than lighting.

2.0 SCOPE AND PURPOSE

The primary purpose of this publication is to establish guidelines for the design and implementation of security lighting.* It addresses security illumination but does not give advice on construction practices. The objective is to provide guidance for designing security lighting systems for new facilities and for evaluating existing facilities and systems. This publication is intended for the use of property owners and managers, crime prevention specialists, law enforcement and security professionals, risk managers, lighting specifiers, contractors, the legal profession, and homeowners who are concerned about security and the prevention of crime. Crime, its prevention, and the application of lighting to help minimize criminal activity, are considered in a less technical and user-friendly manner for the benefit of property owners, but illuminating engineers, architects and other professionals should find the concepts useful to review with their clients.

The primary measurement references throughout this document are metric, with the English equivalent in parenthesis. For example, 1.5 meters will be displayed as 1.5 m (5 ft), and 100 lux will be displayed as 100 lux (10 fc). These conversions are approximate, but considered sufficiently accurate in this context.

In this publication will be found a discussion of basic security principles, illuminance requirements for various types of properties, a protocol for evaluating current lighting levels for different security applications, and security survey and crime search methodology. The guidelines are based on consensus among members of the IESNA Security Lighting committee and other security experts.

Suggestions are given for exterior and interior security lighting practices for the *reasonable protection of persons and property*. This document also promotes a concept of *best practice*, which takes into account the following lighting design issues:

- Economics (including cost, maintenance and operational costs)
- Environmental issues (including light pollution, light trespass and the adverse effects of light on animals and plants)
- Municipal lighting ordinances, by-laws or codes
- Energy conservation, and maintenance requirements

Minimum guidelines for the safe movement of persons and equipment and for performing specific tasks can be found in other IESNA publications. This document is intended to provide specific guidelines where it has been determined that *security is an issue*, and where security is an important determining factor in the design or retrofit of a given property.

Note that throughout this guideline the phrase when *security is an issue* is used to differentiate the lighting design suggestions presented herein from those contained in other IESNA publications. While these other publications may make reference to security, in G-1 it is the only issue. Note too that when *security is an issue*, not only lighting,

* Note the distinction made in this document between security lighting and lighting for safety. Security lighting is intended to protect people and property from criminal activities. Lighting for safety is intended to provide safe working conditions, safe passage and identification of hazards or obstructions.

but all measures and system components are increased and/or strengthened; for example, personnel, surveillance, gates, locks, and fences.

Security lighting, as part of a well-balanced security plan, should have the following objectives:

1. Provide a clear view of an area from a distance and enable anyone moving in or immediately around it to be easily seen
2. Deny potential hiding spaces adjacent to frequently traveled foot routes
3. Permit facial identification at distance of at least 9 m (30 ft), and create the perception of being identifiable
4. Facilitate the proper use of other security devices available on the property
5. Deter crime against persons or property
6. Enhance the public's feeling of comfort in accessing spaces and increase night-time pedestrian traffic

3.0 BASIC PRINCIPLES OF SECURITY AND SECURITY LIGHTING

3.1 Principles

Security lighting is installed to help protect people and property from criminal activities, and to create a perception of security. To better understand the principles of security lighting, it is first appropriate to look at several key security tenets.

Responsibility - In North America, the burden of security and safety is generally placed on the individuals who have primary control over a given property. With the rights of control comes the responsibility of control. For example, a property owner can enforce rules of trespass, install security systems, restrict access, and make other decisions that may have far reaching consequences for those who access the property. To a lesser degree, a tenant of the property may share in this control and responsibility for the sublet space. Owners and operators have or should have, a superior knowledge of the site's history, including crime. Casual visitors, invitees, or customers generally have no responsibility for security at a given site since they are not able to exercise reasonable control over the events at the location, or influence the environment. It is generally the responsibility of a resident, business operator, or property owner to provide for the safety and protection of human life and the property.

Anticipating the threat - A helpful approach in determining the security needs of a property or operation is to study the *opportunity, means,* and *motivation* of potential perpetrators. Security works to deny *opportunity*, and increase the level of *means* or resources necessary for the criminal to successfully attack the target, and escape. When opportunity is limited, and a large amount of time and resources are required to successfully complete a criminal act and escape, criminal *motivation* declines.

Time - Time is the criminal's enemy. The longer a criminal act takes in *planning, execution,* and *escape,* the more likely the crime will be deterred. Most common criminals will choose a property that requires the least amount of stealth, equipment, and planning.

Target hardening - A target is harder to attack when coordinated security elements are provided. In the process of target hardening, deterrent objectives are set, options reviewed, and steps taken to improve security. The *target* is the people or property to be protected, and the various security features are the *hardening elements.* Each separate security element adds to the others, making the target harder to attack. Security elements available to the professional will vary by situation, but often include management controls, perimeter protection, a means of surveillance, response capabilities, and security lighting. A good security plan will contain layers of security features, and will not rely on one single security feature for success.

Fight or flight - The basic decision made by persons when threatened is fight or flight. In other words…*is defense or evasion the appropriate measure?* Sometimes, the act of fleeing danger is simply not an option due to circumstances. *Fight* may be the physical act of defense or a call for help. For police or security officers, it usually means some form of physical defense for serious threats. *Flight,* on the other hand, may mean moving to a safe place, or getting out of the way of a presumed threat. Lighting, if properly installed and maintained, can play an important role in helping people make this basic decision.

Security elements - Security elements can be *active* or *passive* deterrents. Active elements have the capacity to interact with persons or generate a response to a criminal's actions. Passive elements include those security features and applications that are static in nature and do not interact with a would-be intruder or criminal.

Passive elements for a home or business may include deterrent features such as perimeter fencing or walls, open or barrier landscaping, exterior and interior illumination systems, safes, open areas, and warning signs.

The most active deterrent is a patrol officer. The effectiveness and response of uniformed individuals making patrol rounds is often hard to predict, causing a would-be criminal to pause. Other active applications, in wide use, include: interactive alarm systems, card or coded entry devices, metal detectors, security and police officers, and trained animals such as dogs and geese. Some elements may be classified as both active and passive deterrents. For example, monitored closed-circuit television (CCTV), where there is a response or interactive capability is *active,* whereas CCTV that is not monitored is *passive*.

Illumination as a key element in security design - Security lighting is usually passive in application. Exceptions to this general rule include luminaires that are automatically turned on and off by electronic motion sensors. By applying both passive and active elements to some security lighting applications, the designer can create uncertainty in the mind of the would-be criminal about being detected and observed.

The principles of security lighting applicable to new facilities, or existing facilities, those being upgraded, or converted, include:

- Integration of illumination into the total security system, thereby facilitating the effectiveness of other security devices or procedures;
- Illumination of objects, people, and places to allow observation and identification, thereby reducing criminal concealment;
- Illumination to deter criminal acts by increasing fear of detection, identification, and apprehension;
- Lessening the fear of crime by enhancing a perception of security;
- Illumination that allows persons to more easily avoid threats, and to take defensive action when threats are perceived.

3.2 Community Responsive Design

Community responsive design applies to all exterior lighting, regardless of its purpose (security, safety, aesthetics). Security lighting should be evaluated for its appropriateness in the context of the overall environment and surrounding community. Lighting for commercial, residential and transition areas in an urban setting may have very different requirements (lighting levels and luminance ratios) than lighting in a rural or remote location where glare and light trespass issues may have increased importance.

Light trespass usually fits into one of two categories:

- Adjacent property receives unwanted light (high illuminance levels)
- Excessive brightness occurs in the normal field of vision (nuisance glare)

Efforts have been made in numerous jurisdictions to write ordinances or bylaws controlling light trespass. One method is based on using specific Environmental Zone descriptions that underlie any restrictions on outdoor lighting. Areas may be classified into a series of Environmental Zones (E1 through E4) based upon the extent to which control of light trespass is considered necessary or desirable. These have been developed by the International Commission on Illumination (CIE) and have been accepted by IESNA as suitable for application in North America. The Zones are defined by CIE as follows:

E1 Areas with intrinsically dark landscapes. Examples are national parks, areas of outstanding natural beauty, or residential areas where inhabitants have expressed a strong desire for strict limitation of light trespass.

E2 Areas of low ambient brightness. These may be suburban and rural residential areas. Roadways may be lighted to typical residential standards.

E3 Areas of medium ambient brightness. These will generally be urban residential areas. Roadway lighting will normally be to traffic route standards.

E4 Areas of high ambient brightness. Normally this category will include dense urban areas with mixed residential and commercial use with a high level of nighttime activity.

Within any category a curfew of “after hours” time may be established, allowing higher lighting levels during those hours when the curfew is not in effect.

There is no single set of values/limits that will work in every situation. The following recommendations[3]** are suggested illuminance limits to control light trespass. The values for the various zones are measured at a very specific location-at the property line on adjacent property and at the eye in a plane perpendicular to the line of sight. Illuminance values for security lighting needs in **Section 7.0** are measured in different planes and viewing angles and are not incompatible with the light trespass limits when issues such as glare and control of light distribution are addressed.

Zone and Description	**Recommended Maximum Illuminance**
Zone E1 *Intrinsically dark*	1 lux (0.1 fc)
Zone E2 *Low ambient brightness*	3 lux (0.3 fc)
Zone E3 *Medium ambient brightness*	8 lux (0.8 fc)
Zone E4 *High ambient brightness*	15 lux (1.5 fc)

** These recommendations are based on those in the “Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations.” Report of CIE committee TC5.12 - Obtrusive Light. Commission Internationale de l’Eclairage, CIE, Vienna, Austria

The challenge for the designer of security lighting systems is to determine the appropriate solution not only for the site to be lighted but also for the surrounding community, especially when different jurisdictions adopt different Environmental Zones.

3.3 Security Lighting Planning

To achieve the objectives of security lighting, attention must be given to both vertical and horizontal illuminances, the uniformity of the illuminance distribution, the effect of obstructions, the reflectance of surfaces, background contrast, degree of glare, the spectral power distribution of the light source, the interaction with electronic surveillance systems, and the effect on the surrounding area.

Lighting can be a deterrent to criminal acts. Properly installed security lighting is cost effective, easy to operate, and dependable. The extent and type of lighting to be used as part of a balanced security system will be determined by several different factors:

Criminal History - In the case of an existing site, it is critical that security and lighting professionals consult data that details prior criminal history on or near the premises before changing the lighting or other security elements at the site. Generally, such an analysis should be performed annually, and the security profile of the property and adjacent properties adjusted accordingly. If the site is being developed in a previously unoccupied area, or if there is a fundamental change in use, an analysis of crime in the surrounding area is acceptable. If the site is in a high-crime area, many physical defenses, including lighting, will probably be required to maintain overall security on the premises. As success in controlling or reducing crime is realized, it may be possible to reallocate valuable resources. Security is an issue for a property when a history of relevant crime exists. For more information on the analysis of crime, see **Annex C.**

Nature of the Site - The type of facility or business, the hours of operation or access, and surrounding conditions affect the approach to security.

Degree of Obstruction - Landscape design, fences and other obstructions, and building configurations should not retard detection and identification of unauthorized persons on premises. Lighting should be designed to avoid deep shadows, be uniform, and permit observation of the activities of those allowed on the site.

Ambient Luminance of the Surrounding Area - Security elements at one site affect the security elements on adjoining sites. It is acceptable practice to rely on off-premises sources of ambient lighting when planning security, provided that the ambient source is consistent in quantity, quality, and performance.

Impact on Surrounding Area - Stray light from a security installation may be considered as *light trespass* by neighbors. Stray light or over-lighting may also have effects on safety on nearby roads and railroads. Where signal lights are used to control traffic on roads, railroads, rivers, or at sea, care should be taken to avoid confusion caused by disability glare from the security lighting system. Lighting can also have an environmental impact on nocturnal animals, migratory birds and nesting sea turtles. Local lighting ordinances should be consulted prior to design work for any limitations on mounting height, source type, wattage, shielding, and other local requirements that must be followed. Permission for variances should be obtained from the authority having jurisdiction.

4.0 UNDERSTANDING "WHEN SECURITY IS AN ISSUE"

Designers, prevention professionals, managers, and owners should consider *security an issue* when one or more of the following conditions exist:

1. The persons and/or property in the area to be secured present a desirable target to would-be criminals.
2. The property has a history of relevant crime or increases in crime. (See **Annex D**.)
3. Crime in the surrounding area is high compared to other political subdivisions, parts of the city, or county. (See **Annex D**.)
4. The results of a physical security survey or threat analysis indicate a problem. (See **Annex B**.)
5. There are changing conditions, which expose persons to new security hazards or increased risk.
6. Obvious physical signs of antisocial behavior near or on the property such as graffiti, vagrants, broken windows, trash buildup, trespass, or poorly maintained properties.
7. There are recurring, reasonable resident or customer complaints or concerns about security, or fear of crime.
8. High profile or troublesome areas exist such as bars, nightclubs, gambling halls, gang or teen gathering spots.
9. There are industrial or commercial applications where persons or property are prone to attack, such as ATM and night depositories, convenience stores, and railway yards.
10. Restricted access industrial or government installations are in the area.

11. A time of national emergency such as war, acts of terrorism, and declared emergencies.

When it is determined that *security is an issue,* reasonable and necessary measures need to be taken to improve security and safety conditions at the site in response to the potential threat. Each site will have its own set of relative conditions, pressures, usage, and threats. However, the following suggestions are a place to start:

1. Are there mission and objective statements regarding the security and safety of others, and are these up to date?
2. Are there adequate post orders (job descriptions) for those responsible for carrying out security duties?
3. Are policies and procedures up-to-date, and do these documents reflect the true needs of the site?
4. Have tenants, and those that occupy or use the space, been advised of the potential threat level or the hazard?
5. Have public and private law enforcement agencies been notified of the condition, and did this notification include a request for assistance or additional patrols?
6. Has a security survey or audit been performed or updated since the *security is an issue* determination was made?
7. Do changes in procedures, staffing levels, and security hardware need to be made?
8. Do illumination systems, levels, uniformity ratios, glare control, and maintenance schedules meet recommended practices, standards, and code requirements?

If there is a history of violence or violent-prone attacks against persons, then it is likely that crimes of a similar nature will occur in the future, given the same circumstances. If a property has a history of incidents such as car thefts, gang graffiti, abandoned cars, vandalism, or broken fences, lighting fixtures (luminaires) or windows, a reasonable person could conclude that the site is not secure, and the owners need to take action. Similarly, ongoing complaints from users of the property, changing conditions, or when a high-risk business moves into the area, may indicate a threat to both property and persons. The professional security and/or lighting designer should take note of this, and plan accordingly.

When operations are conducted at night or during instances of poor visibility, the quantity and quality of the lighting may need to be increased to aid in the protection of persons and property. Conversely, if conditions improve, it is reasonable to reduce the level of security, to a point equal to the perceived threat. In such cases, a test phase should be conducted and evaluated with defined achievement goals. A test period of six months should be considered, with monthly evaluation increments for comparison.

Good lighting alone cannot guarantee security. Good security lighting, when integrated into a balanced security plan, will, however, play a critical role in reducing or displacing crime and make the other security elements more effective.

5.0 VISIBILITY CONCERNS IN SECURITY APPLICATIONS

It is mostly at night that the highest fear of crime occurs. Sometimes common sense or intuition enables good decision making; other times the physical senses alert one to danger. Although all of the senses provide information about the environment, it is through vision that the majority of information is acquired and processed by the brain. Vision, therefore, has a tremendous impact on the decision making process.

Lighting facilitates visual perception of a space and area around the observer, and the observers' ability to see. For security purposes, the important lighting criteria are *illuminance, uniformity, glare* and *shadows*. Refer to **Table 1** for the relative importance of these and other quality factors for specific applications.

5.1 Illuminance

Illuminance is the density of light that impinges (falls on) a surface. Illuminance, or quantity of light values are provided for a variety of applications in **Section 7.2.** Measurements are made using an illuminance meter (often referred to as a light or footcandle meter). The primary unit of measurement for illuminance is lux (metric) or footcandle (US-English).

The two primary planes for measuring illuminance are *horizontal* and *vertical*. As a general rule, values not specifically labeled as *vertical*, are assumed to be *horizontal lux (footcandles)*. (A summary of illuminance values for specific applications in **Section 7.2** can be found in **Table 1**.) Note that for security lighting, vertical illuminance is often more important than horizontal because of the need to identify people.

Table 1.
SECURITY LOCATIONS AND TASKS

Very Important | Important | Somewhat important

Design Issues	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Direct Glare	Light Distribution on Surfaces	Light Pollution/Trespass	Identification of Faces or Objects	Peripheral Detection	Point(s) of Emphasis	Reflected Glare	Shadows	Specific task lighting	Aesthetic emphasis	Surface Characteristics	Illuminance, Lux (Horizontal) - Average unless otherwise noted	Illuminance, Lux (Vertical)	Footnotes on special considerations	Ratios (average to minimum)	Reference Section(s) in **G-1** text
Unoccupied Spaces																		7.2.1
(acceptable losses)																		
Storage yards, industrial equipment														5-20			8:1	
areas and container terminals																		
Unoccupied Spaces																		7.2.1
(unacceptable losses)																		
Storage yards, industrial equipment														10-20			6:1	
areas and container terminals																		
Building façade															5-20		8:1	7.2.2
Building interior																		7.2.2
(unoccupied patrol areas)														10			6:1	
Facial Identification															5-8	(a)	4:1	7.2

NOTE: Recommended horizontal and vertical illuminances are in lux (divide by 10 for fc)

Table 1.
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Design Issues	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Direct Glare	Light Distribution on Surfaces	Light Pollution/Trespass	Identification of Faces or Objects	Peripheral Detection	Point(s) of Emphasis	Reflected Glare	Shadows	Specific task lighting	Aesthetic emphasis	Surface Characteristics	Illuminance, Lux (Horizontal) - Average unless otherwise noted	Illuminance, Lux (Vertical)	Footnotes on special considerations	Ratios (average to minimum)	Reference Section(s) in **G-1** text
Guarded Facilities																		7.2.2
Entrances and gatehouse inspection	Somewhat important	Very Important	Very Important	Very Important	Very Important	Very Important	Very Important	Very Important	Very Important	Very Important	Very Important		Very Important	100	(a)	(b)	3:1	
Guardhouse interior	Somewhat important	Important	Very Important	Very Important		Very Important	Very Important		Very Important	Very Important	Important		Important			(c)		
Automated Teller Machines and Night Depositories (Exterior)																(d), (e), (f)		7.2.3
Face of ATM		Somewhat important	Very Important	Important	Very Important	Very Important	Very Important		Somewhat important	Very Important			Important		150		3:1	7.2.3
Within 3.5 m (10 ft) of face of ATM		Somewhat important	Very Important	Important	Very Important	Very Important	Very Important		Somewhat important	Very Important			Important	100	(a)			
Beyond 3.5 m (10 ft) to 15.2 m (50 ft)		Somewhat important	Very Important	Important	Very Important	Very Important	Very Important		Somewhat important	Very Important			Somewhat important	20	(a)		3:1	7.2.3
Supported parking 18.5 m (60 ft)		Somewhat important	Very Important	Important	Very Important	Very Important	Very Important		Somewhat important	Very Important			Somewhat important	20	(a)		3:1	7.2.3
Side of building out to 12.2 m (40 ft) when ATM is within 3.5 m (10 ft) of corner		Somewhat important	Very Important	Important	Very Important	Very Important	Very Important		Somewhat important	Very Important			Important	20		(e)	3:1	7.2.3
Automated Teller Machines and Night Depositories (Interior)																(d),(e),(f),(g)		7.2.3
Face of ATM	Very Important	Very Important	Very Important	Very Important		Very Important	Very Important		Very Important	Very Important	Very Important		Very Important		150		3:1	
Preparation counter 3 m (10 ft) of ATM	Very Important	Very Important	Very Important	Important		Very Important	Very Important		Important	Very Important			Important	150	(a)		3:1	
All other areas of the enclosure	Very Important	Very Important	Very Important	Important		Very Important	Very Important	Important	Important	Very Important		Somewhat important	Important	100	(a)			

Table 1.
SECURITY LOCATIONS AND TASKS

Very Important | Important | Somewhat important

Design Issues	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Direct Glare	Light Distribution on Surfaces	Light Pollution/Trespass	Identification of Faces or Objects	Peripheral Detection	Point(s) of Emphasis	Reflected Glare	Shadows	Specific task lighting	Aesthetic emphasis	Surface Characteristics	Illuminance, Lux (Horizontal) - Average unless otherwise noted	Illuminance, Lux (Vertical)	Footnotes on special considerations	Ratios (average to minimum)	Reference Section(s) in **G**-1 text
Parking Facilities, Garages and Covered Parking Spaces																(h)		
On pavement														60	(a)		4:1	
Gathering points (stairs, elevators, ramps)														50	(a)		4:1	
Parking Garages for the Elderly **(Entrance)**														500	(a)	(i)		7.2.12
Exterior walkways around senior facilities														50	(a)	(l)		
Parking Lots, Areas for Public Parks																		7.2.6
Open parking spaces														30	(a)		4:1	
Park trails and walkways														6	(a)	(j)	4:1	
Likely loitering areas														10	(a)		4:1	
Supermarket, Major Retail Parking																		7.2.7
Parking lot														30	(a)		4:1	
Low activity - close-in parking														50	(a)	(k)	4:1	

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Fast Food Restaurants																		7.2.8
General parking														30	(a)		3:1	
Drive up window out to 9.1 m (30 ft)														60	(a)		3:1	
Refuse area														30	(a)		3:1	
Convenience Stores and Gas Stations																		7.2.9
Pump island														60	(a)		4:1	
Sidewalks, refuse areas and grounds														30	(a)		4:1	
Interior of store														300	(a)		4:1	
Single-family Residences																		7.2.10
Exterior doorways															8			
Multi-family Residences																		7.2.11
Common areas														30	(a)		4:1	
Common mailbox area														100	(a)		4:1	

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Senior Housing																(i)		7.2.12
Hallways/Room Entrances (Active hours)	VI	VI	VI	VI		VI	VI		VI	VI		VI	VI	300	(a)			
Hallways/Room Entrances (Sleeping hours)	VI	VI	VI	VI		VI	VI		VI	VI			VI	100	(a)			
Schools and Institutions																		7.2.13
General parking	I	I	VI	I	VI	VI	VI		I	VI		SI	I	30	(a)	(l)	4:1	
Sidewalks and footpaths	I	I	VI	I	VI	VI	VI	I	I	VI		SI	I	10	(a)	(l)	4:1	
Law Enforcement, Fire, Ambulance and other Emergency Service Facilities																		7.2.14
Within 18.2 m (60 ft) of all vehicle and pedestrian movement areas	SI	I	VI	I	VI	VI	VI	I	I	VI	I		I	80	(a)		3:1	
General parking and walkways	SI	SI	VI	I	VI	VI	VI	SI	I	VI			I	30	(a)		3:1	
Hotels and Motels																		7.2.15
General parking	I	I	VI	I	VI	VI	VI	I	I	VI		I	I	30	(a)		4:1	
Sidewalks and grounds	VI	VI	VI	I	VI	VI	VI	I	I	VI		I	I	10	(a)		4:1	

Table 1.
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Footnotes:

(a) Vertical illuminance of 5 to 8 lux or values that produce a unifromity ratio of no more than 4:1 (twenty five percent of horizontal illuminance).
(b) Horizontal illuminance should be as shown or twice that of immediate surrounding area, whichever is greater.
(c) Interior illuminance should be minimum recommended for specific task performance.
(d) Redundant lamps so loss of any one lamp will not reduce lighting levels below minimum.
(e) Good to excellent facial recognition required at a distance of 9.1 m (30 ft).
(f) Unobstructed view out to 15.2 m (50 ft) in all directions from face of machine.
(g) Unobstructed view from inside enclosure outside to 6.1 m (20 ft).
(h) Interior lighting should allow for safe movement and easy detection of hazards to a distance of at least 9.1 m (30 ft).
(I) See IESNA RP-28, *Lighting and the Visual Environment for Senior Living*.
(j) Lighting should extend out on both sides of trail to a distance of 9.1 m (30 ft).
(k) Size of parking area determined by estimated customer count.
(l) For special events, parking lots and grounds should be lighted 2 hours prior to 2 hours after the event.

5.2 Horizontal Illuminance

The density of luminous flux on a horizontal surface is referred to as horizontal illuminance. Most illuminance measurements or discussions about security lighting refer to horizontal values. These readings are recorded with the light meter held in a horizontal plane or placed on a horizontal surface, such as the pavement in parking lots, grounds, on roofs of buildings, or tabletops. Unless otherwise stated, horizontal illuminance is measured at grade. Note that many manmade surfaces such as roads, parking lots, or landscaped areas are not exactly level and may contain deliberate grades for drainage. As a practical matter, these are considered horizontal, unless the grade is steep. For more information on vertical and horizontal illuminance, and taking measurements, refer to **Annex B**.

5.3 Vertical Illuminance

Vertical illuminance is important for identification of people. There should be sufficient light to positively identify a face and read body language as either familiar, unfamiliar, or threatening at a distance of at least 9 m (30 ft) from the viewer. Unless otherwise noted, vertical illuminance is measured at 1.5 m (5 ft) above grade. (See **Annex B**.)

Lighting that allows identification of faces is a relatively new concept in security lighting, but important in certain applications, such as parking facilities, peep-hole viewing, or at security checkpoints. If the luminance of the background (behind the face) is more than four times the luminance on the face, the image will be in silhouette. As a practical matter, in an empty parking lot the background may be the pavement at a considerable distance away with luminances less than those necessary to cause the face to go into silhouette. However, areas with vertical surfaces immediately adjacent to the person being viewed, such as a light colored wall behind the customer at a drive-up window, could easily produce luminances exceeding the recommended luminance ratio of 4:1 (background-to-face).

5.4 Uniformity

Uniformity refers to the evenness of the distribution of light on the surface(s). In determining uniformity, minimum, average, and maximum illuminances are compared using ratios; either average-to-minimum or maximum-to-minimum. Uniformity in security lighting aids security perception, while reducing the necessity for eye adjustment when scanning or using the area. Uniformity ratios (average illuminance divided by minimum illuminance) vary depending upon the application. (See **Section 7.2**.)

5.5 Glare

Glare is the sensation produced by luminances (within the visual field) that are sufficiently greater than the luminance to which the eyes are adapted. Glare causes annoyance, discomfort, or loss in visual performance or visibility, and usually reduces the benefits of security lighting. There are two types of glare, disability glare and discomfort glare. Disability glare is the effect of stray light in the eye whereby visibility and visual performance are reduced. It can often be attributed to poorly shielded or non-cutoff luminaires. Discomfort glare produces discomfort but may not interfere with visual performance or visibility. Overhead glare is manifested by reflections off eyeglasses, eyelashes, cheekbones and other reflective areas around the eye. Direct glare results from high luminances or insufficiently shielded light sources in the field of view. Reflected glare is caused by a high luminance image on a specular or glossy surface, causing detail to be partially or totally obscured. Perimeter glare, however, when oriented to the outside of the site, may be desirable and useful in some secure sites to make the inside area less definable to would-be trespassers.

5.6 Shadows

Shadows reduce the effectiveness and impair security lighting. When shadows are sharply defined at or near an area, they may be annoying and discourage a feeling of safety. In addition, shadows make it difficult for users of property and equipment to maintain quality surveillance. Shadows reduce uniformity of lighting.

5.7 Establishing Site Divisions

When planning or evaluating security lighting, designers will find it helpful to divide a facility into sections such as *total site, pedestrian, pedestrian path, building,* and perimeter zones. Each may require consideration of a differing set of perception factors.

5.8 Total Site Zone

Large sites, with a need to provide protection for persons and property, are lighted most economically with high-wattage, high-mounted luminaires, spaced to provide uniform illuminance. (See **Figure 1**.) Mounting height limitations and other restrictions imposed by local ordinances may dictate more numerous luminaire locations to achieve adequate uniformity. Two other important issues that must be addressed are light trespass and light pollution (obtrusive light). Luminaires with cutoff or semi-cutoff distributions can provide adequate vertical illuminance and “be good neighbors” for most applications.

(See **Section 6.0**, item 9 and **Figure 11**.) The typical mounting heights for luminaires in the total site zone are 9 to 18 m (30 to 60 ft). Each pole may have one or more luminaires usually housing 250 W to 1000 W high intensity discharge (HID) lamps. A selection of light distribution patterns are available that lend themselves to a variety of parking lot, walkway and site geometries, with the outward appearance of the luminaire housing remaining consistent. Well-designed glare-control louvers or visors can be used to reduce pedestrian glare, while allowing the floodlight to perform as intended.

5.9 Pedestrian Zone

Pedestrian areas require increased visibility and different quality considerations than the site zone. Luminaires for mounting heights lower than those used for site lighting produce wider beam characteristics than equipment designed for high mounting heights. The use of full cutoff luminaires, however, at low mounting heights in this zone will not provide high vertical illuminance levels. The typical mounting height for the pedestrian zone is in the 3 to 6 m (10 to 20 ft) range. Note that if floodlights are installed and aimed at high angles from vertical in areas adjacent to pedestrian zones, such as for building façade lighting, they may produce direct glare and light trespass if the light shines through the pedestrian zone.

5.10 Pedestrian Path Zone

Paths require luminaires on a pedestrian scale, delineating the walking area and connecting the site with the structure. The path zone defines the traffic patterns and establishes a sense of welcome and security, particularly important for facilities with 24-hour operations. Bollards or landscape-style luminaires are often used to delineate paths and to provide highlighting without visual obstruction. The typical mounting height for bollards housing lamps from 50 to 100 watts is 60 to 105 cm (24 to 42 inches). Spacing and mounting height depends on the lamp type and photometric distribution, according to manufacturers' recommendations. Note that this type of low-level luminaire often produces little or no facial illumination, and should be used only to supplement pole-mounted luminaires on a pedestrian scale at 2.4 to 3 m (8 to 10 ft).

5.11 Building Zone

Building floodlighting can be employed as a security lighting technique, creating large areas of vertical illuminance and adding to the ambiance of the area by means of light reflected off the building surface. Luminaire setback position from the building facade should be three-fourths the height of the building for uniform lighting; the spacing should not exceed twice the setback. The ground-mounted aiming point should be at least two-thirds up the building height. If the setback is reduced, the aiming point must go higher. (See **Figures 2 (a)** and **2 (b)**.) Local ordinances should be

Figure 1. High-mounted luminaires provide uniform illuminance for approach driveway, sidewalks and parking areas in this complex. (Photo courtesy of Holophane.)

consulted to determine if this lighting technique is permissible. Care must be taken to avoid producing glare to the users of the area, light impinging on pedestrian zones, and over-lighting. Careful control of the light output is essential to avoid wasted light and energy, as well as creating adverse effects of sky glow.

5.12 Building Perimeter Zone

Wall mounted luminaires are often used to provide illumination for walkways, entrances, and underpasses. Luminaire manufacturers' data provide recommended spacing to mounting height ratios.

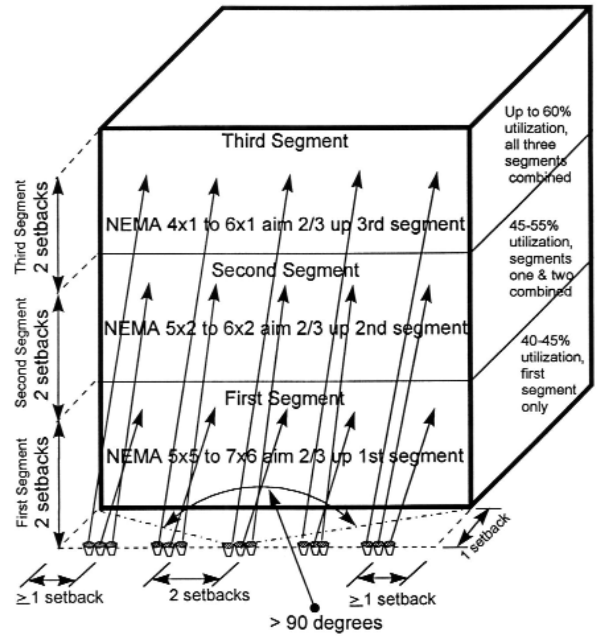
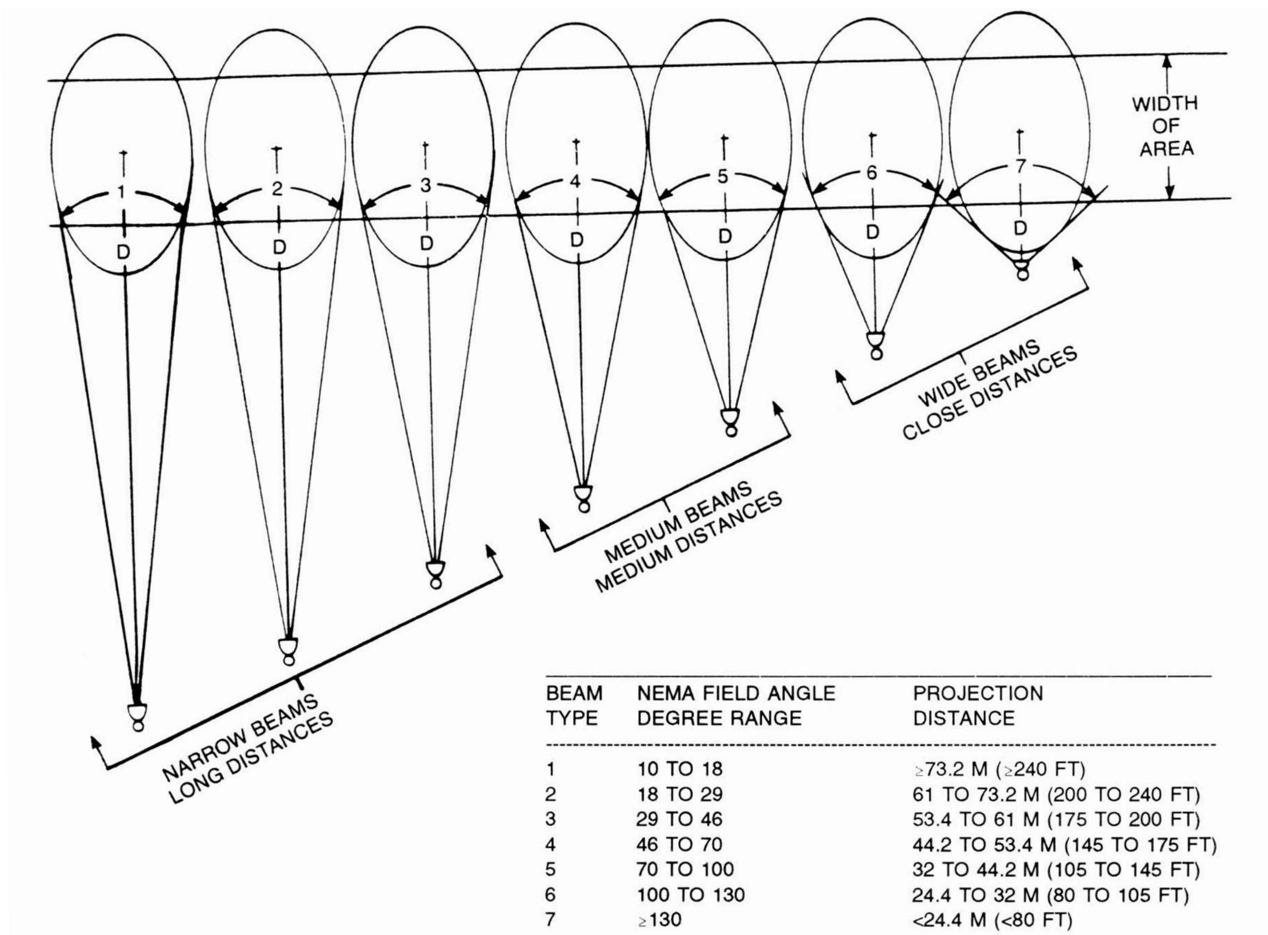


Figure 2 (a). Ideal geometry for "uniform" floodlighting where the total angular coverage to the floodlight locations is greater than 90 degrees and the building height is greater than two setback distances (but does not exceed six setback distances).



BEAM TYPE	NEMA FIELD ANGLE DEGREE RANGE	PROJECTION DISTANCE
1	10 TO 18	≥73.2 M (≥240 FT)
2	18 TO 29	61 TO 73.2 M (200 TO 240 FT)
3	29 TO 46	53.4 TO 61 M (175 TO 200 FT)
4	46 TO 70	44.2 TO 53.4 M (145 TO 175 FT)
5	70 TO 100	32 TO 44.2 M (105 TO 145 FT)
6	100 TO 130	24.4 TO 32 M (80 TO 105 FT)
7	≥130	<24.4 M (<80 FT)

Figure 2 (b). An explanation of NEMA field angle classifications and their effective projection distances are widely used by the lighting industry to classify the overall candela distribution patterns of floodlights.

6.0 LIGHTING EQUIPMENT

Selecting and applying the proper lighting equipment can make the difference between a security lighting installation that deters crime and one that actually aids criminals. Careful selection and appropriate placement of equipment will insure that required light levels are achieved with limited glare and reliable operation. A well-designed lighting system will make the space attractive during the day and attractive at night. (See **Figure 3**.) It is important, however, not to judge decorative luminaires solely on their daytime appearance. Of greater significance are nighttime performance issues such as light distribution, and control of glare and light trespass.

Considerations affecting an installation include:

1. Light Source Color - For the purposes of security lighting, color rendition is an important consideration in the choice of light sources used. There are several important measurements of color, including *Color Rendering Index, Color Temperature,* and *Spectral Power Distribution.*

a. Color Rendering Index - How do things appear under a light source? Do colors look the same at night as they do during the day? Is it important to be able to describe the color of a potential suspect's clothes? Or the color of an automobile involved in a hit-skip accident? Color Rendering Index (CRI) is a method used for measuring and specifying color rendering properties of light sources. It measures the degree of color shift objects undergo when illuminated by a particular light source as compared with the same objects when lighted by a reference source of comparable color temperature. CRI is 100 or less. The higher the CRI, the better the color rendering ability of the source. Research has shown that almost any nominally white light source (CRI of 50 or higher) allows accurate and confident color identification at the illuminances used in public spaces at night. High-pressure sodium lamps allow accurate but less confident color naming at high illuminances used for public spaces, but both accuracy and confidence declines at lower illuminances. Low-pressure sodium lamps do not allow accurate color identification under any illuminance level.

b. Color Temperature - Light sources are often described as "warm" or "cool" in appearance. The designation of a lamp's color temperature (or correlated color temperature (CCT)) can be thought of as heating a piece of metal, which causes the color of the metal to change, until the color of the metal and the lamp are almost the same. The temperature of the metal is

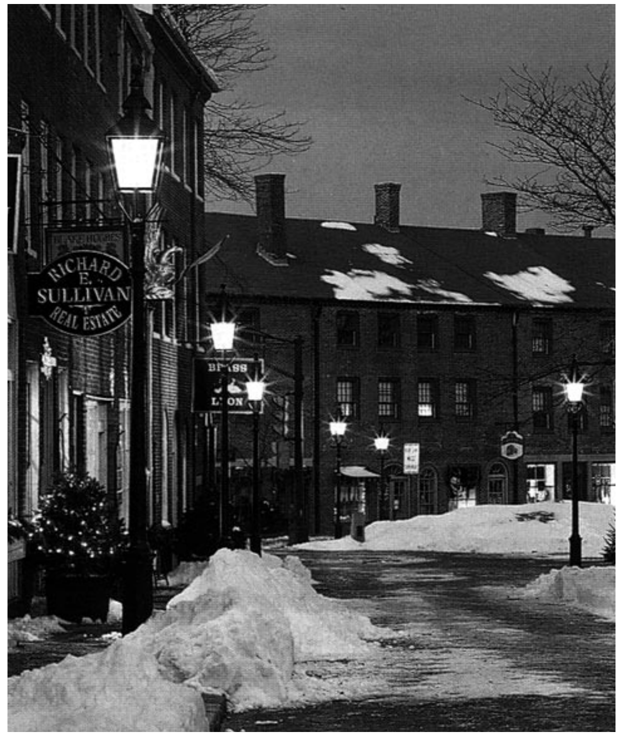


Figure 3. Pole-mounted "lantern-style" luminaires help create a turn-of-the-century theme for this street, which is home to numerous upscale businesses and stores. They are equally attractive during the day or night. Care should always be exercised in choosing decorative luminaires, which may produce glare and light trespass. (Photo courtesy of OSRAM SYLVANIA.)

recorded (in Kelvin) and that number is used to describe the lamp's color. Warm sources like incandescent, high-pressure sodium, and "warm" white fluorescent lamps have color temperatures between 1800K and 3200K. Cool sources like mercury vapor, metal halide, and "cool" white fluorescent lamps have color temperatures between 4000K and 7500K. (See **Figure 4, color insert**.)

c. Spectral Power Distribution - The composition of light can be described by its spectral power distribution (SPD), which shows the relative amounts of power at wavelengths of different colors. The visible wavelength range extends from about 380 to 780 nanometers. (See **Figure 5, color insert**..) When a light source contains energy throughout the visible spectrum, it is seen as emitting "white" light. Also, when the primary colors (monochromatic red, green and blue wavelengths) are combined, the result appears as "white" light. Many electric light sources, however, produce light that is generally unequal in various parts of the visual response range, which affects the way objects appear. If a light source is weak in red wavelength output, materials normally interpreted as red during the daytime may be muted or appear dull under the source at night. The SPDs of various lamps can be obtained from lamp manufac-

Figure 6. Color temperature, Color Rendering Index and Spectral Power Distribution Effects of Various Sources.

Light Source	CCT[a] (K)	CRI[b]	Spectral Power Distribution Effects: Colors Enhanced	Spectral Power Distribution Effects: Colors Dulled	Efficacy (LPW)[c]	LLD[d]	Life (Hours)	Starting and Warmup Time[e] (Minutes)	Dimming Range (% Light Output)
Standard Incandescent filament	2700	100	Red, Orange, Yellow	Blue, Green	17	85	750	0	100-0
Tungsten Halogen (Reflector)	2850	100	Red, Orange, Yellow	Blue, Green	14	95	2500	0	100-0
Fluorescent (Halophosphate phosphors)	3000-4100	62	Yellow, Blue, Orange	Red	82	85	20,000	0	100-1
Fluorescent (Rare earth phosphors)	2700-5000	72-90	All	None	89	85	20,000	0	100-1
Mercury vapor	5700	15	Blue, Red	Green	45	60	24,000	<10	100-10
Metal Halide	3000-6000	65-90	Blue, Green, Yellow	Red	90	80	20,000	<10	100-50
High Pressure Sodium	1800-2200	22	Yellow	Red, Blue	104	90	24,000	<5	100-50
Low Pressure Sodium	1800	-44	Yellow	All but yellow	126		18,000	<10	na

(See manufacturers' catalogs for specific data.)
a Correlated Color Temperature Kelvin
b Color Rendering Index
c Efficacy for lamp is shown in lumens per watt. Ballasting is required for all lamps except standard incandescent and tungsten halogen.
d Lamp Lumen Depreciation as defined in the *IESNA Lighting Handbook* for each light source.
e Time intervals to reach usable light output.

turers. The SPD looks like a graph with bars (or a continuous line) from the blue to the red end of the spectrum. Peaks in the SPD represent strong energy output from the lamp in that area, while valleys in the SPD indicate the lamp's weakness to illuminate certain colors.

Figure 6 shows several different light sources commonly used for safety and security lighting. Depending on the needs of the application, the chart can be used as a guide for lamp type selection, but is not intended to be a comprehensive list of all light sources. Light source manufacturers' data should be consulted for more specific and comprehensive information.

2. Poles: In general, the taller the poles, the fewer poles will be required for a given area, resulting in improved uniformity and less likelihood of vandalism to the luminaires. In many localities, however, pole height is restricted. When lower mounting heights are used, more poles and lower luminaire wattages will likely be required to maintain adequate uniformity and to avoid over-lighting. (See **Figure 7**.)

3. Controls: Many existing lighting ordinances require that lighting in certain areas or for certain lighting applications be extinguished at a particular hour. Establishment of curfews is a logical method to provide partial control of light trespass. However, when considering application of a curfew, the needs of safety and security must first be evaluated to determine how, when or if curfews should be relaxed or modified in the Environmental Zone (**Section 3.0**) or Site Zone (**Section 5.0**).

For non-residential applications, security lighting units should always be controlled automatically with photocells, timers, or other sensors; and not assigned to an individual user, except perhaps in a guardhouse application where light is needed only occasionally for undercarriage or periodic inspections. Types of controls include time switches, photocells, dimmers and motion detectors. These may be used individually or in combination to control a single luminaire or a group of luminaires.

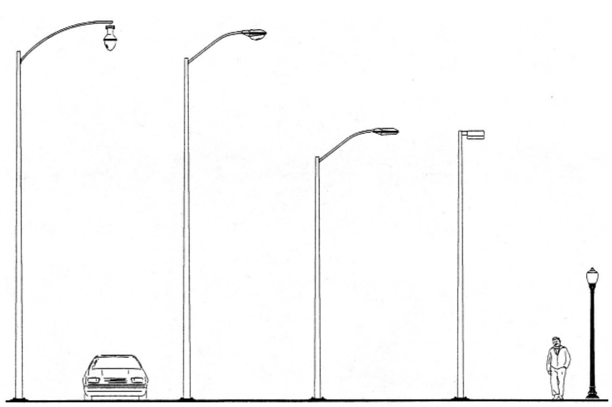


Figure 7. A typical family of luminaires exemplifying various pole heights and luminaire configurations. (Illustration courtesy of Clanton and Associates, Inc.)

a. Time Switch - Generally used when a defined on/off cycle is required without regard for whether or not the light is actually necessary when energized. Unless used in conjunction with a photocell, the adverse impacts on energy consumption should be considered. Time switches or clocks that can be programmed to adjust on/off times with the seasons and to energize dimmers during low traffic periods should be selected. Time switches are not effective where heavy weather causes darkness/reduced visibility during daylight hours. AC power time switches operated on commercial power should have an AC or DC backup to respond to primary power disruption.

b. Photocells - Used to control an individual luminaire or a series of luminaires when operated in combination with a contactor. Photocells can also automatically energize luminaires during dark periods, regardless of time of day. When photocells are combined with a time switch, they can be used to energize lights at dusk and then de-energize them at a specified time when the lighting is no longer required; e.g., after business hours. The photocells should be placed where they will sense the darkest scene and where they are not influenced by the light output of the luminaire(s) they are controlling. When *security is an issue,* photocells should be located where a flashlight, or other extraneous light cannot defeat them.

c. Dimmers - Used to reduce illumination (and power) during low traffic periods in such areas as industrial employee parking lots during working hours, or late night mall parking, when no one should be in the area. By dimming all units, the entire area remains uniformly illuminated, compared to the uneven lighted appearance that occurs when half of the units are de-energized to save electricity. Dimmable fluorescent and HID units require special ballasts.

d. Motion Detectors - Used to energize specific or all units when motion is detected. Motion detectors should only be used with incandescent and fluorescent sources because of the slow start up of HID sources, unless the luminaires are dual-level HID types. Motion detectors can be effective in introducing an element of surprise. These devices can activate a strong light beam toward a potential intruder, who senses detection, while at the same time alerting off-site personnel. Motion detectors are especially effective in residential applications and when used in pairs in "traps." A motion detector trap is used in confined areas, such as spaces between buildings, or fences and buildings. The first motion detector is left exposed to the eye, and the second detector is disguised and aimed to respond to the "blind spots" of the first detector.

4. Maintenance: No security lighting system can remain effective without regularly scheduled maintenance. A planned maintenance program should include immediate replacement of failed lamps, electrical components, photocells, and vandalized or damaged luminaires, and involve regular cleaning of luminaires and shrubbery pruning. Inspections of all lamps should be performed at least monthly during hours of darkness to look for dirty or broken lenses, failed lamps or those not performing to specified standards, tree limbs blocking light paths, and for evidence of vandalism. In the case of large properties where there are on-site security patrols or maintenance personnel, lamps should be checked nightly, and observed outages reported in patrol logs or maintenance request records.

5. Lamp replacement: A well-designed system should have overlapping light patterns so that no area is dependent on a single luminaire. Failed lamps, however, should be replaced immediately, in case a second lamp in the same area also fails. When installations require special lift equipment to service the luminaires, consideration should be given to replacing all of the lamps in the luminaire(s) on the pole at the same time to avoid extra labor costs. To prevent problems, lamps should be replaced at or before the manufacturer's published rated life data for that lamp.

6. Cleaning: Regardless of the quality of the equipment, insects and dirt will collect in enclosed luminaires; therefore, all units should be cleaned at least at the time of lamp replacement. When *security is an issue*, cleaning may be required more frequently to maintain equipment within the most effective operating tolerances.

7. Pruning: Trees and shrubbery that would otherwise block light output from security luminaires must be pruned at least annually to prevent interference with the light distribution pattern and eliminate shadowy areas where wrongdoers can hide. Where practical, low branches and bushes should be trimmed to reduce hiding places and improve sight lines. (See **Figure 8**.)

8. Design Considerations: In many situations, luminaires used for security lighting will be part of the general lighting system, as in parking facilities or for building enhancement. Frequently, the daytime appearance of the luminaire and pole is a deciding factor in the choice of equipment, with quality and functionality being of lesser importance. For example, a shopping

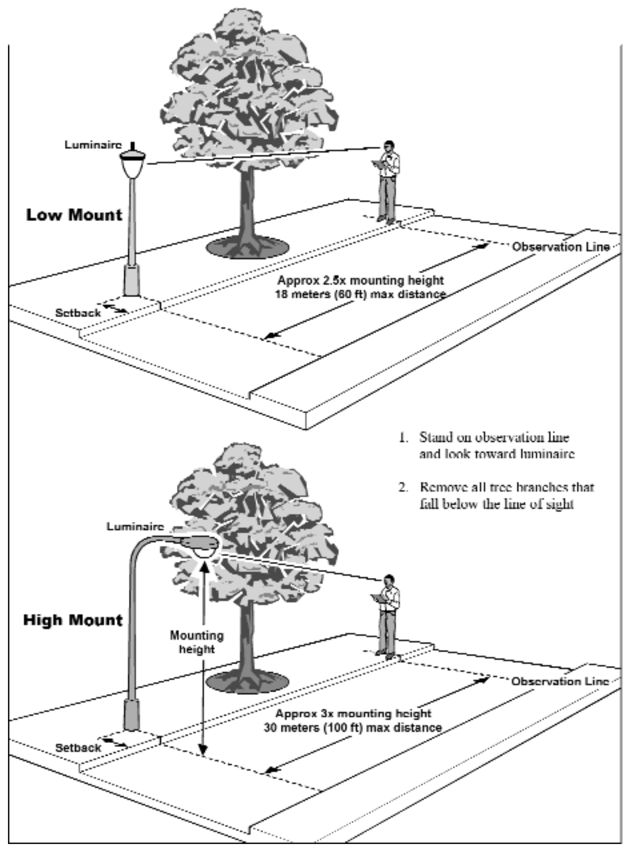


Figure 8. Luminaire must be selected to assure that light distribution will not be obstructed by the foliage as the tree matures. Example shows pruning guide for street lighting.

mall may choose more expensive equipment in public parking areas and lower cost units in employee areas. It is important to consider that employees will usually arrive earlier and depart later, when few customers are present and may, therefore, be subject to a greater security risk.

Any outdoor luminaire can be utilized for security lighting. **Figure 9** shows a small sampling of various types of outdoor lighting equipment. All devices must be properly installed and maintained; and, if exposed to weather, must be approved for and labeled for *wet locations* by an independent or certified laboratory.

The *distribution and degree of cutoff* provided by the luminaire is a critical consideration in new and upgraded projects. (See **Section 8 Glossary of Terms**.) Considerations include:

a. **Distribution** ranging from Type I (narrow), through II, III, IV (increasing width), to Type V (symmetrical round or square). Some have additional performance descriptions such as forward throw, where limited light is projected behind the pole. The selection of the distribution type should be determined by a lighting professional based on the size, shape, and location to be illuminated. Several types may frequently be used on the same project; for example, Type V used in the center and forward throws around the perimeter. (See **Figure 10**.)

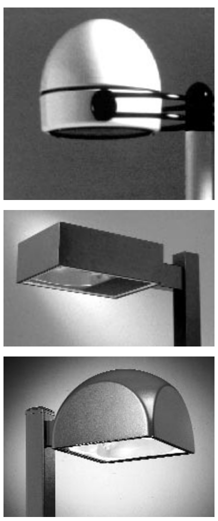
b. Degree of cutoff limits the percentage of total light output emitted above 90˚ (horizontal) and allowable high angle brightness. (See **Figure 11**.) It is outside the scope of this document to recommend the degree of cutoff. While the requirements of the limits are very specific, the actual differences may be very subtle. Photometric tests should be utilized to determine whether actual differences are significant.

7.0 SECURITY LIGHTING FOR CONTROLLED SPACES

7.1 General

The first question regarding controlled spaces is whether to light the space at all. Lighting a secure area advertises the presence of something worth attacking and, hence, may attract criminals. In some applications, keeping the area dark may be a better security approach. Examples of applications *not to light* might include pumping stations in isolated farm country, or isolated telephone relay enclosures. However, if criminals are likely to know that the area contains valuable materials, the absence of lighting may make the target more difficult to defend. Thus, the decision to install a security lighting system depends on an understanding of the risk of criminal

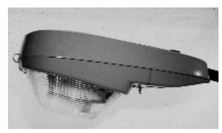
Figure 9. Typical luminaires and motion detector devices for residential and commercial applications. (Photos courtesy of Hubbell Lighting and Ruud Lighting.)



Architectural Luminaires

Applications: Roadways, Parking lots, Walkways, etc. where daytime appearance and/or light pollution and trespass are important.
Sources: HPS, Metal Halide- 70-400 watts
Distribution: Roadway types I to V, forward throw.
Mounting: Structures and poles 15’ or higher with decorative arms
Controls: Time clocks, photo-cells

Figure 9a



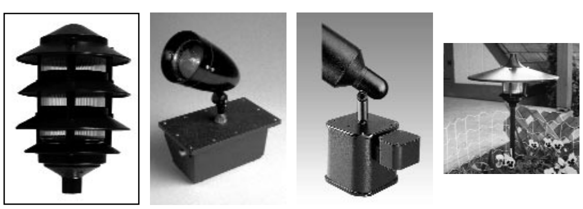
Refractor

Cutoff

Roadway Luminaires

Applications: Streets, driveways, parking areas
Sources: Metal-halide. HPS
Distributions: Roadway types I thru V. Cut-off units reduce glare and light pollution
Mounting: Poles 20' and higher with arms
Controls: Time clocks, photo-cells

Figure 9b



Landscape Luminaires

Applications: Residential, small commercial
Sources: Incandescent, fluorescent, metal-halide, mercury, HPS
Distribution: Floodlight and Type V
Mounting: Ground, trees, structures
Controls: Time clocks, photo-cells, motion detectors (incandescent only)

Figure 9c

General Purpose Floodlights

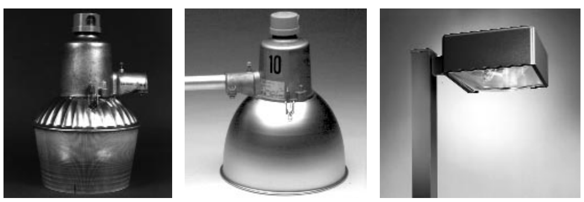
Applications: Parking areas, recreation, facade lighting
Sources: Incandescent, Fluore-scent, HPS, Metal Halide
Distributions: NEMA types 1-7. **Note:** Rectangular units have Horizontal X Vertical designations. 3X6 etc.
Mounting: Poles, structures, ground
Controls: Time clocks, photo-cells, motion detectors (incandescent only)

Figure 9d

activity. If the risk of criminal activity is low, and the target relatively unknown to persons not familiar with the site, then providing security lighting may be counterproductive, especially in rural, isolated, or otherwise dark areas. The risk of criminal attack is not the only concern for the designer. Lighting for safety and the protection of persons are always of vital importance.

Security lighting for a controlled area should provide uniform illumination so that anyone moving in or around can be easily seen. The security lighting design should also provide sufficient illumination so that intrusion or attempted intrusion into the area can be detected, and any electronic surveillance devices such as security cameras can operate within recommended tolerances.

These objectives can be achieved in different ways depending on the site and the nature of the security system. **Section 7.2** provides examples of security lighting for some common controlled sites.

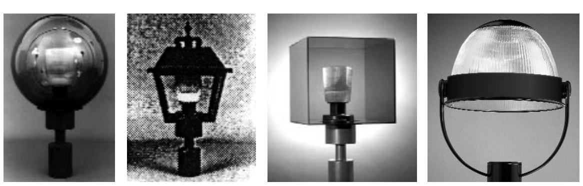


Prismatic Cutoff

General Purpose Luminaires

Applications: Small parking and rural areas. Cutoff units reduce glare, light pollution and trespass.
Sources: Mercury, HPS, Metal Halide-70-150 watts
Distribution: Roadway type V
Mounting: Structures and poles
Controls: Time clocks and photo-cells

Figure 9e

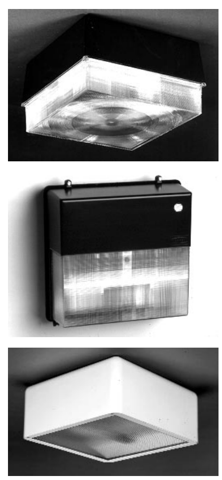


Post-top Luminaire
A wide varioety of styles in clear and colored enclosures
Applications: Walkways, residential parking areas where lower lighting levels are satisfactory
Sources: Incandescent, fluorescent, metal-halide, HPS
Distribution: Symmetrical, most with uplight
Mounting: Wall bracket, poles up to 15'
Controls: Time clocks, photo-cells

Figure 9g

7.2 Specific Applications

The recommended illuminances for each of the applications described in this section are *horizontal*. Note that *vertical* illuminance should be provided in all cases where there is a need to identify people (face and body language) at a distance of at least 9 m (30 ft) from the viewer. (See **Section 5.3**.) Typical recommended vertical illuminance values are 5 to 8 lux (0.5 to 0.8 fc) or values that produce a uniformity ratio of no more than 4:1, average to minimum between the luminances of the background and the face. (The higher the background luminance, the higher the vertical luminance to maintain the 4:1 ratio to prevent silhouetting.) Variations from these recommended values for a particular application are specifically noted. A lighting system that provides illumination from more than one direction is recommended to achieve the goal of facilitating facial identification and minimizing shadows or a silhouette effect as the person moves through a space. For guidance on measuring vertical illuminance see **Annex B**.



Surface Mounted Luminaires

Applications: Perimeter areas near structures, entryways, walkways, parking areas.
Sources: Incandescent, fluorescent, HPS, Metal Halide
Distributions: Ceiling Mtd.-TypeV, Wall Mtd. Wide-lateral
Controls: Time clocks, photo-cells, motion detectors (incandescent only)

Figure 9f

Motion Detectors

Applications: Residential, commercial
Sources: Incandescent and fluorescent
Mounting: Structures with clear view of area to be lighted

Figure 9h

7.2.1 Unoccupied Spaces

Storage Yards, Industrial and Equipment Areas, and Container Terminals: Area lighting is typically accomplished with floodlighting or luminaires mounted on poles 9 m (30 ft) or more in height. The recommended average illuminance on the surface of large open areas is 5 to 20 lux (0.5 to 2 fc) with an average-to-minimum illuminance uniformity ratio not greater than 8:1. The greater the brightness of the surrounding area, the higher the illuminance required to balance the brightnesses in the space, while exercising caution to avoid light trespass and glare. Luminaire spacing will depend on the output, mounting height, and distribution of the luminaires. In storage areas where unacceptable material losses have been sustained, or *security is an issue*, the average maintained illuminance levels should be at least 10 lux (1fc), with an average-to-minimum uniformity ratio not greater than 6:1.

If the area contains a large number of obstructions to visibility (as in container terminals or rail yards), a design utilizing additional multiple source locations and higher mounting heights will reduce shadows. (See **Figure 12, color insert**.) It will be helpful if the luminaires are positioned within the site, between obstructions, and with overlapping light patterns. The reflectance of site materials can also be used to advantage. Light, reflective colors on buildings and in concrete paving will enhance the efficiency and uniformity of the lighting system. (See **Figure 13**.)

While IESNA does not recommend designing lighting systems with disability glare, the technique is sometimes used in special security lighting applications to protect a secure area. The glare renders would-be intruders outside the protected area highly visible to guards inside the perimeter, while masking the guards and other features from the casual outside observer. In such a system, luminaires are mounted at or near eye

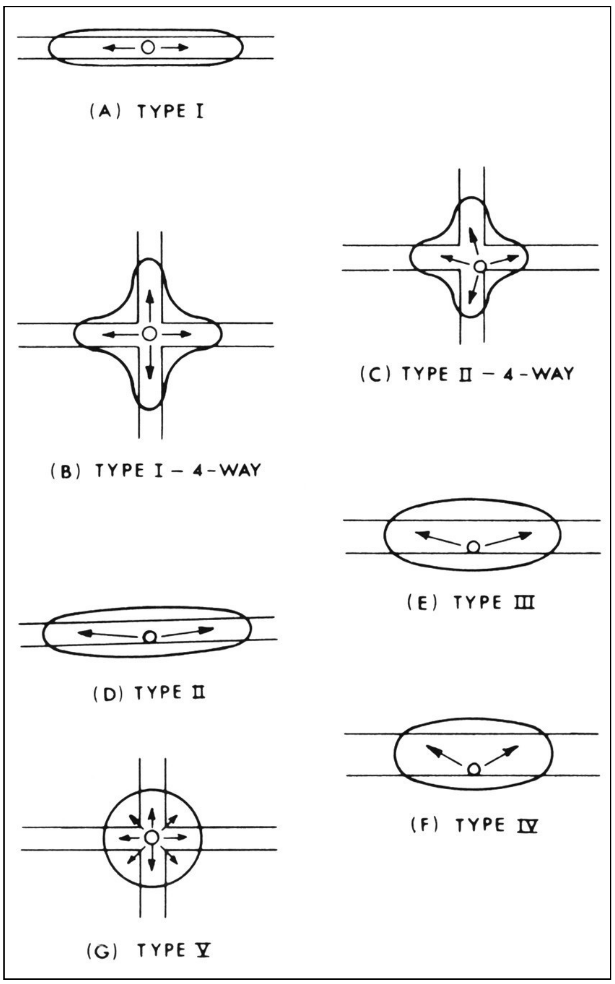


Figure 10. Light distribution patterns for seven different luminaire configurations used to provide coverage for roadways (Type III), parking lots (Type III and V) and pedestrian areas (Type II, III, and V)

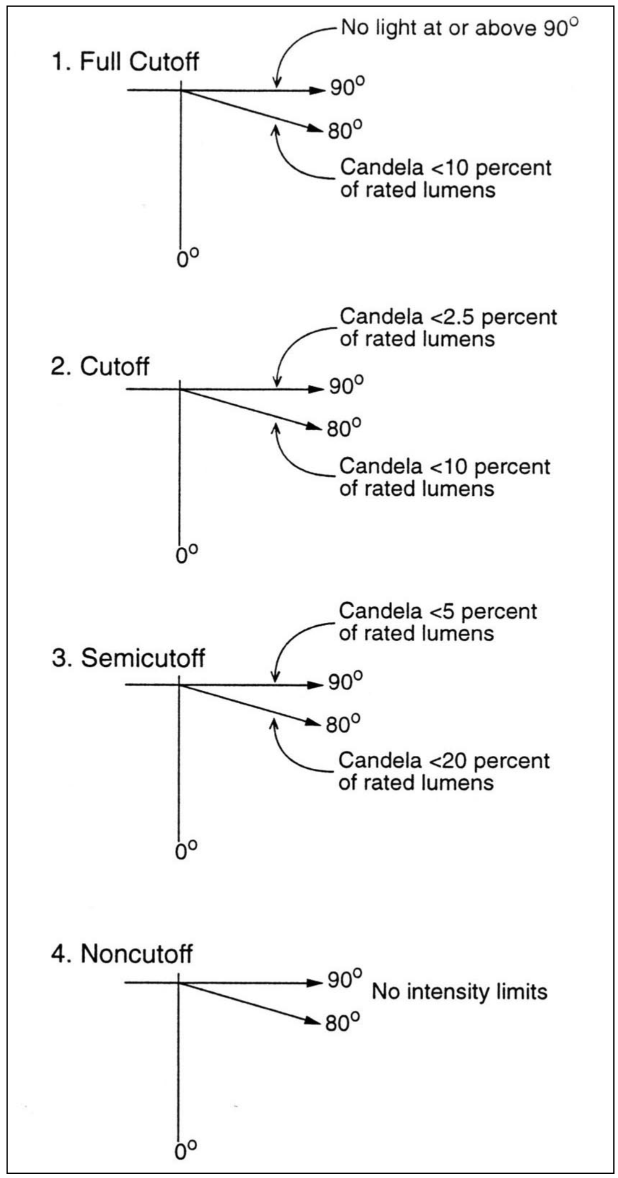


Figure 11. Cutoff classifications

level and aimed outward from the secure area. Typical applications of this principle include sensitive weapons storage facilities, prisons, and jails. This technique has a high probability of producing light-trespass and light pollution problems, and should be considered <u>only in extreme cases, or those instances where facility security is a very high priority.</u> In addition, it can only be effective if the would-be intruders approach from the unprotected side, and when security personnel are positioned on the inside of the installation.

Figure 13. Container storage yard is uniformly lighted with good vertical illuminance between the containers. (Photo courtesy of General Electric Lighting Systems.)

Figure 14. A combination of pole mounted area lighting units, ground mounted floodlights for building surfaces, roof mounted floodlights and an internally lighted glass wall façade provide a well-lighted building environment. (Photo courtesy of General Electric Lighting Systems.)

7.2.2 Offices and Other Commercial Buildings

Building Exteriors: Primary points of entry to the building and the areas around these entrances should be easily visible and identifiable. Depending on the construction of the building, points of entry may include unintended entry points, such as through walls and roofs. Luminaires set in the ground, mounted on the building or under the eaves, or mounted on poles, provide light for these critical areas. While ground-mounted floodlights may provide uniform illuminance, they are accessible and can be readily neutralized. Pole-mounted luminaires are usually the best option for uniformly illuminating the surfaces of the building and the surrounding area with less opportunity for vandalism. (See **Figure 14**.) The average recommended vertical illuminance on the building façade ranges from 5 to 20 lux (0.5 to 2 fc) with a uniformity ratio no greater than 8:1or 6:1 depending on the acceptability of losses as discussed above.

Building Interiors: Security lighting for the interiors of buildings depends on the security methods available. If security officers are on site, or make frequent checks of the location, it is appropriate to have continuous or controlled illumination to allow for quick visual inspections as officers make patrol rounds. The illumination of interior stairwells, hallways, and work areas should be consistent so officers are not subjected to changing patterns of light. Generally, interior lighting for patrol officers in unoccupied buildings should be at least an average of 10 lux (1fc) with an average-to-minimum uniformity ratio not greater than 6:1. Regardless of the illuminance provided, patrol officers should always carry supplemental lighting devices such as flashlights, when patrolling inside enclosed structures. If the building is monitored automatically using electronic devices, enough light should be provided to operate the equipment within recommended tolerances. If there are infrared motion sensors or infrared cameras that do not require light, it is appropriate to design the system to be dark when secure and illuminated once trespass is detected.

Perimeter Fences and Walls: The purpose of lighting perimeter walls and fences is to deter or slow trespass and to enable guards or surveillance equipment to detect intruders. Perimeter barriers have many different forms, from masonry walls to barrier vegetation. The type of lighting used will depend on the objectives, the ability to see through the barrier, neighborhood considerations, and whether one or both sides of the barrier are patrolled. (See **Figure 15, color insert**.) If both sides of a solid barrier are under surveillance, lighting can be provided by positioning luminaires over the top to reduce shadowed areas at the base of the barrier.

If a view through the barrier is possible, and if the obstruction is patrolled, it is useful to be able to see both sides. This can be accomplished with pole-mounted luminaires set back from the barrier. The lighting will be most effective if the luminance of the fence on the patrolled side is lower than the luminance of the area being viewed through the fence. This objective can be achieved by using a low reflectance fence material such as black or dark green-coated chain-link. If galvanized chain link is used, care should be taken with the aiming of the luminaires to reduce the illuminance directly onto the fence.

Guarded Entrances and Gate Houses: Access to secure areas is often controlled by security personnel who stop and inspect people, identification documentation, or vehicles. (See **Figure 16**.) The intensity of the inspections ranges from token checks or wave–through to challenges and detailed searches, depending on the perceived threat. In the latter instance, the entrance or inspection point should be provided with multiple, redundant luminaires so that the loss of any one luminaire will not seriously degrade the lighting available to the guards to perform their tasks. For critical applications, backup powered incandescent luminaires or non-interrupted sources should be employed during electrical outages.

Tasks include inspection of vehicles, vehicle license plates, personal identification, and vehicle contents including the driver and other occupants. Good horizontal as well as vertical illuminance should be provided to allow for easy facial identification, inspection of credentials, and packages, without the need for auxil-

Figure 16. Guarded entrance with well lighted check point.

Figure 17. Driveway approach and canopy at the guard house provide uniform light for checking vehicles. (Photo courtesy of Operational Support Services, Inc.)

iary hand-held devices such as flashlights. In high security areas, some luminaires should be mounted at or below pavement level to facilitate inspection of the undersides of vehicles. Having a concrete or other reflective road surface will increase the reflected light and help in the inspection process. (See **Figure 17**.)

Illuminance at ground level for inspection areas should be an average of 100 lux (10 fc), or twice that of the immediate surrounding areas, whichever is greater, and an average-to-minimum uniformity ratio not greater than 3:1. In addition, vertical illuminance equal to twenty five percent of the horizontal illuminance should be provided at the level of the driver. Good color rendering light sources should also be used so that officers can easily discern the color of clothing, documents, goods and vehicles.

Figure 18. A well-balanced lighting system between the interior of the guardhouse and the exterior surveillance lighting. (Photos courtesy of Operational Support Services, Inc.)

Illuminance inside the guardhouse should be limited to the minimum required for comfortable completion of assigned tasks, such as report writing and equipment use. It should be possible to dim the illuminance in the guardhouse to allow the guard to see clearly through the windows at night and to limit the ability of those approaching the gatehouse to see the guard. (See **Figure 18**.) Well-shielded task luminaires are essential to avoid reflections on surveillance monitors and the windows of the gatehouse. Fitting the gatehouse with specular-reflecting; low-transmission glass at a tilted angle, painting the inside of the gatehouse in dark colors, and ensuring that illumination can be dimmed, will all help limit the view into the gatehouse. For a cutaway view of how these ideas can be integrated into the design of a guard station. (See **Figure 19**.)

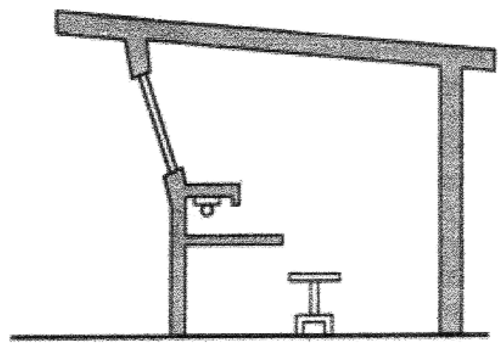


Figure 19. Tilted glass limits view of the interior of the guardhouse.

In installations where entrances are monitored by Closed Circuit Television (CCTV) or electronic devices, illuminance at the checkpoint may be lower than that at sites manned by security staff. Illuminance, however, should be at levels consistent with the surveillance equipment manufacturer's recommendations.

7.2.3 Automated Teller Machines and Night Depositories

Background: Automated Teller Machines (ATM) are installed for customer convenience. In many instances, convenience and marketability override other factors with regard to site selection and placement. As a result, crime against ATM customers has become a major concern for security professionals. The financial industry, and some local, state and provincial jurisdictions have responded with recommendations, standards and ordinances to make after-hours banking safer and more secure.[4, 5] Night depositories (ND) are usually located at a banking facility and pose a somewhat different threat than ATMs in that cash is brought to the facility rather than withdrawn; however the same security lighting techniques should be applied.

There are three essential elements for after-hours banking facilities. These are known as the "Three L's": Location, Lighting and Landscaping.[4]

Location: There are three general types of locations for ATMs: Drive-up, Walk-up and Interior. These may be either attached to a banking facility or free standing. Except during normal banking hours, there are usually no trained attendants at any of these locations. In all cases security is an issue.

Drive-up configurations allow the customer to remain in the vehicle where, in theory, they are surrounded by a protective barrier with a ready means of escape. Problems arise when the customer's attention is on the machine, allowing a perpetrator to enter the vehicle on the passenger side from an adjacent hiding place. Shrubbery and other possible areas of concealment should be eliminated close to the ATM and signs should suggest that customers lock car doors.

Walk-up locations create the greatest danger, as the customer is defenseless. No shrubbery should be located in the immediate area and lighting should be graduated to allow the customer's eyes to adapt from the darker sidewalk to the brighter ATM and reduced as the customer leaves the area. (See **Figure 20**.)

Interior locations may be enclosed or free standing in such areas as supermarkets, malls, transportation terminals and convenience stores. In many such areas, other people may be in the immediate vicinity; however, they are not usually paying attention to ATM customers. Some locations are self-enclosed, which provides privacy for the customer and a view of the surrounding area. Some jurisdictions require that a bankcard be used for access, allowing only one customer at a time. If the ATM is not enclosed, the space surrounding it should be clear and defined to discourage non-customers from close contact. Illuminance values should be higher than surrounding areas to allow identification of potential wrong-doers.

Normal Practice and Standards: Some jurisdictions have enacted ordinances that specify minimum security lighting for ATMs and NDs and frequently establish limits for shrubbery or other obstructions. These ordinances emphasize the importance of security lighting in helping to deter crime against customers. Designers should consult local authorities and use these requirements as *minimum only*, because higher luminance in surrounding areas may necessitate more lighting in the ATM area.

Designers and bank security officers should consider the following guidelines:

(*Note:* Unless otherwise specified, all distances and illuminance values are minimum and should be adjusted for local conditions.)

- To assist the customer in operating the ATM, the face of the machine should have 150 lux (15 fc), with 100 lux (10 fc) on all horizontal surfaces within 3.5 meters (10 ft) of the face of the ATM. An average horizontal illuminance of 20 lux (2 fc) should be provided within a 15.2 m (50 ft) radius of exterior units.
- Supporting parking spaces within 18.5 m (60 ft) of the ATM, should have an average of 20 lux (2 fc).
- When the ATM is within 3 m (10 ft) of the corner of the building, illuminance of 20 lux (2 fc), should extend 12.2 m (40 ft) down the side of the building
- Installation of lighting units should be redundant to the extent that one failed unit will not reduce the illuminance below the above minimums.
- Average-to-minimum uniformity ratio should not exceed 3:1 for each of the zones described above.
- Lighting should not produce glare for the users, pedestrians, drivers and/or light trespass onto neighboring properties.
- Illuminance at the machine and surrounding areas should provide excellent definition of facial identification (vertical illuminance) at a distance of 9 m (30 ft).
- Illuminance levels should support all CCTV operating requirements.
- Customers should have an unobstructed view from the face of the unit to a distance of 15.2 m (50 ft), in all approachable directions. If necessary, this requirement can be augmented by other devices such as mirrors, CCTV, fencing and barriers.
- Potential hiding places should be eliminated within the measured area.
- Luminaires should be tamper proof and/or "wet-labeled" where necessary.
- To insure good maintenance practice, it is essential that all lighting sources be checked at frequent intervals. Nonfunctioning equipment can create life-threatening consequences. Personnel who provide cash service to the ATM should check the lighting system and report any outages to the maintenance department.

Figure 20. Recessed luminaires in the roof overhang provide uniform lighting on the walkway and vertical illuminance for customer transactions at the machine. (Photo courtesy of Ruud Lighting.)

7.2.4 Parking Facilities (Lots and Garages)

Techniques for lighting parking lots and garages are described in IESNA RP-20-98, *Lighting for Parking Facilities.*[5] Walkways are discussed in IESNA DG-5-94, *Lighting for Walkways and Class 1 Bikeways.*[6] *When security is an issue*, the recommended security illuminance for open parking facilities should be an average of 30 lux (3 fc) on the pavement. A uniformity ratio not greater than 4:1, average-to-minimum should be maintained. Attention should be given to the use of the facility and hours of operation. Uniform lighting for an empty lot is of little value, but when space is used to capacity it is important to achieve the desired lighting level between vehicles since these are the likely places for crime to occur. Sidewalks, footpaths, and grounds around or supporting open parking lots should be illuminated to an average of 60 lux (6 fc), with an average-to-minimum uniformity ratio not greater than 4:1. (See **Figure 21**.)

Garages and Covered Parking Spaces

The security threat to unescorted people and unsecured property in covered parking garages can be high. Isolated floors, numerous places to hide, lack of effective surveillance, and limited escape routes often combine to create this condition. (See **Figure 22, color insert**.) *When security is an issue*, in parking garages and covered parking facilities, the recommended average illuminance should be 60 lux (6 fc) on the pavement, with an average-to-minimum uniformity ratio not greater than 4:1. These illuminances should be maintained whenever access is allowed to the parking areas. Glare should be avoided in such installations. Back-up generators or battery-operated lighting are necessary in parking areas, stairwells, elevators, and exit ramps when the public is allowed access. *When security is an issue*, at locations where people gather, such as at elevators and stairs, illuminance should be an average of 100 lux (10 fc) in a 9 m (30 ft) radius from the center of the gathering point with an average-to-minimum uniformity ratio not greater than 4:1.

Figure 21. Cut off luminaires in an employee parking lot provide uniform illumination for workers leaving after normal business hours and excellent surveillance opportunities for observers from an upper floor in the building. (Photo courtesy of Ruud Lighting.)

Perimeter or boundary lighting should allow detection of those who loiter outside the site and those who are entering or exiting the site. Interior lighting should allow safe movement and easy detection of hazards and threats out to a distance of at least 9 m (30 ft). (See **Figure 23 (a)** and **(b)**.)

Visual adaptation occurs when going between regions of high and low light levels, such as from a parking structure into the street or vice versa. Transitional lighting helps the eyes to adapt. For example, during the daytime the lighting levels at the threshold of the structure might be increased and reduced at the entrance during nighttime use. The use of electronic sensors provides an effective solution to adjusting the entry and interior illumination when transitioning from day to night. The quality of the light should be uniform to avoid shadows and glare.

Retro-reflective material should be used for wall signs, common walkways, gathering points, and hazardous areas. Location signs (level and bay) on columns that face the aisles are useful indicators. Letter, number and color patterns should indicate floor locations. The background of such signs should be the floor color. Candy striped columns, black and yellow, are useful to highlight drive paths. All of these safety features will help pedestrians to locate exits and their vehicles more quickly, reduce exposure to criminal hazards, and encourage a feeling of well being and self control.

7.2.5 Residential Parking Areas

Common use parking structures or open parking areas should be lighted according to IESNA RP-20-98, *Lighting for Parking Facilities*[6] and *when security is an issue* to **Section 7.2.4** of this document.

7.2.6 Parking Lots and Areas for Public Parks

Where *security is an issue* in parks and public spaces, the recommended average maintained horizontal illuminance for open parking facilities in or adjacent to parks should be no less than 30 lux (3 fc) on the pavement with an average-to-minimum uniformity ratio not greater than 4:1. (See **Figure 24**.)

Parks and public areas by their very nature are open to the public, often creatively or naturally landscaped with thick vegetation, and are difficult to patrol and protect. As with any other area where criminal activity is likely, lighting systems should enable fight or flight decisions to be made at a distance of at least 9 m (30 ft), by illuminating potential hiding places, movement paths, and escape or movement routes. This is of particular importance in parks and open public areas, where other security and safety amenities are usually not present.

Locations where loitering and criminal attacks are likely to occur should be illuminated to a level of at least 10 lux (1 fc) at ground level, with an average-to-minimum uniformity ratio not greater than 4:1. Glare should always be avoided. Planners need to consider the following issues when designing lighting and other security components for parks open at night:

- Prior history of crime in the park and surrounding areas
- Social conditions and citizen participation
- Local cultural values
- Traffic patterns and access
- Patrol frequency
- Light pollution and light trespass

Park trails and walkways[7] open to the public at night should be illuminated to at least 6 lux (0.6 fc) maintained along the length of the trail, and on all sides out to a distance of 9 m (30 ft) on both sides of the trail or walkway. The average-to-minimum uniformity ratio should be 4:1. Where trails are situated in woods, landscaped areas, or even broken terrain, lighting designers should also consider aesthetics issues in the lighting design.[8] For example, it may not always be possible or desirable for light to impinge out on both sides of the trail. Creative combinations of lamps and mounting devices can assist in these applications. Again, glare should be avoided and the designer must be especially sensitive to issues of transient adaptation, wildlife and other environmental issues in these applications.

7.2.7 Supermarkets and Major Retail Outlets

In 1998 the Food Marketing Institute, the food industry's trade association representing 40,000 supermarkets across the United States and Canada, published a study titled "Consumer Trends in the Food Industry." Consumers ranked their personal safety as very important. Many supermarkets today are high volume operations, well in excess of 100,000 square feet, offering a vast array of services, while attracting thousands of customers a day. Many operate 24-hours a day and parking lots for these facilities are enormous. Forty percent of crime in retail facilities occurs in the parking lots where customers and employees are most vulnerable. Proper illumination is a critical component of the overall security plan for most 24-hour retailers. (See **Figure 25**.)

When security is an issue, illuminance levels should be at least an average of 30 lux (3 fc) on the pavement with an average-to-minimum uniformity ratio not

Figure 23 (a). Structural elements afford concealment of luminaires. When coupled with a low ceiling, the designer may be challenged (successfully in this case) to provide uniform lighting in the space, especially between parked cars. (Photo courtesy of Holophane.)

Figure 23 (b). A higher ceiling and light surfaces throughout results in a uniform distribution of light and a shadow-free environment . (Photo courtesy of Ruud Lighting.)

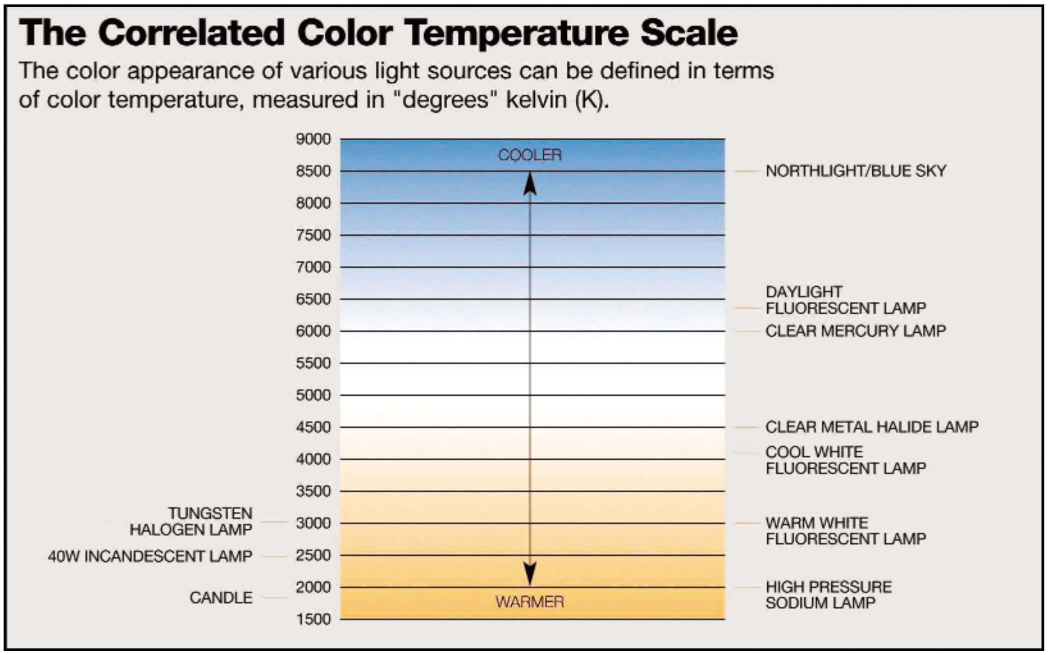


Figure 4. The color appearance of various light sources defined in terms of color temperature. (Illustration courtesy of OSRAM SYLVANIA.)

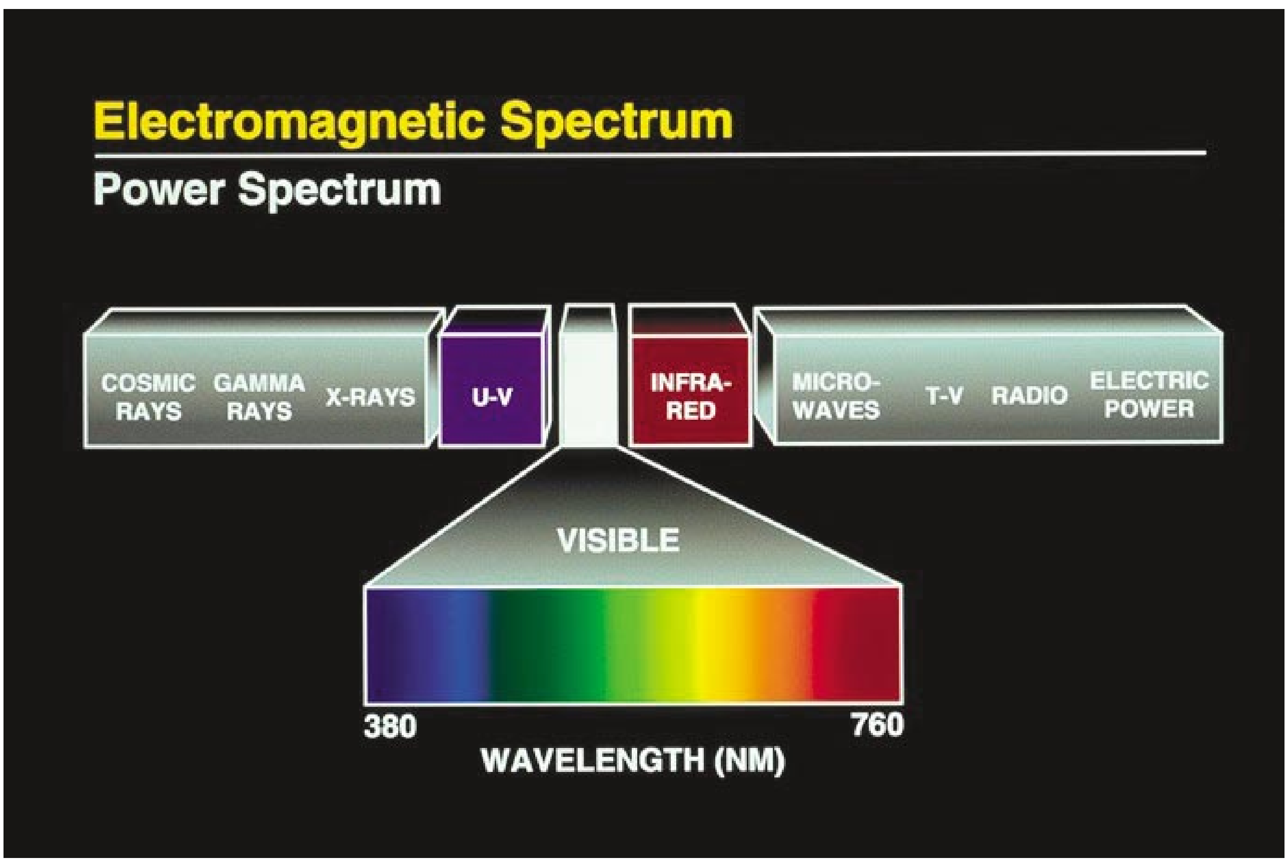


Figure 5. Electromagnetic spectrum. (Illustration courtesy of OSRAM SYLVANIA.)

Figure 12. Uniformly spaced poles and luminaires provide lighting at each crane assembly area in this cargo terminal. (Photo courtesy of Holophane.)

Figure 15. Instant on, reflectorized fluorescent prison lighting appears as a “wall of light” to inmates. Patrol personnel and vehicles cannot be detected during patrol. (Photo courtesy of Magnaray.)

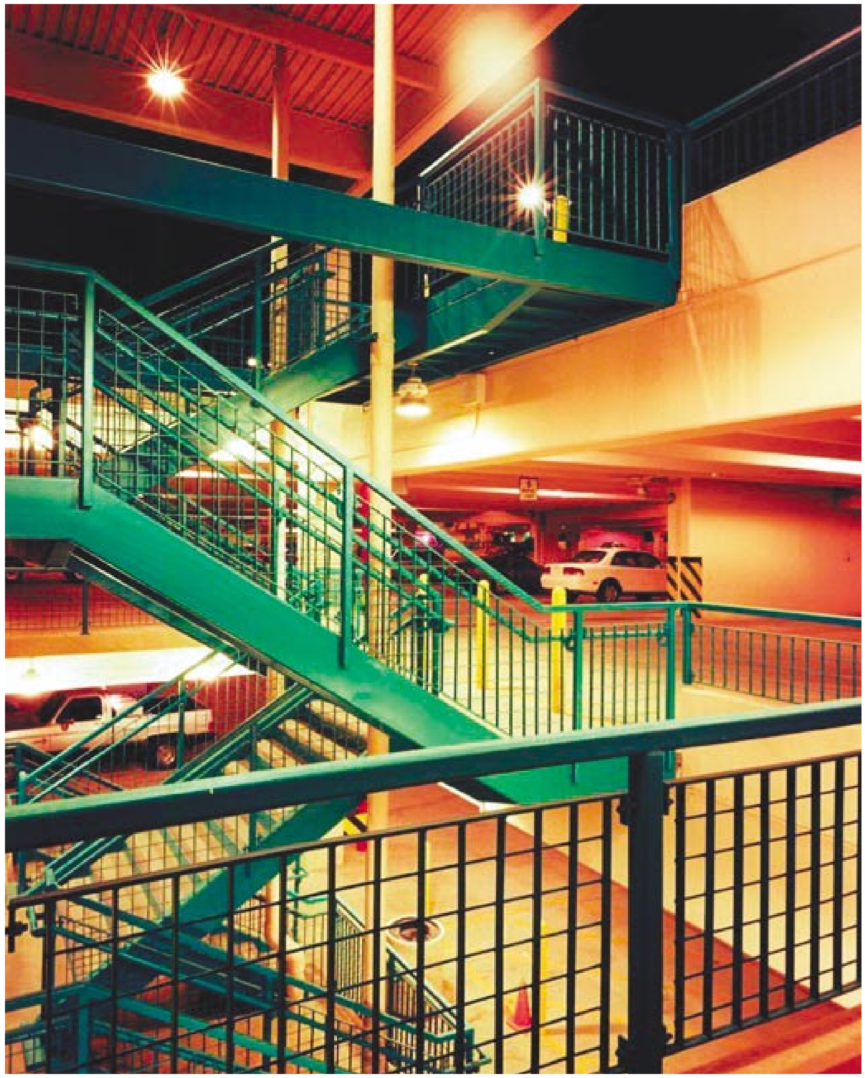


Figure 22. A well-lighted stairwell reduces apprehension and facilitates observation of other people in the space. (Photo courtesy of Holophane.)

Figure 30. Security lighting around a residence can be achieved with landscape lighting to highlight plants and trees. Luminaires are well concealed and the lighting effects “frame” the driveway entrance. (Photo courtesy of Ruud Lighting.)

Figure 34. Lighting for vehicular and pedestrian traffic facilitates surveillance when security issues are a high priority on campus. (Photo courtesy of Holophane.)

Figure 35. Clearly defined walkways through a campus assure safe passage for visitors and students, (Photo courtesy of Ruud Lighting.)

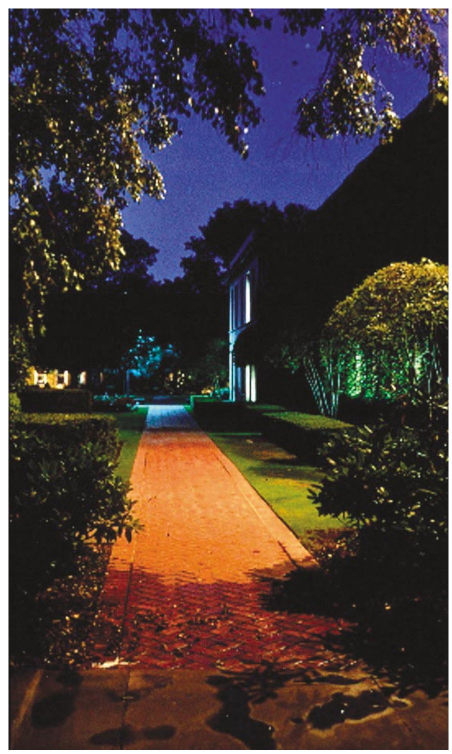


Figure 36. and transition from one building to another. (Photo courtesy of General Electric.)

Figure 24. Parking spaces at a sports event may be some distance from the stadium resulting in long walks across parking lots. High mast HID lighting in this facility provides good horizontal and vertical illuminance for pedestrians and vehicular traffic pre- and post-game. (Photo of Holophane.)

Figure 25. Parking lot lighting designed with cutoff-type luminaires not only provides a well-lighted environment for shoppers but prevents glare for drivers on adjacent roadways. (Photo courtesy of Tampa Electric Company.)

greater than 4:1 in the parking lot (including parking and support areas used by employees). For stores operating in the early morning hours or 24-hours-a-day, additional illumination should be provided in the parking area closest to the store and outside the main entrance where customers will be parking during these low-activity, high-vulnerability hours. Illuminance in this area should be at least an average of 50 lux (5 fc) on the pavement with a uniformity ratio not greater than 4:1average-to-minimum.

Roadways and rear areas of the store should be illuminated based on ANSI/IESNARP-8-00, *Roadway Lighting*,[9] and IESNA RP-20-99, *Lighting for Parking Facilities.*[6] If *security is an issue*, illuminance in the area of delivery docks, outdoor trash compactors, and recycling bins in the back of the store must be at least an average of 30 lux (3 fc) on the pavement with a uniformity ratio not greater than 4:1 average-to-minimum. This will provide adequate security lighting for delivery personnel as well as employees needing to work or move about in these areas.

7.2.8 Fast Food and Franchise Restaurants

Many *fast food and franchise restaurants* have 24-hour or late-night operations, with a high priority on patron and employee security. Safety effectiveness for fast-food security personnel results from proper site planning, quality illumination, staff training, and integration of layers of security. Critical among these security features is lighting. Areas of most concern to fast food managers are the customer drive-thru, general parking, and refuse disposal areas.

The customer is most vulnerable to attack on the blind sides of the building and the drive-thru lane, particularly when patrons are transacting business at the payment or order window(s). Customer attention is on the tendering of payment, collecting purchased food, or receiving change. An attacker typically approaches the patron between the building and the left rear of the automobile. Building and lighting designs should allow window-service personnel to view the driver's side of cars, as this is a major deterrent to this type of attack. The best designs provide a setback from the window-service area to the rear of the building, and a side window from which the store personnel can view this area and various approaches. See **Figure 26 (a)** and **(b)**.

Lighting that is mounted on the building, above the side-window, allows good observation by the employee; however, glare for the patrons in their cars can be prevented with the use of side visors. The average maintained illuminance for the area within 9 m (30 ft) of the drive up window(s) should be an average of 60 lux (6 fc) on the pavement and an average-to-minimum uniformity ratio not greater than 3:1. General parking areas, sidewalks, footpaths, play areas, and areas adjacent to the structure, should be illuminated to at least an average maintained illuminance of 30 lux (3 fc), at grade, and an average-to-minimum uniformity ratio not greater than 4:1.

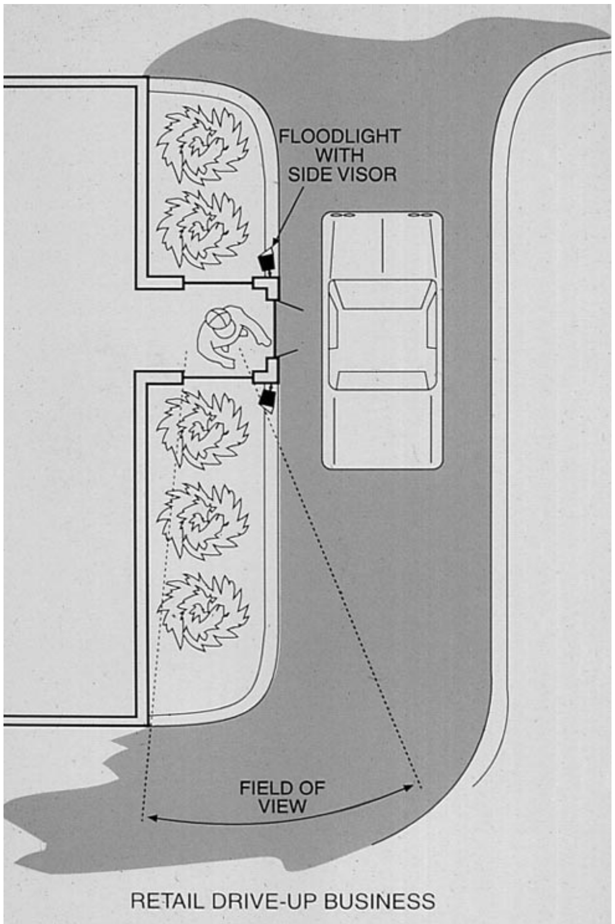


Figure 26 (a). Light is emitted from the floodlights to project down the lane and parallel to the car to enable detection of intruders from the rear corner of the building. (Illustration courtesy of Occupational Safety Systems Inc.)

Figure 26 (b). Recessed luminaires define the building with a soft wash of light and highlight the drive-up window, allowing window-service personnel to clearly see the arriving customers. Light surfaces reflect light onto the driveway for easy way-finding. (Photo courtesy of Ruud Lighting.)

Most municipalities and franchised operators require refuse disposal areas to be enclosed. Such statutory requirements increase the security risk to employees using these enclosures. Simply lighting this area without other security considerations is not effective. The design of the facility and the written procedures need to address critical security concerns after hours. The illumination of the refuse area, however, both inside and outside the enclosure, should be consistent with the rest of the lighting in the general parking areas.

7.2.9 Convenience Stores and Gas Stations

Convenience stores and gas stations often operate around the clock. Extended hours of operation, ease of access and egress, ready availability of money and alcoholic beverages, and proximity to major thoroughfares make these types of retail outlets susceptible to violent crime. *When security is an issue*, the average maintained illuminance should be at least of 60 lux (6 fc) on the pavement. These recommended values apply to storefront entrance and sidewalk areas, gasoline pumps and islands, air and water stations, telephones, and other customer use areas. The site should have a uniformity ratio of not more than 4:1. (See **Figure 27 (a)** and **(b)**.) These levels are minimum, and the designer or operator should also review IESNA RP-2-01, *Lighting Merchandising Areas (A Store Lighting Guide)*[10] when considering illuminance levels in these areas. Surrounding, adjacent, or internal sidewalks, footpaths, refuse disposal area(s), and grounds should be illuminated to at least 30 lux (3 fc) at ground level and an average-to-minimum uniformity ratio not greater than 4:1. Glare should always be avoided.

Properly placed horizontal and vertical illuminances will improve the visibility of outdoor areas to people inside the store, provided the luminance of objects exceeds the luminance of the reflections on the inside of the windows. Ambient lighting within the store should be an average maintained illuminance of 300 lux (30 fc). Store employees and customers should always have a clear view of the outside area from within the store, and especially from behind the clerk's counter. (See **Figure 28**.) Lighting and construction must eliminate a condition where windows act as a mirror, making it difficult for clerks to view the lot and pump areas. Tilting or coating store window glass can also avoid this condition, as well as controlling the reflectance values of objects reflected in the window. (Dark-colored merchandise will present little or no image reflected in the glass, compared with white merchandise.) Covering windows with opaque sales promotion posters that block the view of the outside

Figure 27 (a). Transition between pump island and service building is facilitated when uniformity ratios do not exceed 4:1. (Photo courtesy of General Electric.)

Figure 27 (b). Well-balanced horizontal and vertical illuminance insures safe and secure task performance at the pump island and visibility of outdoor areas to people inside the store. (Photo courtesy of Ruud Lighting.)

areas should be discouraged. Clerks should also be clearly visible to outside customers.

7.2.10 Single-Family Residences

Lighting of exterior doors is usually provided for the identification of callers, safety, and for more routine tasks such as finding keys quickly and locating lock keyways. Luminaire location is important. Light from luminaires installed on both exterior sides of the door will help the homeowner recognize faces when viewed through peephole security viewers. Luminaires mounted overhead will create harsh shadows or a silhouette effect if they are located directly above or behind where the person would normally be standing. The minimum vertical illuminance for security lighting at exterior doorways should be 8 lux (0.8 fc), measured 1.5 m (5 ft) above the doorway threshold, or at the midpoint elevation of the viewing device or door window, out to a radius of at least 3 m (10 ft). Facial luminance should be no less than one-fourth of the background; otherwise the face becomes silhouetted and indistinguishable. (See **Figure 29**.)

Illumination installed at single-family residential doors is usually manually controlled, but timer or motion sensor devices are highly recommended. As visitors approach, the sensor-controlled light will be turned on, and callers perceive a presence in the home. The time delay for the switch should remain on for at least five minutes. Sensors can also alert the homeowners that someone is at or passing the doorway. Using a motion sensor and photocell combination device will preclude the luminaire coming on during daylight hours. Timer switches are less effective in this role because they are insensitive to ambient light level.

In exterior residential applications, spotlights mounted on walls and under building eaves, and oriented towards approach paths, can be an effective deterrent. Floodlights should be employed at safe distances from adjoining roads or highways. Top visors that limit glare and wasted uplight are recommended. Passers-by (whether sidewalk pedestrians or drivers in cars) and neighbors should not be subjected to glare from security lighting. Very careful design and installation is essential in controlling glare off the property so as not to impede surveillance from patrol car occupants, produce glare on adjacent streets, or create light trespass on neighboring properties.

Figure 28. In-store clerk has a clear view of the pump island outside. (Photo courtesy of Occupational Safety Systems, Inc.)

When it is determined that lighting is necessary for additional security protection, walls, fences, perimeter barriers and similar features should be lighted from above. Plant landscape materials can be uplighted to eliminate shadows or hiding spaces and for aesthetics. (See **Figure 30, color insert**.)

Interiors of the home should have several timer switches that operate lamps throughout the house during normal time of use. The timing pattern will be determined by the makeup and behavioral patterns of the residents. The homeowner should not wait until going out of town to establish this practice. Neighbors should be educated about the light patterns. For long life and energy savings, compact fluorescent lamps (rather than incandescent) provide an ideal source type for these timer-controlled table lamps. Lamps should be located in a bedroom, reading or sitting area, and even in the kitchen. If properly planned, members of the family should be able to come home to a familiar and safe lighted pattern throughout the house. This serviceable pattern is most effective when it flows from the exterior approach into the relative safety of the home. Timer controls, infrared sensors, or photocells effectively augment established patterns.

Figure 29. Luminaires mounted on either side of the door uniformly light the front door. Supplementary landscape lighting in the surrounding area contributes to a lighted welcome to visitors and enables the homeowner to easily identify the caller. (Photo courtesy of Occupational Safety Systems, Inc.)

7.2.11 Multi-family Residences and Dormitories

Multi-family dwelling units present a security lighting challenge different from that for single-family dwellings. Even when inside the complex perimeter, occupants are not in a totally secure environment. The building and grounds are naturally accessible to other residents and their guests. As a result, occupants may feel at risk when moving about on the grounds and into the building where their individual residence is located. (See **Figure 31**.) Owners and operators of multi-family facilities should take this into consideration when planning the security of their properties. Special attention should be given to crime reports, vandalism, graffiti, and local crime statistics, as gathered through resident complaints, security agencies, and the police. These data should be reviewed at least yearly, and the information made available to residents. Criminal activity at night and the areas where it occurs will be of particular importance when considering upgrading or improving lighting patterns and values.

Common Areas: Common areas such as hallways, stairways, entrances, and assembly areas have inherent critical safety and security considerations. (See **Figure 32**.) Lighting that enables recognition of faces is essential to determine who belongs in the space and who does not, who is perceived as safe and who may present a danger. An average maintained illuminance of at least 30 lux (3 fc) should be provided in

Figure 31. Clearly defined walkways and easily identified entrances provide safe transition from the parking area to the dwelling units. (Photo courtesy of Magnaray International.)

Figure 32. A well-lighted entrance to a dormitory building insures safe passage for returning occupants and easy identification of arriving visitors for someone inside the building. The light distribution from wall-mounted luminaires also enhances the texture of the building surface. (Photo courtesy of Ruud Lighting.)

the space with an average-to-minimum uniformity ratio not greater than 4:1. If the residential complex shares a common mailbox area, the space, open or enclosed, should be uniformly illuminated to an average of 100 lux (10 fc), with an average-to-minimum uniformity ratio not greater than 3:1.

Other Areas: Illuminance is required for other high-use gathering points such as laundry rooms, showers, locker rooms, and exercise rooms, regardless of whether such facilities are of closed or open construction. (See **Figure 33**.) Care should be given to illuminate probable hiding or seclusion areas where perpetrators can prey on tenants approaching or exiting these areas. This includes spaces under stairways, unsecured storage lockers, vending areas, roof access wells, furnace, and maintenance rooms. Transitional lighting should be provided for exits.

Individual Residence Controls: Individual residences should have, as a minimum, an individual luminaire by every entry door to provide light for viewing someone prior to opening the door. Regardless of whether visitor viewing is through a window or security-viewing device (peephole), illumination should enable clear recognition of facial features. Consider the approaches discussed in **Section 7.2.11** for single-family residences.

Parking Areas: Parking structures or open parking areas should be lighted in accordance with the recommendations contained in other applicable IESNA publications under low risk conditions.[6] When security is an issue, lighting should be installed consistent with guidelines contained in **Section 7.2.4**.

Maintenance Considerations: Maintenance of luminaires for a multi-family residential complex is a challenge. Stocking the number and variety of lamps and coping with vandalism, wear and tear, and tenants who intentionally circumvent security systems, are just some of the problems faced by residence managers. Nevertheless, management must maintain a formal inspection routine and record keeping process for repair and replacement of lighting equipment. These inspections should be performed no less than weekly, with a short turn-around time for repairs of no more than 36 hours. Formal records of the inspection process, and resulting repairs should be kept and referred to often. Where police or security officers work on the property, this inspection process should be performed daily as the officer makes rounds, and reported on his daily activity log, or other forms. Also, if battery-operated lights are used, spare batteries and lamps should be available.

7.2.12 Multi-family Residences for the Elderly

As the average population age in North America increases, security for the elderly becomes more of an issue. Multi-family housing units designed specifically for the elderly are increasing in popularity, and frequency of use. IESNA RP-28-98, *Lighting and the Visual Environment for Senior Living*[11] includes specific recommendations for senior citizens that may be sight-impaired.

Parking garages may offer a seeing problem to older drivers. Seniors' ability to readily adapt to rapid and/or extreme changes in lighting levels is diminished. They typically drive more during the day than at night because they are sensitive to glare, such as from oncoming headlights. Most parking garages have very low illuminance levels as compared with day lighting. With proper design, the extreme difference between outside daylight and interior electric lighting levels can be adequately transitioned. Parking garages used frequently by seniors should be designed with a greater transition area for adaptation between the interior and exterior lighting conditions. The recommended minimum maintained *daytime* illuminance for the transition zone is 500 lux (50 fc).

In all spaces, glare and contrast levels are important to seniors. Their sensitivity to glare from exposed point sources is extreme. Bare lamps and luminaires that exceed 850 cd/m^2 should be well shielded from older eyes. Contrast is one of the most important visual cues for older people. Excessive differences in lighting levels should be avoided in transition areas between exterior driveways, entrances, lobbies and corridors. Exterior walkways should have a minimum maintained illuminance of 50 lux (5 fc). Doors, handrails and obstructions should have good contrast with the backgrounds. High light levels (e.g., an average of 300 lux (30 fc)) in interior corridors and at entrances to apartments help to produce a secure feeling for individuals in the space. Illuminance may be reduced to more appropriate levels (e.g.,100 lux (10 fc)) for sleeping hours. Entrance doorways should be free of shadows.

7.2.13 Schools and Institutions

The traditional role, utilization, and occupancy rates of many schools are changing. Most schools in the past were used only during the day and only nine months out of the year. Roles have expanded for many schools. There are now sporting events, evening classes, community meetings and organizational activities, all of which may meet during the evening hours. During such gatherings, there is movement of persons in the buildings, on the grounds, and in parking lots. Combining this with mass hurried movement of vehicles creates a potential hazard. *When security is an issue*, parking facilities should be illuminated to at least an average maintained illuminance of 30 lux (3 fc) on the pavement with a uniformity ratio not greater than 4:1, average-to-minimum. Sidewalks, footpaths, and grounds supporting mass movement of persons should be illuminated to at least an average maintained illuminance of 10 lux (1 fc), with an average-to-minimum uniformity ratio not greater than 4:1, during planned use periods. Illuminance levels specified are only required for a period of two hours before a scheduled event, and up to two hours after

Figure 33. Clear sight-lines in a well-lighted space enable the user of the exercise equipment to focus on the workout without concern for surprise intruders. (Photo courtesy of General Electric.)

all participants have departed the school grounds. (See **Figure 34, 35** and **36, color insert**.)

During periods of inactivity, some rural and suburban school administrators choose to use a black-out method to protect buildings and contents, whereby buildings and grounds are deliberately left in the dark. In this approach, patrol officers are able to readily detect individuals using hand-held lighting devices when on the grounds. In addition, energy is conserved and the property is less visible to unknowing passers-by. When planning such an approach, administrators need to consider a means of allowing patrol officers (private or public) to quickly illuminate the grounds or buildings when responding to alarm calls or making a determination that the integrity of the facility is being violated. Installation of locked or remote- controlled on/off devices, and coordination with local security or law enforcement providers can address this concern.

7.2.14 Law Enforcement, Fire, Ambulance, and Other Emergency Services

The facilities of public law enforcement departments are places that require a high quality of outdoor light in order to safely move prisoners from place to place, load and handle firearms, make rapid vehicle movements, and be perceived as safe havens for the public seeking refuge and assistance. This is no less true for fire, ambulance or trauma centers, where excellent visibility at night is a critical life safety issue (see **Figure 37**.) Lighting that enables recognition of faces is essential to determine who belongs in the space and who does not, who is perceived as safe and who may

Figure 37. A well lighted hospital entrance and driveway provides a sense of security and enables patients and visitors to transition between the building and parking lot without concern. (Photo courtesy of Tampa Electric Company.)

Figure 38. Parking areas and entrances to guest suites are well lighted to enable guests to safely transition from cars to rooms. The absence of any obstructions or vegetation eliminates hiding places and provides unobstructed views of the parking lot. (Photo courtesy of Ruud Lighting.)

present a danger, and what their intentions are. An average maintained illuminance of at least 80 lux (8 fc) should be provided at ground level with an average-to-minimum uniformity ratio not greater than 3:1, on and within 18.2 m (60 ft) of all emergency vehicle and pedestrian movement areas. This includes entrances, interior, and exits to sally ports and holding areas of law enforcement agencies. General parking for these emergency facilities should have average maintained illuminance of 30 lux (3 fc) on all parking and walking surfaces, with an average to minimum uniformity ratio not greater than 4:1.

7.2.15 Hotels and Motels

In recent years the hospitality industry has been moving more and more toward the concept of personal security away from home. Security application improvements for hotels and motels now include electronic keys for individual room and door access, and increased lighting for parking lots, grounds, and footpaths. (See **Figure 38**.) *When security is an issue*, parking facilities should be illuminated to at least an average of 30 lux (3 fc) on the pavement with a uniformity ratio not greater than 4:1, average-to-minimum. Sidewalks, footpaths, and grounds around supporting mass movement of persons should be illuminated to an average maintained illuminance of 10 lux (1 fc) at the ground, with an average-to-minimum uniformity ratio not greater than 3:1. Management, security, or maintenance personnel should check for lamps that are out or not performing according to specifications while walking the grounds nightly. Repairs or replacement should be made within 48 hours of a major deficiency being

8.0 GLOSSARY OF TERMS

Various terms and phrases are used throughout this text. The following is a listing of some of these terms. For a more complete listing of terms and lighting techniques, refer to the I*ESNA Lighting Handbook*[2] and ANSI/IESNA RP-16-96, *Nomenclature and Definitions for Illuminating Engineering.*[12]

Adaptation. The process by which the eye becomes accustomed to more or less light than it was exposed to during an immediately preceding period. It results in a change to the sensitivity to light.

Dark adaptation – the process by which the eye becomes adapted to a luminance less than about 0.034 cd/m^2.

Light adaptation – the process by which the eye becomes adapted to a luminance greater than about 3.4 cd/m^2.

Transient adaptation – where the human eye has to adapt from low to high light levels and back in short intervals. This happens when the visual environment has very high contrast. Excessive transient adaptation soon results in eye fatigue and reduces visibility momentarily until the eye fully adapts to the new luminance level.

Brightness. Brightness is a psychological response to luminance and not synonymous with it.

Candela (cd). The SI unit of luminous intensity in a specific direction equal to one lumen per steradian (lm/sr).

Candlepower. Luminous intensity expressed in candelas.

Charge Coupled Device (CCD). Television camera utilizing an integrated circuit, semi-conductor array of light sensitive picture elements (pixels) arranged on a silicon chip to sense light passed from the scene through the lens, frequently referred to as a ‘chip’ camera.

Cutoff. A means of defining the distribution of a luminaire based on candela per 1000 lamp lumens. Luminaires are rated as F*ull cutoff, Cutoff, semicutoff, or Noncutoff.*

Full cutoff - A luminaire light distribution where zero candela intensity occurs at an angle of 90˚ above nadir, and all greater angles from nadir. Additionally the candela per 1000 lamp lumens does not numerically exceed 100 (10 percent) at an angle 80˚ above nadir. This applies to all lateral angles around the luminaire.

Cutoff - A luminaire light distribution where the candela per 1000 lamp lumens does not numerically exceed 25 (2.5 percent) at an angle of 90˚ above nadir, and 100 (10 percent) at a vertical angle of 80˚ above nadir. This applies to all lateral angles around the luminaire.

Semicutoff - A luminaire light distribution candela per 1000 lamp lumens does not numerically exceed 50 (5 percent) at an angle of 90˚ above nadir, and 200 (20 percent) at a vertical angle of 80˚ above nadir. This applies to all lateral angles around the luminaire.

Noncutoff - A luminaire light distribution where there is no intensity (candela) limitation in the zone above maximum intensity.

Dark adaptation. The process by which the eye becomes adapted to a luminance less than about 0.034 cd/m2.

Footcandle (fc). A unit of illuminance equal to 1 lm/ft^2 or 10.76 lux.

Glare. The sensation produced by luminances within the visual field that are sufficiently greater than the luminance to which the eyes are adapted, which causes annoyance, discomfort or loss in visual performance and visibility.

Direct glare - Glare resulting from high luminances or insufficiently shielded light sources in the field of view. It is usually associated with bright areas, such as luminaires, ceilings and windows, which are outside the visual task or region being viewed. A direct glare source may also affect performance by distracting attention.

Disability glare - The effect of stray light on the eye whereby visibility and visual performance are reduced. A direct glare source that produces discomfort may also produce disability glare by introducing a measurable amount of stray light in the eye.

Illuminance. The density of the luminus flux incident at a point on a surface measured in lux or footcandles.

Horizontal illuminance - Luminous flux incident upon a horizontal surface

Vertical illuminance - Luminous flux incident upon a vertical surface.

Incident light. Light falling on an object or surface.

Infrared (IR) radiation. Radiant energy within the wavelength range of 780 to 1200 nanometers.

Light. Radiant energy that is capable of exciting the retina and producing a visual sensation. The visible portion of the electromagnetic spectrum extends from about 380 to 780 nanometers.

Light pollution. The scattering of electric light into the atmosphere, usually caused by luminous flux above the horizontal. Often referred to as sky glow or sky brightness.

Light trespass. Light that strays from its intended purpose, causing visual annoyance. A severe form of light trespass involves glare.

Light adaptation. The process by which the retina becomes adapted to luminances greater than about 3.4 cd/m^2.

Lumen. SI unit of luminous flux. Photometrically, the luminous flux emitted within a unit solid angle (1 sr) by a point source having a uniform luminous intensity of 1 cd.

Lumen per square meter. A unit of incident light equal to one lumen equally distributed over one square meter of area producing an illuminance of one lux.

Luminance. (Formerly *Photometric Brightness*.) The luminous intensity of any surface in a given direction per unit area of that surface as viewed from that direction.

Luminaire (light fixture). A complete lighting unit consisting of a lamp or lamps and ballast(s) (when applicable) together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to the power supply.

Lux. The international unit of illuminance equal to one lumen evenly distributed over a surface of one square meter. One lux is equal to approximately 0.093 footcandles.

Reflectance of a surface or medium. The ratio of the reflected light (flux) to the incident light (flux). A surface that has the same luminance regardless of viewing angle is called a lambertian surface.

Tube type TV camera. A general term for television cameras that utilize a vacuum cathode ray tube (CRT) to sense luminance passing through the lens. Category includes Vidicon, Intensified Vidicon, Silicon Target, Silicon Intensifier Target, and Intensified Silicon Intensifier Target. The last four are intended for applications with increasingly low light levels.

Vision.

Mesopic vision - Vision with fully adapted eyes at luminance conditions between Photopic and Scotopic vision, that is, between 3.4 cd/m^2 and 0.034 cd/m^2.

Photopic vision - Light adapted vision that occurs at moderate and high levels of luminance so as to permit discrimination of colors. It is generally associated with adaptation to luminance of greater than 3.4 cd/m^2 and is vision mediated essentially or exclusively by the cone receptors in the retina of the eye.

Scotopic vision - Vision mediated essentially or exclusively by the rods. It is generally associated with adaptation to a luminance below about 0.034 cd/m^2.

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ANNEX A

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ANNEX B

Physical Security Survey

A physical security survey may also be known as an audit, risk assessment, threat assessment, vulnerability/criticality analysis, or needs identification. No facility can be properly protected until there is a logical process to evaluate risks to life and property and application of appropriate countermeasures.

For large sites, or those supported by a management staff, surveys should be conducted by a team whose members might include the facility manager, security director, security consultant (if employed), architect (if there is remodeling or new construction), lighting specialists, a representative from any security and/or safety committees, and a representative of any contract guard or police employed on the site. In the case of health care institutions, it is wise to include a nursing representative, or patient care professional. The team should always remember that criminals like the dark. For smaller facilities, or those properties supported by a small staff, all these functions may by necessity be performed by a smaller group of people.

The purpose of any physical security survey is to gauge the risks, vulnerabilities and threats at a particular site, and the effectiveness of existing security (policies and procedures, hardware and personnel performance) in addressing those risks. The outcome will be a series of recommended short-term, intermediate, and long-term improvements where warranted, and the cost and cost-effectiveness of such recommendations. The survey is a fact-finding process.

No security plan or program can be effective unless based upon a clear understanding of the actual risks involved.1 The role of lighting is a critical component in a risk analysis and the lighting system must be evaluated in conjunction with any other planned physical security measures.

Factors to Consider

In determining the threat level, as much objective information as possible about the location and its surroundings must be gathered. The site should be visited during the day and at night. Illuminance readings should be taken at the site, as well as at surrounding properties. Specific locations to be considered include pathways that employees, residents and customers must take to access the location and any buildings on the site.

Other factors include whether the neighborhood is declining or in a state of dynamic growth? Are there signs of gang activity such as graffiti on walls or equipment boxes? What is the current population or site use, in terms of numbers of people? An assessment should consider how the intended and unintended uses of surrounding properties affect the vulnerabilities or risk of the property under investigation. A key element in determining the threat level to a property is an analysis of the crime associated with the property over time. For more information on performing a crime analysis, refer to **Annex D**.

Space

Safety is enhanced when people can see each other beyond a 10 m (30 ft) distance. The closure rate of two people walking towards each other yields about a 5 to 6 second closure time within which to make a decision to avoid, evade, flee, ignore, or defend against the other person, if necessary. Confined areas and areas that restrict the ability of people to see ahead 10 m (30 ft) promote the ability of would-be attackers to surprise potential victims. Lighting can play a key role in the defense principal of allowing individuals to see potential threats and identify escape routes at greater distances, and instilling in would be attackers the sense of being discovered before or during the commission of the crime.

Open sight lines

Areas that have no obstructions to lines of sight, no hard corners, no hiding-places, use low-level landscaping, have a tree canopy trimmed to at least 2.1 m (7 ft) above the ground, and are well maintained, enhance feelings of personal security. Elements of *hardscape* (buildings, retaining walls, sidewalk) and *softscape* (trees, bushes, plant materials), all have an effect on the lighting design. Areas with many abrupt angles, large changes in elevation and/or copious landscaping are a challenge to the design of security lighting and can add to the system costs. Poorly planned and maintained landscaping can defeat the most elaborate lighting designs.

Patrol response time

In designing a security program, the lighting designer needs to consider how lighting can enhance the effectiveness of the local patrol force. Relevant questions may include: How often is this area routinely patrolled? Do patrol officers actually come on the property or simply drive by? Where are they most likely to patrol? Are patrol officers equipped with auxiliary lights for viewing into alleys, doorways, and hallways? Will the placement of lights create a glare that will limit the ability of the patrol to see into areas that may appear to be well lighted? How easy is it for emergency personnel to identify buildings and locations on the site from the streets? What is the response time if there is an emergency? How can lighting enhance or inhibit that response time? A benchmark for measuring the effectiveness of a patrol system is response time. This is a measurement of the length of time expressed in minutes and seconds that it takes the first officer to receive a signal from the dispatcher, and arrive at the crime or emergency scene. For example, most major city police departments will strive to reduce their response time down to 5 minutes or less. Internal facility or base security personnel often have even quicker response times, due to shorter distances of travel, greater familiarity with the property, and a smaller population to serve. Operations utilizing contract security forces may contractually designate maximum response times, and are wise to periodically test the system. Public police are usually less responsive to such request or monitoring. The lighting designer may need to consider this time factor into the final design package. For example a small plant or office building in a rural county may need more active and passive protection at the site, as patrol service is simply not practical, and emergency response times are twenty to thirty minutes or more.

Supplemental Security Design

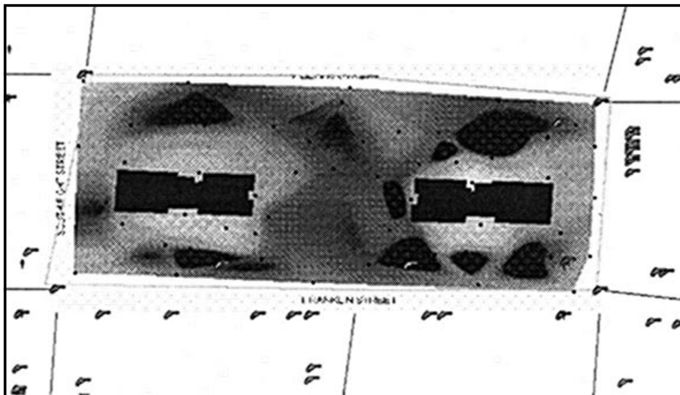
Increasingly, security strategies include the use of electronic surveillance to supplement the on-site surveillance of both public police and private security. Electronic security, including closed-circuit television (CCTV), provides “always-on” capabilities that are not possible through security personnel without extremely large security budgets. Lighting is a critical part of an electronic security design that relies on CCTV as well as on regular patrols. Although cameras capable of operating under infra-red and low level lighting are available, the quality of these pictures, as well as video images used for identification and investigation, will be enhanced by ensuring that adequate lighting exists in those areas that are most vulnerable and reinforced by video patrols.

Survey Process

The survey process includes several steps. Surveys should be conducted annually, at a minimum, and as needed (especially after a serious incident) on built properties. Surveys are regularly conducted whenever new construction or renovation of an existing property takes place on the site.

Survey Tools

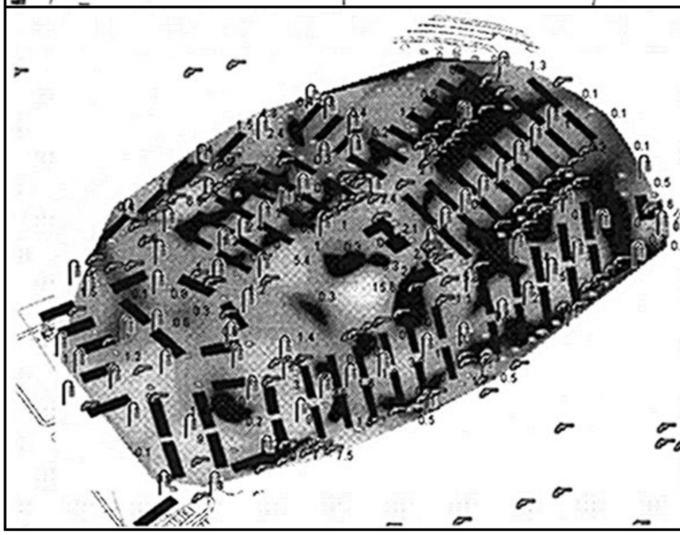
- Pad and pen to record locations measured and marked on a site diagram or plan
- Survey form or template to guide the assessment
- Calibrated, cosine corrected, digital light meter



Lighting and Crime in and Around Elderly High Rises

Example of light mapping and crime assessment associated with high-rises for the elderly. Black dots are the locations where readings were taken around the property. Readings were taken between 10:00 and 11:00 pm.

Provided courtesy of SPARTA Consulting Corporation



Lighting and Crime in and Around a Multi-Family Housing Complex

Example of a light map associated with an apartment complex. Location of light poles and crime are shown, as well as location of trees. Numbers indicate the location of the light reading and the value in footcandles. Readings were taken between 12:00 and 2:00 am.

Provided courtesy of SPARTA Consulting Corporation

Figure B1

- Small flashlight
- Tape recorder
- Tape measure to record distances from light sources
- Clipboard and several pens

Two people are optimum for the light measurement. An assessment template or survey needs to be created that ensures that all critical areas are included in the assessment. A lighting survey for a building that houses senior citizens, for example, should include assessment of the lighting on either side of the property lines, at the bus stops, parking lot entrances, parking lots, in the common areas inside and outside the building, along walkways, under the canopy or vestibule, in the entrance and lobby, at the elevators and on the elevators, in front of the mail boxes, inside and outside the emergency exists, in the stairwells and on several of the floors.

Recording Light Values

The illuminance, as registered on the illuminance meter, should be noted in the survey plan. For details on taking and recording photometric readings refer to **Annex C**.

Technical Specifications

As part of the survey process, technical specifications of lamps, luminaries, locations, aiming angles, mounting heights, and controls should be examined to see if existing conditions require change. The most important lighting considerations are:

- Quantity of light – lumen output of each light source
- Spatial distribution of light (composition of two- and three-dimensional lighting patterns)
- Spectral distribution of light (color attributes of lighting)
- Temporal distribution of light (sequential changes in light emitted, visual effects when passing through, or redirecting vision)
- Added elements (visible components of the lighting system).

Use of Light Values

Light measurements should be evaluated for adequacy, recommended minimums and maximums, and uniformity. Measurement of light values on any property allowing public access, *where security is an issue* should be evaluated and recorded on a scheduled program basis.

Additional Factors of Lighting

In addition to taking light meter readings, and evaluating technical specifications, there are psychological considerations. Light and shade, highlights and shadows, and variation in color will affect the senses. It is wise to consider the advice of non-technical personnel, both males and females, in evaluating psychological responses. For example, consideration should be given to how the physical senses are impacted when passing through each lighted area. Does the ambient lighting stimulate alertness or dullness, fear or tranquility? Are the shadows harsh, creating very dark areas or are they soft, permitting one to look into the shadows easily?

Light Pollution, Light Trespass and Glare
The surrounding environment will affect lighting needs on the property. Adjacent street lighting, or light spillover from adjacent properties, may interfere with CCTV cameras by producing too much backlighting against which an intruders face will appear in silhouette. Neighboring property owner/operators, or civil authorities, may complain. Ambient light that spills over onto neighboring properties, or into the wrong internal area(s), can be controlled through the use of internal or external light shields as one option.

Glare can work for or against an effective security lighting system. Glare reduces visibility when low mounted luminaires are aimed out and away from the property to be protected. This will create glare in the eyes of the potential trespasser, while allowing the guards or cameras positioned behind or directly under the lights to view the perimeter without being detected. The glare makes the criminal uncertain about what is in the area and how well it is guarded. To be effective, the secure area should be left dark and the low-mounted luminaires should floodlight all the approaches to the area.[2] Glare, however, in the wrong areas can limit ability to see a perpetrator. Just as glare can hinder the trespasser, it can also hinder the police officer or security guard who is patrolling from the perimeter. If glare is used within a facility, it must be carefully placed so as not to inhibit the operation of cameras or security personnel assigned to protect an area. Unnecessary or unwanted glare can be minimized by using higher fixture mounting heights and steeper aiming angles, thereby putting the light where it is needed, while reducing the visibility of the actual light source (direct glare), and minimizing light pollution and light trespass.

Special Needs
In addition to the security requirements already discussed, the visual needs of senior citizens must be considered. Older eyes have special needs. ANSI/IESNA RP-28-98, *Lighting and the Visual Environment for Senior Living* (reference 10 in the main document) should be consulted if seniors frequent, shop, work in, or visit the location to be surveyed.

Structuring the Assessment
Assessments should be as thorough as possible and should be graphical. Below are some examples of lighting maps that were designed based on a lighting assessment in a Northeastern community. The crime data are for 2000 and are indicated using icons. Lighting values were taken in footcandles and plotted on the site maps for each development.

Recommendations
Following an analysis of the survey, the next step is to consider the need for change. Recommendations for any changes in lighting patterns, or for improved lighting should be detailed and specific, providing a rationale for the change. These recommendations should mention applicable alternatives, and the cost involved for each. Lighting professionals can provide the necessary data.

REFERENCES

1. Protection of Assets Manual, Chapter 2-1; Revision 2-1, April 2000.
2. Leslie, R.P. and Rogers P.A., The Outdoor Lighting Pattern Book. New York: McGraw-Hill, 1996, p. 4.

ANNEX C

Taking Security Illumination Measurements – A Practical Guide

Background

Taking lighting measurements in the field for security purposes is often quite different in practice and purpose than taking measurements for other lighting applications. Security lighting recordings are often performed by police officers investigating a crime scene, a security officer, or maintenance personnel making rounds, a property manager or security consultant evaluating an incident location. In these cases, the security lighting evaluation is most often conducted in conjunction with other tasks. As a result, the recordings need to be conducted efficiently, and with a minimum of mathematical calculations or equipment.

Preparing for the Evaluation:

Preparation and study are essential for security lighting surveys. First, if possible a typical night should be selected. Test times to be avoided include completely overcast conditions, full phase of the moon, snow on the ground, rainy or stormy nights, or nights with no moon. An average night hypothetically will have a sky with half cloud cover, mid phase of the moon, no rain, no snow cover, and no light trespass from a nearby sporting event. In other words, reasonable not perfect conditions are optimal. However, many exposures are open to the public during all hours and weather conditions and light readings must be taken under representative times and conditions. Lighting measurements should be made under reasonable conditions, taking into account weather conditions such as moisture and temperature and their effect on the meter and its ability to provide reliable information. If readings have to be taken under adverse conditions such as snow cover because of the time of the year, these conditions should be noted in the assessment.

Taking Measurements – The following is a step-by-step approach to taking security and safety lighting measurements for property:

Step 1. Select the equipment - Measuring security lighting is not an expensive proposition. An illuminance meter, often referred to simply as a light meter, is the first requirement. The meter must be cosine corrected and color corrected. Measurement results should be displayed in both lux and footcandles. Typically, these meters have a sensor attached to the body by a flex cord. Meters of this type are produced by a variety of manufacturers, and can be purchased commercially from an industrial meter or instrument shop or electrical supply house. For a view of a typical meter refer to **Figure C1**.

Figure C1. Typical illuminance meter. (Annex C photos courtesy of Operational Support Services, Inc.)

For accurate and repeatable results, the meter should be calibrated. It should be recalibrated as recommended by the manufacturer. Other helpful items include a compass for determining cardinal directions (north, south, east, and west); a measuring tape or ruler for determining height above ground; a distance measuring device, such as a wheeled foot and inch counter; flashlight; fisheye level; plot plan or sketch; and, recording materials. As a helpful hint, the fisheye level should be attached to the light meter sensor, without it interfering with the sensor head. This will aid in keeping the meter level, if the placement or slope of the terrain is in doubt.

Step 2. Orientation to the property – Orientation to the property, i.e., the cardinal directions (north, south, east, and west) should be determined with the aid of a plot plan and a compass, and the plan or sketch marked accordingly. This will be useful later when describing results, and identifying objects.

Step 3. Layout of the area - The area of the property where the measurements are to be made should be determined. If the area is clearly defined, such as a parking lot or fenced school playground, the measurement locations can be planned on a straight line that samples a typical section of the area. To take a correct sample, a line location should be selected that includes a good range of what appears to be the best and the worst lighting conditions. An easy "trick" in this regard is to look at one's own shadow on the ground. Certainly, the best place to start looking for the lowest values is midway between the widest luminaire spacing. However, if the two luminaires have different sources, optical systems, or differ in aiming, the physical mid-point may not be the area of lowest illuminance. In this case, a comparison of the two shadows (usually one's own body-shadow) may be the best estimator. When the shadows are of equal darkness, the contribution of light from each luminaire will also be comparable, and give the lowest light readings. Scanning back and forth with the meter is also useful to find *absolute* levels.

If measuring an irregular or poorly defined area, such as a curving sidewalk, or exposed ATM or ND in an outside area, or a crime scene, the flow of logical pedestrian movement should be followed. A determination should be made about where and how many readings will be taken. The number and location of the test points will be determined by the layout, size, and shape of the area and the degree of accuracy desired. A reasonable number of test points would be *no less* than eight, of equal distance apart, along either a straight line or terrain following course. For example, to check the security lighting at a large guardhouse entrance that is 30 yards across, measurements might be taken at intervals of 3 yards (paces). In this example, readings will be taken at ten different points. The area to be surveyed is measured or paced off. Positions to be measured should be flagged, or distances measured by pacing from point to point. For larger areas such as supermarket or mall parking lots the readings should be taken in at least one half (½) the mounting height intervals.[1] This exercise should be repeated as often as needed to secure a reasonable sampling of the area being measured. Readings should also be taken at least 5 m (16 ft) on either side of the path to ensure visibility into the areas near where people walk or travel. Readings should also be taken on either side of fences and perimeters of the property.

Step 4. Determine height - Primary readings will be taken at ground or floor level; however, consideration should be given to any secondary heights above ground or floor that might apply. For example, if the protection of persons or facial recognition is the primary concern at this property, additional readings should be taken at 1.5 m (5 ft), or other determined heights above ground level. See **Figure C2**. These above ground readings should be taken at the same points or locations as ground level readings. (See **Step 5**.) In the case of ATM machines a state statute may require a 0.9 m (3 ft) above ground level measurement (the estimated height of an ATM transaction face). Practical field experience shows that measurements at height are usually comparable to or higher than those taken at ground level. Once the secondary height is determined, the location can be measured with a tape measure or ruler. This height can be determined in relation to the operator's own height. For example, the 5 ft mark may be just above or below eye level, or the 3 ft mark may be at belt height. With this in mind, the measurements can be completed more easily, with no need to carry height-measuring equipment, and progress will be faster.

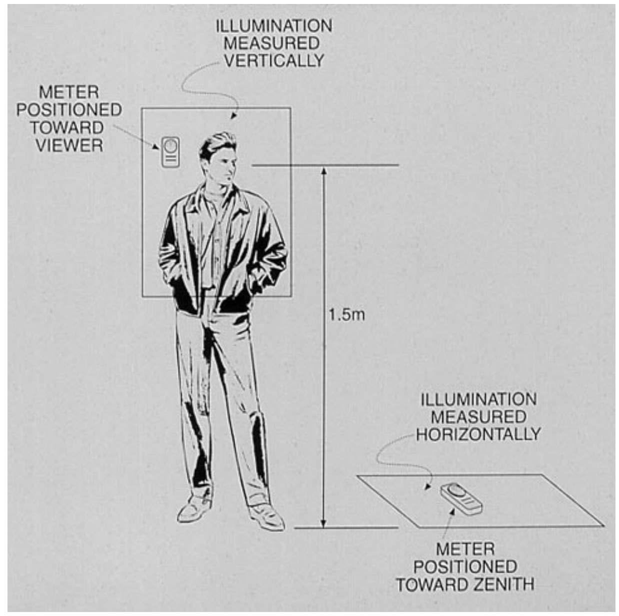


Figure C2. Meter position for measuring horizontal and vertical Illuminance.

Step 5. Reading at grade - At the first test point, a horizontal reading should be taken at ground level. This is accomplished by placing the meter on the ground or pavement surface, with the sensor face up, taking care not to block light from reaching it, or cause shadows on the sensor. A good practice is to move away from the meter as far as possible, while still being able to read the digital display. Special remote-cords on some meters allow the read-out portion of the meter to be separated from the light sensor. Results should be recorded and marked as *point 1 – ground level*. See **Figure C3**.

Step 6. Reading at height - (readings taken at the work plane). For many applications, it may be appropriate to take measurements at a height above ground that is considered a work or functional plane. Examples of these planes include interior and exterior ATM machines, guard posts where drivers' faces and identification papers must be viewed, and tops of vehicles. Once the appro-

[1] One half (½) the mounting height is equal to the distance from luminaire to finished grade, divided by two.

Figure C3. Recording meter reading at *point 1 – ground level.*

priate task application is determined, another reading should be taken at the first location, just above the *point 1-ground level* position, at the height above ground as determined in **Step 4**, above. The meter should be held in a horizontal position, as level as possible, with as little obstruction or shadow to the meter's sensor as possible. Results will be recorded as *point 1 – height level*.

Step 7. Complete taking readings - The process described in **Steps 5** and **6** should be repeated until all *ground level* and *height level* measurements have been completed for each designated point.

Step 8. Calculating the results - With the results recorded, the summary data can then be determined. First, all of the *ground level* readings should be added, and then divided by the number of readings taken at *ground level*. The result will equal the *average lux (fc) at ground level*, for that area where readings were taken. The average lux (fc) level for the entire site can best be calculated when readings are taken over the entire site. Extrapolations can be accurate only if the site is lighted throughout with the same equipment, and at the same spacing and with the same number of burning hours on all the lamps. The *average-to-minimum* ratio can now be determined. This is usually expressed as a ratio to unity, e.g., an average of ten and a minimum of one will be expressed as 10:1 and an average of ten and a minimum of two will be expressed as 5:1. To determine this ratio, the statistical average of all *lux (fc) readings at ground level* should be taken. This is the average. *The minimum in the calculation is the absolute lowest lux (fc) reading recorded at ground level.* This is written as average *lux (fc) at ground level: lowest lux (fc) reading recorded at ground level.* For example, using the guardhouse scenario, imagine that the *average lux (fc) at ground level* was 37 lux (3.7 fc), and the *lowest lux (fc) reading at ground level* was 14 lux (1.4 fc). This is expressed *as a ratio of 2.6:1*. The *average* illuminance and the ratio of *average-to-minimum* illuminance at this location is now determined. These figures can now be compared to the recommended standard.

Step 9. Vertical illuminance readings – Lighting that allows identification of faces is a relatively new concept to security lighting, but important in certain applications, such as parking facilities, lighting for peep-hole viewing (looking at a person through the optical device or small window in a door), or at security checkpoints. The light meter is held in a vertical position, at an average facial height of 1.5 m (5 ft) above ground level to determine the incident light on a face. (See **Figure C2**.) But in which direction on the compass does one hold the meter (in this vertical position)? For some applications, the answer is simple: for peephole viewing, the meter should face the peephole; for checkpoints, it's the direction facing the officer when viewing people passing through the checkpoint. Open and semi-open areas present no such easy determination. An accepted method for taking vertical illuminance readings when no set direction of vision is established is this: readings should be taken in North, East, South, and West directions and averaged. If the average exceeds 6 lux (0.6 fc), and the lowest of the four readings is no less than one-fourth of that average, there should be adequate vertical illumination to see and identify a face from a distance of 10 m (30 ft) or more. If the minimum reading is less than that, a determination of threat in that direction should be reassessed and principles similar to those in the case of the peephole can be applied. Background illuminance should also be considered. If the background (behind the face) is more than four times the illuminance on the face, the image will be in silhouette. Thus, if the background illuminance is 100 lux (10 fc), the facial illuminance must be above 25 lux (2.5 fc) in order to have visibility of the face. In some cases silhouetting may be the best strategy when landscaping or architectural features limit the ability to adequately illuminate a face along a perimeter area. Creating a silhouette may be sufficient for one to determine that a potential threat exists and to determine whether to continue along a path or avoid the area to reduce risk.

Step 10. Look for trouble - Before leaving the site, it is important to stop and consider why this process was started in the first place. It was to determine the *security lighting* posture of this location in relation to recommended practices, codes, standards, and/or in response to a perceived threat. Such testing is best utilized when part of an overall security effort or inquiry. Determine what other security issues or questionable practices there are. Can any of these problems be addressed by improved security or safety lighting? Conditions should also be recorded that may only indirectly relate to security lighting but create a threat to the property, such as overgrowth of foliage or trees that either obstruct lighting, or provide hiding places. The weakness or problem areas should be recorded and reported. The individual responsible for this location should consider improvements. Things that are done well should also be included in the report.

For properties open to the public, security lighting surveys should be performed at least annually, and compared with adjoining properties. The lighting on this property could appear to be comparatively weak and vulnerable if more robust lighting or relighting has occurred at one or more adjoining properties and could be a more attractive crime site to persons seeking to stay out of the better lighted neighbor's property. Lighting maintenance inspections for servicing of luminaries and replacement of lamps and fixtures should be performed at least monthly, if not weekly when there is a history of vandalism and efforts to defeat the lighting system.

ANNEX D

Crime Analysis and the Foreseeability of Crime

Background

The extent and type of lighting to be used as part of a balanced security system is determined by several factors. Critical among these is the actual criminal history on or near the property. An analysis of prior events and crime that have occurred on or around the site can help to establish the foreseeability of future crime at the location. For the professional security and lighting designer, or occupants of a particular site, *foreseeability* of crime should be considered in formulating the original security and safety lighting design, as well as planning for future needs.

In the case of an existing site, it is appropriate to consult data that details prior criminal history *on the premises* as part of a recurring assessment. Generally, such an analysis should be performed at least annually, and the security readiness of the property adjusted accordingly. If the site is being developed in a previously unoccupied area, or there is a fundamental shift in use, an analysis of crime in the area is acceptable, as opposed to an exact address research. On property where a history of relevant crime exists, *security is an issue*.

The most reliable means of determining future security needs and criminal vulnerabilities is to conduct a crime analysis of the property and immediate neighborhood. Such an analysis utilizes established crime reporting sources considered most credible by criminologists, security, and police professionals throughout North America. In the United States and Canada, most city and county governments have a central crime reporting capability. This capability exists at the state, Commonwealth, and provincial level as well. Data is available to the public through a variety of reporting sources. End users can request the raw data from various government agencies, or choose to use the services of an experienced analyst. Costs for this data range from free to an hourly charge, depending on the source(s) and depth of analysis.

Crime searches within the United States can be requested for specific street addresses, police patrol beats, cities, counties, states, and the nation. This is also the case within many of the major metropolitan areas of Canada. Mexico is more fragmented in its reporting efforts, and more reliance is placed on local police to collect and retain criminal data.
Restricted use sites, government property, and businesses with an established guard or loss prevention staff may also have internal record keeping capabili-

ties that can supplement public police data. Maintenance departments may also have records of vandalism and damages to the property that can be invaluable in determining the most vulnerable areas on a site.

In recent years the availability of information on criminal incidents from both governmental and private sources has caused security and lighting professionals to focus on analysis of the data to alter both existing and future designs. Additionally, the on demand availability of crime data from government sources to individual employees, supervisors, and managers places the professional on notice that historical crime information should be consulted and analyzed when security lighting design is being considered. This is especially true when the lighting design is in support of facilities open to the public. Recent advances in computer analysis have resulted in the ability of some larger police departments and researchers to map crime in their communities. Such mapping increases an understanding of how and when crime affects properties in order to better plan lighting and prevention strategies.

Terms:
As an aid to the reader, it is appropriate to list and briefly discuss some of the terms used in the analysis of crime. Key terms:

Police call reports - Calls for service as recorded by the local police department. The most common form of data collection is through emergency operator systems and police radio dispatcher logs. Data is collected and reported by date, time, location from which the call originated, and categories of activity code as interpreted at the time of the call. Call reports are almost never corrected by the responding officer(s) upon arrival or after an initial investigation. For example, a call for service is received as an assault, and after officers arrive and conduct their investigation, the activity is found to be friendly but aggressive horseplay. The call will usually remain recorded as an "assault."

There are other factors to consider in better understanding call reports. The caller may have reported the incident from a location other than where it occurred. This could be "a safe place" from which to place the call, such as a nearby grocery store, or the alleged incident could have occurred in a public street, which does not have an address or phone. The call is recorded as having occurred at the store address where the original report is made, instead of where it actually took place. These and similar scenarios are especially true in areas where phone service is limited. Police call reports are, therefore, not usually a reliable resource in determining or predicting actual crime.

Police Incident Report - Sometimes referred to as an offense or patrol report, incident reports are completed by the original responding officer after arriving at the scene, completing some inquiry, and determining that a violation of the law is likely to have occurred. The reports are usually assigned control numbers, and are filed for future reference or follow-up. If the incident is considered a criminal act, the report may become part of the Uniform Crime Reporting system. Depending on the nature of the potential crime or activity, other officers may make more detailed inquiries and reduce these findings to a written investigation report.

Uniform Crime Reporting (UCR) Program[1] - This is a nationwide cooperative crime statistics gathering effort for the United States and Canada. The program began in 1930 in the United States, and was subsequently adopted by Canada with modifications. Reporting by local, state and provincial, and federal law enforcement agencies in both countries is on a voluntary basis. UCR data represents approximately 97 percent of the United States population living in Metropolitan Statistical Areas (MSAs)*[2]; and, 89 percent of the population residing in smaller communities, cities, and rural counties. Canada receives a similar response in its data collection effort. Mexico does not have a UCR program. Under the UCR program, data is compiled annually from contributing departments utilizing established definitions and criteria. Such uniformity in reporting makes comparative analysis possible and generally more accurate.

Index Crimes** [1,2] - a category that includes the most serious crimes as defined, collected, and reported by the United States federal government, and utilized by most other agencies through the UCR program:

1. Murder and non-negligent manslaughter
2. Forcible rape
3. Robbery
4. Aggravated assault
5. Burglary
6. Larceny theft
7. Motor vehicle (auto) theft
8. Arson***

All crime occurring on property may be relevant,

* Metropolitan Statistical Area (MSA) includes a central city of at least 50,000 people or an urban area of at least 50,000. The county containing the central city and other contiguous counties having strong economic and social ties to the central city and county are also included. Sourcebook of Criminal Justice Statistics, 1998.

** Also known as Part I offenses, these are used to compile the Crime Index. Sourcebook of Criminal Justice Statistics. 1998.

*** Arson is considered an Index Crime but is not included in the tabulation of all Index Crimes for the United States.

and can be considered in the following context. Violent crimes such as murder and non-negligent manslaughter, forcible rape, robbery, aggravated assault, and assault are considered to involve force or threat of force. In addition to criminal acts considered violent, certain other criminal acts are prone to violence, or could evolve into serious threats to human life. Although not always violent in and of themselves, violent-prone crimes degrade the overall quality of life by placing reasonable persons in fear and indicate a loss of control of the property. Violent-prone acts may change depending on the locale, but may include crimes such as burglary, larceny theft, motor vehicle theft, arson, terrorist threats, stalking, gang graffiti, vandalism, trespass, and vagrancy.

Factors Affecting Crime Reporting:[3,4]
The level of crime reported to police or a security department is dependent on numerous variables.

1. Classification of offenses by security and local police departments is often based on calls for service, rather than the final determination of a detailed investigation, court, medical examiner, coroner, jury, or other judicial body.
2. Some incidents are falsely reported to the police as crimes and may not be removed from the crime data.
3. Public attitude toward law enforcement causes underreporting of crime, perhaps by as much as 63 percent.
4. Size, population, and demographic composition of an area may result in many calls for service not being investigated and recorded as incidents.
5. Economic status and unemployment rate in the area tend to influence the types of crime that are reported.
6. Stability of the population, i.e., level of transients, commuters, and seasonal population may decrease reporting or influence the accuracy of where crime occurs if the crimes are reported after the incident and in another location.
7. Climate may create variations in crime patterns over a short period of time.
8. Standards, practices, and relative strength of the law enforcement agency(s), including the policies and practices of courts and prosecutors, the law enforcement agency's administrative effectiveness and efficiency, investigative effectiveness, efficiency, and accuracy, and reporting methods.

Of particular note to those conducting statistical research is Item 3. Members of society do not report all crime to police. According to the *National Crime Victimization Survey (NCVS)* 1999,[5] only 37 percent of all crimes were reported to police. Crimes of violence were reported only 43 percent of the time and only 33 percent of property crimes were reported. As far as why victims did not report violent crime to police, 19 percent said that the crime was a private or personal matter, and of those victimized by property crime, 25 percent said the object was recovered, or the offender was unsuccessful. The data for this one year is typical.

Equally discouraging is the fact that even when the police are called, more that 80 percent of the calls are never classified as crimes and never appear in police incident reports or the UCR crime data, against which the level and seriousness of crime in communities is judged.

Both non-reporting of crime and the failure to classify incidents as crimes can lead to false impressions about the relative safety of various environments. At the same time, some neighborhoods, particularly those of lower-income, have a much higher rate of reporting crime or conflicts than do more affluent neighborhoods. This may be because they have a greater incidence of crime, and also because they tend to use the police as mediators and authority figures in disputes more than other groups.

The local police, constable, or sheriffs' department should be contacted for site-specific data. If the department does not collect and report the information, the question should be asked . . . *who does?* As with the other reporting levels, there are private firms that can collect and interpret the information.

A. Patrol Beat or Division - Most major cities are divided into districts that encompass geographic areas, which are patrolled by police. The layout of these areas is logically configured according to such factors as population and geographic features, thus creating defined areas called patrol beats or patrol divisions. Crime data may be requested for a particular police beat, patrol division, or neighborhood geographic area, in addition to exact address, and compared to other similarly divided areas, or the city as a whole. Data that is derived from arbitrary sizing such as *"1 mile square area"* or *"a 2 mile radius"* should be avoided. Such arbitrary plots often include unwanted information, such as sections of other communities, making the data difficult or impossible to use for comparison purposes. Many major police departments in the United States and Canada have web sites that provide a breakdown of city or county crime into subdivisions that can be compared one to another.

B. City or County - Compare the city or county as a whole to other cities in the nearby area, state, and nation. Consider comparisons to cities or counties with similar demographics, industry, and other comparative features. For companies operating in different cities, this information can be used as a prime indicator regarding the allocation of security resources.

C. State or Province - Each state (United States) and province (Canada) collects and reports crime. Comparison of one state or province to another may provide needed insight. For enterprises operating in different states, this information can be another important indicator regarding the allocation of security resources.

D. National - As the public moves from place to place more frequently, a look at the national crime report card is important in understanding both the reality and the perceptions regarding crime. Those interested in Canadian crime data can contact: Statistics Canada by calling 613-951-8219 or on the web at <www.statcan.ca>. In Mexico, the contact is the Department de Justicia, in Mexico City. Contacting United States Department of Justice, Office of Justice Program, Bureau of Justice Statistics at 800-732-3277 can access data on the various states, and national crime in the United States. United States data is also on the Internet at <www.fbi.gov>, <www.usdoj.gov>, <www.icpsr.umich.edu/nacjd/ucr.html>, and <www.ojp.usdoj.gov>.

E. International - During the 1990's the United Nations began to take an interest in comparative analysis among member countries and encouraged countries to collect and report crime using the general format and definitions found in victimization studies conducted in the United States, Canada and other industrialized countries. This project is known as the *International Crime Victim Survey.*[6] At the present time this survey reports on the primary eleven industrialized countries, including the United States and Canada. This comparative data may be of particular interest to lighting and security practitioners operating across international boundaries. The data details trends since 1991, and provides breakdowns by types of crime.

F. Analytical Process - Once the data is available for review, an analysis should be made of the types of crimes that have been occurring on the property. While considering that all crime is relevant, a determination of whether to focus on incidents of violent crime (crimes directed against persons), or on property crimes (crimes directed against property) is recommended. For facilities open to the public, the initial focus will rest on the protection of people, not property. In the case of a controlled site, such as a volatile fuel processing plant, property protection may be critical. When combining data from police with data collected internally, care should be taken to present the clearest representation of the property, and to eliminate duplication of information. Good internal security reporting is just as credible as information collected by the police.

Important questions to ask are: *"What is likely to happen on this property in the future?"* and *"Is the owner in control of the property?"* If there is an increasing pattern of violent or violent-prone crimes, it is reasonable to *foresee* similar crimes occurring in the future. Conversely, if crime has been declining on the property, it is reasonable to expect the trend to continue. If there are conflicting patterns or questions remain unanswered, a professional should be consulted. Local police commanders, or security consultants, may have much to offer.

After considering the crime at the site, examine crime in the patrol beat, city, and/or county. If the site is located in a comparatively high-crime area, it is probable that many physical defenses, including lighting, are necessary to maintain overall security on the premises. As success in controlling crime is realized, it may be possible to reallocate valuable resources. With this same theme in mind, a review of state or provincial, and national statistics will provide insight into long-range trends.

It is reasonable for property owners to check statistical crime data annually. Convenience stores, shopping centers, malls, food markets, fast food restaurants, multi-family housing complexes, hospitals, banks and similar businesses open to the public should consider making results of their findings available to employees, tenants, and users of the property. By informing regular users of the property, they are placed on notice, and can participate in solutions, while taking personal precautions, if needed. Findings should not be concealed from those who have a reasonable need and vested interest in knowing true conditions at the location.

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ANNEX E

Crime Prevention through Environmental Design (CPTED)

Security lighting is only one element, albeit a critical one, of an overall security program. To better understand the relationship between security lighting and other security measures and practices, it is important to consider lighting in relation to other crime prevention design concepts. This broader understanding can be gained by a study of Crime Prevention Through Environmental Design (CPTED).

CPTED (acronym is pronounced *sep_ted*) has emerged as one of the most promising and effective approaches to creating safer properties and physical environments. CPTED contends that architects, designers, municipal planning boards, law enforcement officials, security professionals, and citizens can work together in the initial design or redesign of the built environment. Emphasis placed on the proper approach to design and effective use of the built environment will thus lead to a reduction in the incidence, opportunity, and fear of crime. The proper application of CPTED concepts creates improvement in the quality of life, while providing for prevention-oriented, rather than reactive-oriented, approaches to crime.

CPTED has become increasingly recognized as a cost effective approach in the design or re-design of an environment to reduce the opportunity for crime and the fear of crime through natural, mechanical, and procedural means. A partial history of the evolution of CPTED1 as a practical approach is summarized below.

CPTED Objectives

The primary objective of CPTED is to enforce a design fundamental of "form follows function," in creating a productive use of space, while providing an aesthetically pleasing built environment. The goal is to create a climate of safety by designing environments that positively influence behavior; encouraging desired activities and discouraging undesired ones. Additional objectives focus on crime and loss prevention through the facilitation of inherent human territorial behaviors, while incorporating natural access control measures and natural observation.

Prevention of undesirable and criminal activity in an area may be achieved by measures as simple as trimming a hedgerow, locating a window to overlook a parking area, installing a fence to control access, or by providing adequate parking lot lighting.

CPTED principles applied to lighting design in a public access area include the use of luminaires that are tamper-proof, durable, and, where practical, that blend into the surroundings. CPTED principles encourage the protection of lighting system components from vandals while providing sufficient light levels for users.

When incorporating CPTED principles, consideration should be given to all the players. They fall into three primary categories: normal users, abnormal users, and observers. The environment must give the normal user a sense of security, the abnormal user the feeling of being at a disadvantage or at risk, and the observer the opportunity to keep the area under appropriate surveillance. The abnormal user's perceived disadvantage may come from a lack of cover and concealment, a restriction of access to the territory of a normal user, or a sense of not being able to adequately avoid either the casual viewer or trained observer.

The following questions will assist in incorporating the three 'Ds' of CPTED (designation, definition, and design) into a facility or area:

- Does the facility or space clearly belong to the normal user?
- Who is responsible for the facility or space?
- Is the intended or proposed use of the facility or space clearly defined? Does it correlate with the surroundings?

Figure E1. Situational Crime Prevention Matrix

1. Target hardening	5. Entry/exit screening	9. Target removal	13. Rule setting
2. Access control	6. Formal surveillance	10. Identifying property	14. Stimulating conscience
3. Deflecting offenders employees	7. Surveillance by	11. Reducing temptation dis-inhibitors	15. Controlling
4. Controlling facilitators	8. Natural surveillance	12. Denying benefits	16. Facilitating compliance

Figure E2. Application of Situational Crime Prevention in Multi-Family Housing

1. Target hardening. Definition: Target hardening uses physical barriers and impediments—locks, bolts, safes, screens, toughened glass, and reinforced materials—to obstruct the vandal or the thief.	**Examples:** • Minimum security standards for locks, doors, door frames, windows, screens • Routine inspections of premises security • Avoiding glass panels next to doors, or replacing glass next to door hardware with security glass or polycarbonate equivalent • Increasing security hardware for all openings within 18 feet of ground level • Toughened glass in unsupervised areas • Thorny shrubs to discourage climbing • Removing trees that facilitate scaling perimeter wall • Removing drainpipes or structures that facilitate climbing to upper levels • Strict security for housing unit keys in management offices • Securing sub-floor and attic spaces
2. Access control. Definition: Access control measures are intended to exclude people from spaces, premises or facilities, who have no legitimate reason for entering and who may be potential offenders.	**Examples:** • Manning entrances to site • Reducing number of site entrances • Perimeter fencing • Parking lot barriers • Keyed access to laundry rooms • No outside access to rear of buildings • Emergency exits with alarm-connected panic bars and no exterior handles • Front access to rear yards in conventional housing • Rear yards should not adjoin open space
3. Deflecting offenders. Definition: Deflecting offenders refers to measures that are intended to influence the routine activities of potential offenders so as to keep them away from possible crime targets.	**Examples:** • Limited pedestrian routes across sites • Clear signage and numbering to discourage wandering • Routing footpaths used by schoolchildren away from housing and parking • Placing fuel meters in front of buildings • Defining front yards for ground floor dwellings • Careful placement of recreational space • Locating kiddy play areas away from sidewalk • Locating bus stops away from residences • Placing railings on low walls to discourage loitering • Traffic routing and street closures to divert drug purchasers
4. Controlling facilitators. Definition: Crime "facilitators" are tools that make crime easier, including weapons, but also many everyday objects—cars, telephones, credit cards, cans of spray paint, beer glasses—that in some circumstances can facilitate crime. Situational controls on such facilitators, which include removing them, modifying them and restricting access to them, seek to impede their use in crime.	**Examples:** • Removing or modifying pay phones to prevent use in drug dealing • Removing abandoned furniture that drug dealers sit on • Prohibiting rear-in parking, which assists drug dealing • Towing of abandoned vehicles used to stash drugs • Prohibiting on-premises car repair used by drug dealers as excuse to "hang out". • Reducing vacancies and securing empty units that can be used for drug dealing. • Controlling the sale of spray cans by local ordinances/voluntary agreements.

5. Entry/exit screening. Definition: Entry screening differs from access control in that the purpose is less to exclude potential offenders than to increase the likelihood of detecting people not in conformity with entry requirements. These requirements may include having legitimate business on the premises. Exit screens serve primarily to deter theft by detecting objects that should not be removed from the protected area, such as items not paid for at a shop.	**Examples:** • Installing electronic access controls ("entry phones") • Installing spy holes for front doors • Concierge or receptionist for apartment blocks • Resident photo IDs • Guest sign-in schemes
6. Formal surveillance. Definition: Police, security guards and store detectives, whose main function is to furnish a deterrent threat to potential offenders, provide formal surveillance. The surveillance afforded by security personnel may be enhanced by electronic hardware, such as burglar alarms and monitored closed circuit television (CCTV).	**Examples:** • Police and security guard patrols • Police bike patrols • Police substation on site • CCTV at entrances to buildings • Install burglar alarms • Supply temporary burglar alarms for repeat victims • Screening of resident applicants
7. Surveillance by employees. Definition: In addition to their primary work-related function, some employees, particularly those dealing with the public, also perform a surveillance role by virtue of their position. These include a variety of "place managers" such as shop assistants, hotel doormen, park keepers, train conductors and receptionist or concierges in apartment blocks. All these employees are expected to assume some responsibility for monitoring conduct in their workplaces.	**Examples:** • Encourage housing authority employees to reside in public housing • Encourage crime reports by mailmen, delivery workers and maintenance crews • Locate pay phones where visible to employees • Facilitate surveillance of estate from management office
8. Natural surveillance. Definition: Natural surveillance is designed to promote the kind of supervision exercised by people going about their everyday business. Householders may trim bushes at the front of their homes to make it easier for neighbors or passers-by to see burglars. Enhancing natural surveillance is a prime objective of defensible space architecture, of improved street lighting, and of "neighborhood watch".	**Examples:** • "Neighborhood watch", "apartment watch" and resident patrols • Supplying free phones to block watch organizers • "Call 577-TIPS" to report crime • Overlooking building entrances and parking spots from residences • Reducing number of units per entrance in apartment blocks • Improving interior lighting in hallways and corridors • Improving exterior lighting on paths, at entrances and in parking lots. • Free electricity for porch lights • Removing greenery obstructing view of public areas • Replacing solid stockade fencing with see-through picket fencing • Eliminating blind spots in stairwells or corridors • Clearing sightlines along pathways • Providing a greenery set back of 3 yards from paths

9. Target removal. Definition: Some objects are particularly attractive targets for crime. For example, targets for theft include cash and objects that can be easily sold, such as car radios, VCR machines, handguns, and jewelry. Target removal measures seek to remove attractive targets from the situations in which offenders can access them; e.g., converting pay phones from coin to phone card use, or installing drop safes in convenience stores.	**Examples:** • No-cash policies in housing manger office • Tokens for laundry and vending machines • Payphones operated by phone cards • Off-site food stamp distribution • Door-to-door mail delivery • Storing maintenance equipment/supplies in secure lock-ups Identifying property.
10. Identifying property. Definition: School students write their names on their backpacks or sneakers, not just to guard against loss, but also against theft. The most developed programs of identifying property relate to vehicles. Registration of motor vehicles was required in some U.S. states from almost the beginning of the century and, subsequently, all vehicles sold in the United States were required to carry a unique Vehicle Identification Number (or VIN).	**Examples:** • Defining private areas and yards around residences • Property marking schemes for residents • Resident vehicle registration policy • Coded bumper stickers linked to residences • Logo or property tags for all housing authority equipment
11. Reducing temptation. Definition: The surface characteristics of some walls almost invite graffiti, and already damaged facilities or equipment can provoke the vandal to further attacks. Wearing a gold chain in some parts of the city almost invites it to be snatched. Some sport cars left on the street at night may prove an irresistible temptation to the joy rider. Reducing temptation reduces such invitations to crime.	**Examples:** • Hiding graffiti-prone walls behind shrubbery • Rapid repair of vandalism • Gender-neutral lists of residents • Closing children's playgrounds at night
12. Denying benefits. Definition: Benefit denial measures try to insure that the offender does not obtain the benefit sought by crime. The recent development of security-coded car radios that require a thief to know the radio's PIN before it can be used in another vehicle constitutes an excellent example of this principle. Another example would be the use by clothing stores of ink tags, which cannot be removed by thieves without spilling ink on the stolen garment.	**Examples:** • Cleaning graffiti and gang "tags" • Using anti-graffiti paint • PIN for car radios

13. Rule setting. Definition: Rule setting is the introduction of new rules or procedures, and the clarification of and publicizing of those already in place, which are intended to remove any ambiguity concerning proscribed conduct or actions.	**Examples:** • Establishing drug-free zones • Posting notices of local ordinances • Posting and enforcing parking ordinances • No trespass and private property signs • Notifying clear eviction policy to residents
14. Stimulating conscience. Definition: This situational technique can be distinguished from society's more general informal social control by its focus on specific forms of crime occurring in discrete, highly limited settings. Rather than attempting to bring about lasting changes in generalized attitudes to law breaking, these measures serve simply to stimulate feelings of conscience at the point of contemplating the commission of a specific kind of offense.	**Examples:** • CCTV surveillance of drug purchases • Postcards to homes of drivers suspected of purchasing drugs • Publishing license tags of cruising vehicles
15. Controlling dis-inhibitors. Definition: Crime is not only facilitated by tools such as weapons, but also by psychological dis-inhibitors, especially alcohol and drugs, which undermine the usual social or moral inhibitions, or impair perception and cognition so that offenders are less aware of breaking the law. Most examples of this technique relate to controls on drinking.	**Examples:** • Controls on drinking in semi-public and public areas • Moving or closing down liquor stores • Closing local bars
16. Facilitating compliance. Definition: Measures that facilitate compliance seek to make it easier for people to comply with rules, regulations and laws. These measures include the provision of facilities, such as litterbins or public urinals, and the simplifying of procedures for paying rent or checking out library books.	**Examples:** • Provision of public lavatories • Provision of garbage cans with secure lids • Frequent collection of refuse • Painting lines and numbers for parking stalls

- Does the facility or space correlate with the surrounding environment adequately?

  1. Designation:
     a. What is the designed purpose of the space?
     b. Will the new facility or space fulfill the original intention?
     c. How well does the facility or space support its current use or its intended use?
     d. What, if any, conflicts exist with the proposed use of the facility or area?

  2. Definition:
     a. How is the facility or space defined?
     b. Is it clear to the normal user or observer who owns the space?
     c. Are the borders of the facility or space clearly defined?
     d. Do any social or cultural definitions of the

facility or space affect how the area will be utilized?

3. Design:
   a. Does the physical design support the intended function of the facility or space?
   b. Does the physical design of the facility or space support the definition for desired behaviors?
   c. Does the physical design support the productive use of the facility or space?

After responding to the three 'Ds' of CPTED development, a strategy can be determined, which may include some of the following:

a. Lighting should provide clear border definition of controlled spaces.
b. Strategic lighting should clearly mark any transitional zones, i.e., areas where there is movement from public to semipublic to private spaces.
c. In areas where people gather or where there is a need for access control for normal users the lighting should provide for natural surveillance by observers.
d. Distant or isolated areas should be evaluated for improvement using CPTED principles for lighting design.
e. Lighting of formal gathering areas should be adequate for normal users, thus creating the perception that all other areas are "off limits."
f. Proper lighting and design of a facility or area should stimulate normal users and observers to scrutinize anyone not in proper areas; or lighting can create an environment wherein abnormal users perceive greater risk (with fewer excuses for being in the wrong areas).

CPTED generally follows five principles: *natural surveillance, access control, territorial reinforcement, image and maintenance, and location setting and place considerations.*

Natural surveillance focuses on the placement of physical features, activities, and people in such a way as to maximize visibility. This includes the lighting of public spaces and walkways at night.

Access control includes physical features that guide people who are coming and going from a space through the judicious placement of entrances, exits, fencing, gates, landscaping and lighting.

Territorial reinforcement refers to the encouragement of ownership through the use of physical attributes such as fences, pavement treatment, art, signage, landscaping and lighting.

Image and maintenance refers to the image, reputation and stigma often associated with locations. CPTED recognizes the relationship between maintenance of an area and the image that it projects to others.

Location setting and place considerations-vigilant management practices that sustain territoriality, access control and surveillance are critical to the continued use of a space for its intended purpose, and serve as an additional expression of ownership. CPTED concepts also consider environmental settings of crime and how crime is influenced by the proximity and juxtaposition of safe and unsafe activities.

The application of CPTED principals, integrated with other theories about crime prevention, results in safer properties. CPTED emphasizes the use of natural elements for crime and loss prevention measures. Modern criminology emphasizes how people use the environment. An example of the integration of CPTED with the concepts of situational crime prevention can assist the planner in understanding how to approach the initial and re-design issues that often confront security planners.

There are sixteen (16) opportunity-reducing techniques of situational crime prevention and crime prevention through environmental design. (See **Figure E1**.) The techniques, with examples of their application, are applied to public housing and other settings.[2] (See **Figure E2**.)
Although lighting may not be the primary focus of CPTED, it is a key fundamental to the proper application of CPTED fundamentals and principles. Designation, definition, and design questions will assist in proper strategy utilization of CPTED concepts.

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ANNEX F

Lighting for Television and Photographic Surveillance

Any TV camera, given adequate lighting, will “see” the same objects the eye sees. The various hues and shades of color perceived by the eye, however, will be displayed as shades of gray by a black and white TV camera and can only be rendered accurately with color cameras and monitors. TV camera imagers can also pick up scenes lighted in the infrared band, not visible to humans. The most important illumination factors in regard to scene viewing are the type, quality and quantity of useful light available.

Type of lighting. Lighting can be from sunlight, moonlight, or electric sources including the following types: incandescent, fluorescent, mercury vapor (used infrequently), metal halide, high- pressure sodium, and low-pressure sodium.

Incandescent lamps contain energy in a broad band of the spectrum, with the exception of violet and blue wavelengths. The other lamp types have narrower bands and lack one or another wavelength of the visible spectrum. Color rendering will vary with the source type selected. (See Section 6.0 of the main document G-1.)

Quality of light refers to its compatibility with the image sensor in the television camera. Formerly, the imager would have been a vidicon or other type vacuum tube. Currently the imager will more likely be a Pixel (picture element) array in a CCD camera.

Characteristic differences among the sources, solar and electric, affect the television camera image. These are differences in the spectral quality of the light and the color temperature. Differences in the visible spectrum are emphasized in an effect termed “spectral response.” It is important that the camera selected for a particular scene be capable of acquiring at least a usable image and preferably full video within the spectral response area of the lighted scene. Analysis of camera specifications is a first step, but the most convincing test is to sample the scene under the expected lighting conditions, using the specific camera being considered.

Quantity of light Quantity is equally as important as the quality of light. The amount of light needed to produce a TV image at the monitor is stated as the amount of illumination on the solid state camera image sensor or the tube type camera face plate. This measure is the most useful because it is an absolute value and does not depend upon factors outside the CCTV system, such as the amount of light falling on the scene or the reflectance characteristics of surfaces in the scene. It specifies the actual intensity of light needed at the camera imager.

TV camera manufacturers specify in footcandles or lux the amount of illumination needed for minimum function (sometimes called “usable picture”) and for complete performance (called “full video”). It may be specified as scene illumination or as illumination at the faceplate or image sensor. The latter identifies the light intensity that must reach the image sensor. The intensity of the light source is often reduced or attenuated by scene reflectance. Scene luminance may be less intense then the incident light from the source and light intensity at the image sensor may be still less than that reflected from the scene. Actual TV camera performance under any light source may be increased by selecting lenses with lower “f stop” ratings, allowing more light to reach the imager. Each increase in f-stop numbers typically reduces the light transmitting capability of the lens by one-half. Thus, if a 1.4 lens has a relative brightness of 1, an f-2 lens will have a relative brightness of ½ and an f-2.8 lens ¼, and so forth.

The amount of light falling upon or reflected from a scene can be determined with a good grade illuminance meter. Readings should be taken at about the location at which the camera lens will be positioned, in all the directions in which the camera may be pointed. Allowance must be made for the amount of light the camera lens will transmit (generally between 70 and 90 percent), and the focal length or f-stop rating of the lens. Both values are available from lens or camera manufacturers. Although scene illuminance can be read directly with the light meter, the light reaching the camera imager requires a calculation. If the actual light level read by the light meter when placed at the approximate location of the camera lens is used in place of the term “Is” in the following equation, the equation can be used to determine illumination on the image sensor.

$$E = \frac{\pi L T}{4 N^2}$$

Where:

E = Illuminance on the image sensor, lm/m^2 (lm/ft^2)
L = Luminance of scene, cd/m^2 (cd/ft^2)
T = Transmittance of lens (usually 0.70 to 0.90), and
N = f-number (f-stop) of lens

When selecting television cameras for surveillance under electrical light, a determination should be made whether the general scene luminance will be sufficient to permit full video from conventional cameras, or whether special image intensifier cameras will be needed. The first criterion for general scene luminance should be the security lighting intensity levels for various applications as recommended elsewhere in this publication. After that minimum has been satisfied, any problem of lighting adequacy can be addressed either by installing additional lighting or by using low light level cameras. This decision is usually based upon economic considerations.

Light Source Color Considerations for Closed Circuit Television

For the purposes of safety and security lighting, color is an important consideration in the choice of light sources used. There are several important measurements of *color* including *Color Rendering Index, Color Temperature*, and *Spectral Power Distribution*. Highest on the list is *Color Rendering Index*, or *CRI*. (See **Section 6.0**, 2 a., b, c. and d., and **Figure 1** in the main document G-1.)

Spectral Ranges

Figure F1 indicates the spectral responses of the various types of CCD and tube-type television cameras. The illumination necessary for good color rendering depends on the color balance of the camera. Generally, a source that does not provide reasonable color rendering for visual viewing will not provide good color for TV surveillance.

Camera Type	Spectral Response Range (In Nm)	Peak (In Nm)
CCD	400 –1120	950
CCD with IR filter	400 –1100	550
Vidicon	400 – 650	530
Intensified Vidicon	350 – 800	480
Silicon Target	280 - 1100	700
Silicon Intensifier Target	320 –1100	740

Figure F1

Infrared. Television cameras with highly sensitive infrared spectral response, i.e., above 800 nm, should be used for viewing scenes where infrared sources are installed. Note that any infrared filters should be removed from the camera under daylight or conventional lighting conditions. Infrared radiation (IR) can be produced by incandescent or xenon lamps with the visible wavelengths filtered out, or by IR light emitting diode (LED) arrays. Filtered incandescent lamps have a high spectral intensity in the 800 to 1000 nm ranges, falling off to lesser intensity above 1000 nm. Filtered Xenon lamps have a slightly lower spectral intensity and are most effective in the 800 to 900 nm range. Arrays of Gallium Arsenide diodes can emit high intensity, narrow band IR, peaking between 880 and 950 nm. The LED sources are cooler and have a longer life cycle than incandescent lamps.

Images produced under IR will be viewed by the TV camera and displayed on TV monitors as black and white with shades of gray but will not be visible when viewed directly. The distance between an IR source and the object or scene to be illuminated, and the beam-spread angle of the light source determine the required lighting intensity. With average scene reflectance of 50 percent, a filtered incandescent source with 100-watt output and a 60° beam angle will be effective at 7.6 m (25 ft), while one with a 500-watt output and a 12° beam angle will be effective at 137 m (450 ft). The practical upper limit for filtered lamp output devices is about 1,000 watts.

Although the illuminated object will not be visible, direct visual observation of the IR source may detect a bright red glow at 650 nm, a dull glow at 750 nm and no visible glow at and above 950 nm. Because IR is invisible, there is potential for eye injury if IR illuminators are viewed directly. A minimum standoff or separation distance should be maintained between the source and the eye. Manufacturers of IR illuminators will specify the safe distances. The distances shown in **Figure F2** may be used as a general guide.

Power of Source	Distance
15 watts	1 foot
30 watts	4 feet
60 watts	10 feet
300 watts	35 feet
500 watts	40 feet

Figure F2.

Still and motion picture camera surveillance lighting. The principles applied for TV lighting will generally apply equally to lighting for still and motion picture camera surveillance, both black and white and color. An additional factor for film cameras is the character of the film and its relative speed (light absorbing capacity) in relation to the intensity of scene luminance. Camera manufacturers will specify the speed of the lenses and film suppliers will specify the speed of the film, relative to f-stop and distance between camera and object. As the camera shutters open only briefly, fixed lighting not supplemented by flash must be of consistent intensity to ensure adequate lighting at the instant of exposure. This consideration is of particular relevance for fixed or motion picture cameras that are event activated.

ANNEX G

Municipal Approvals

Codes or local ordinances that regulate lighting may restrict the type and amount of light that can be used, as well as the types of luminaires and the maximum height at which they can be mounted. There may also be regulations concerning light trespass, glare, and light pollution. Most municipalities have a project approval process that requires formal application and review. This would encompass lighting associated with new construction or for changes to existing layouts, resulting in increased illuminance or different types of light sources. The building department or code compliance office of the local government should be consulted to find out the requirements in a specific municipality.

When a formal presentation is required before a Planning or Zoning Board, it is importation to provide detailed information regarding the scope of the project and the reasons for the lighting layout. The presentation should include a description of the property or facility and how it is used. Drawings showing pole placement and spacing, pole heights and types of luminaires to be used are helpful. Special security issues or concerns should be identifed. The board, in most cases will want to know why the particular layout, luminaire, type and amount of light are appropriate for the particular project. This Recommended Practice, the *IESNA Lighting Handbook, 9th Edition* and the following IESNA publications will provide useful background information:

IESNA RP-33, *Lighting for Exterior Environments*
IESNA TM-10, *Addressing Obtrusive Light (Urban Sky Glow and Light Trespass) in Conjunction with Roadway Lighting*
IESNA TM-11, *Light Trespass: Research, Results and Recommendations*
ANSI/IESNA RP-8, *Roadway Lighting*
IESNA RP-6, *Sports Lighting*

ANNEX H

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