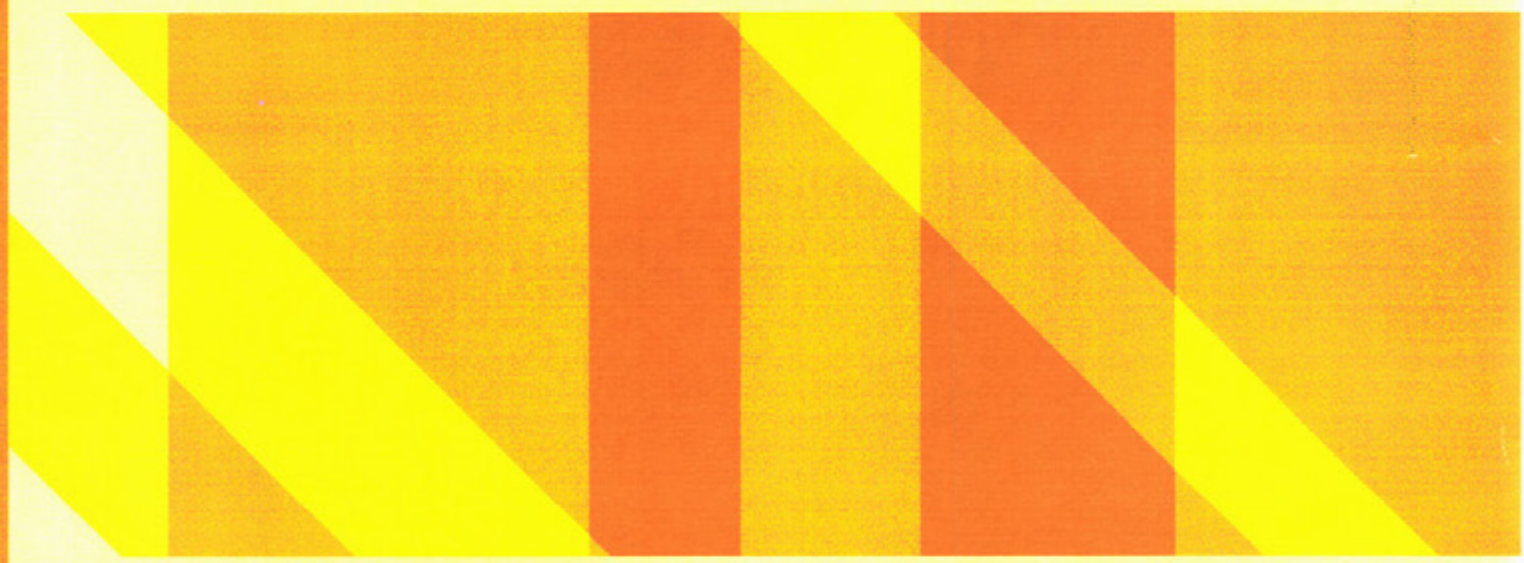
Illuminating
ENGINEERING SOCIETY

IES G-1-16

Guide for **Security Lighting for People, Property, and Critical Infrastructure**



IES G-1-16

Security Lighting for People, Property, and Critical Infrastructure

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has been approved by IES.
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should be directed to IES.

Prepared by:
The IES Security Lighting Committee

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FOREWORD

The many professionals in the Illuminating Engineering Society of North America (IES), the Security Lighting Committee, and the Subcommittee on the Relationship Between Lighting & Crime are proud to provide this publication in support of security goals and objectives. Our committee, comprising lighting designers and providers, law enforcement managers and advisors, crime prevention specialists, criminalists, and risk managers, has focused on producing guidelines that are easy to understand and apply. In addition to lighting guidance, we have included discussions of security issues and techniques to aid readers in considering and applying solutions.

History

The following constitutes a brief history of the relationship between safety, security, and lighting.

- During World War I, the US 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.

- A project to develop a standard on outdoor protective lighting for industrial properties was initiated at the beginning of World War II. This project was a request of the War Department and Military Intelligence, with the assistance of the Insurance Committee for the Protection of American Industrial Plants and the American Standards Association (ASA). The primary purpose of these efforts was to prevent theft and sabotage. It was soon realized that light discipline and improved plant and installation illumination were essential to the war effort. As a result, coastal facilities and buildings were darker, stray light was strictly controlled, and industrial plants and military installations received improved perimeter illumination. North America was learning the importance of good security lighting and light discipline.

- In 1942, the ASA War Standards Procedure was utilized, and a War Standards Committee prepared and published American Standard A85-1942, *Protective Lighting for Industrial Properties*. This eventually became an ANSI Standard.[1]

- In 1948, the ASA Safety Code Correlating Committee terminated War Standards and instituted a revised standard for peacetime use. The Illuminating Engineering Society of North America (IESNA)[2] 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 the American National Standard Practice.

- In 1977, the IES Protective Lighting Committee published IES RP-10, *American National Standard Practice for Protective Lighting*. This standard was primarily a guide to outdoor protective lighting for those responsible for industrial plant protection.

- In 1994, the Protective Lighting Committee was restructured as the Security Lighting Committee. This committee was charged with developing criteria for lighting, enhancing the security of people and property, recommending integration and interaction of lighting as part of a total security system, and writing publications to support public efforts toward a more secure society.

- During 1997 and 1998, the Security Lighting Committee developed material that was the basis for Chapter 29 of *The IESNA Lighting Handbook*, 9th Edition.

- In 1998, an overview of Security Lighting Committee work on *The IESNA Lighting Handbook*, 9th Edition, was formally presented at the IES Annual Conference in San Antonio by members of the Security Lighting Committee.

- During 1999 and 2000, members of the Security Lighting Committee outlined the contents and material design for a new security lighting publication and the peer review process. Peer review presentations were made to the American Society of Safety Engineers, the American Society for Industrial Security, and the International Conference on Shopping Centers.

- In 2002, members of the Security Lighting Committee began final work on an update of and replacement for IES RP-10, *Security Lighting*. The resulting publication, G-1-03, *Guidelines for Security Lighting for People, Property, and Public Spaces*, was approved by the IES Board of Directors on March 1,

2003 as a Transaction of the Illuminating Engineering Society.

- During 2004, IES established the Relationship Between Lighting & Crime Subcommittee of the Security Lighting Committee.

- In July 2010, the Security Lighting Committee and its subcommittee began the update process for IES G-1-03, with the working title of *IES G-1, Security Lighting Guidelines for People, Property & Critical Infrastructure.* Through this revised title and document, the committee addressed the expanding security and enforcement challenges faced by society, public entities, and individuals, as vividly brought home on September 11, 2001 and during subsequent terrorist attacks.

- During the latter months of 2010 and into 2011, members of the Security Lighting Committee designed curricula and made presentations to professional groups and associations, soliciting comments and peer reviews. Recommendations from such groups as the Public Risk Managers Association,[4] ASIS International,[5] Municipal Attorneys Conference,[6] and non-police and security professionals of IES[7] were taken under consideration. In addition, notice of the *IES G-1-11* assessment and peer review process were announced, along with instructions on how to review and comment online,[8] with peer and public comments invited. Reviews and comments received were taken under consideration, and the appropriate ones were incorporated into this final publication.

1.0 INTRODUCTION

1.1 Lighting and its Relationship to Crime and Security

The harnessing of fire forever changed the significance of light in human society. Early cave dwellers learned that this new tool could guide their path, provide warmth, cook food, and keep predators at bay.

As gas street lanterns spread in popularity, the effectiveness of lighting on crime in cities like London and Edinburgh was soon realized. In 1417, the Mayor of London decreed that lanterns with lights must be hung in front of each home and workshop between All Hallows Eve (October 31) and Candlemasse (February 2) to encourage secure passage in the streets for churchgoers. Public security lighting in Paris first appeared in 1524. In 1716, all London homeowners and shopkeepers whose buildings faced a street or footpath were required to provide at least one lantern for the public from 6 PM until 11 PM. Failing to do so was a minor crime, bearing a fine of 1 shilling per night. As the use of community exterior security lighting spread to American and other British colonies, the most common fuels were whale and fish oil, various nut oils, beeswax, and olive oil. Many of these fuels were used until the late 1700s.

In 1802, Humphry Davy demonstrated the principle of incandescence by passing an electric current through a platinum strip. This was the basis of the incandescent lamp. While experimenting with electricity, he invented a relatively efficient electric battery. When Davy connected wires to a battery and a piece of carbon, it produced an electric arc and light.

In 1860, Sir Joseph Wilson-Swan developed a more practical electric light by employing a carbon-paper filament that was efficient but burned out quickly. He worked to improve this process and in 1878 successfully demonstrated his new electric lamps before fellow scientists. The year before in America, Charles Francis Brush employed Sir Wilson-Swan's earlier research and created carbon arcs to light a public square in Cleveland, Ohio. The arc lamps had been installed on Cleveland streets, in stores, and in a few large office buildings.

About this same time in Menlo Park, New Jersey, Thomas Alva Edison experimented with thousands of different filaments to find one that would produce a longer-lasting and efficient glow. In 1879, Edison's experiments revealed that a carbon filament suspended in an oxygen-free bulb glowed but did not burn out until approximately 40 hours of life. Continuing his research, Edison eventually produced a lamp that could glow for more than 1,500 hours. With the advent of Edison's development of the incandescent lamp ("light bulb"[9]; **Figure 1** shows its

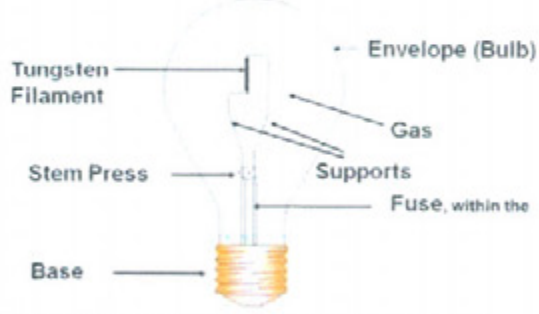


Figure 1. Elements of an incandescent lamp.
(Image ©Illuminating Engineering Society, IES)

components), night movement of people increased rapidly in public spaces.

Experimentation and wide use of night security and safety lighting has since expanded throughout most of the world where sources of electrical energy are readily available. The search for improved and cost effective delivery methods continues. These newer delivery methods will be discussed later.

The US Military and national security agencies throughout the world have long recognized the critical importance of security lighting to aid in the protection of their citizens, critical installations, and infrastructure.[60] During both World Wars, security and light discipline applications expanded rapidly. Since the terrorist attacks on September 11, 2001, the number and type of facilities considered *critical* and receiving upgrades in security lighting have expanded to include such heretofore-ignored elements as bridges, tunnels, communications hubs, transportation transfer points, and international borders. The IES continues to play an important role in our knowledge and application of security lighting.

Although there are many research studies showing inconsistent results on the benefits of improved nighttime lighting, one seminal study was conducted in Stoke-on-Trent, England, in 1999.[61] Three areas of housing were selected: the experimental area, where the lighting was improved; the designated "adjacent" area; and 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 whether 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, including 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,[62] showed that the level of delinquency decreased more in the relighted area than in the control area.

This publication includes specific sections dealing with critical infrastructure[19] and homeland security.[20] In addition, we have incorporated many of the lessons learned and applied by these agencies throughout.

2.0 SCOPE AND PURPOSE

This document is intended to provide specific guidelines for situations where it has been determined that *security is an issue* and is an *important determining factor* in the design or retrofit of a given property.

2.1 An Important Term

Throughout this Guide, the phrase *when security is an issue* is used to differentiate the lighting design suggestions presented here from those contained in other IES publications. While these other publications may refer to *security*, in this Guide, security is the *primary* issue.

When security is an issue, not only lighting but also other measures and system components deserve consideration and integration into the final design. Likewise, *when security is an issue*, there may be instances when other security measures are enhanced but lighting is not a primary consideration due to site location and usage. The primary purpose of this publication is to help users understand *when security is an issue* and provide guidelines for the design and implementation of appropriate security lighting for the private and public sector.

There is a distinction made in this document between *security* lighting and lighting for *safety*. *Security* lighting is intended to protect people, property, and vital infrastructure from criminal and terroristic activities. Lighting for *safety* is intended to provide secure working conditions, secure passage, and identification of hazards or obstructions. This document addresses security illumination but does not give advice on technical construction practices. The objective is to provide guidance for designing security lighting systems for new facilities and for evaluation and retrofitting of existing facilities and systems in response to known or perceived threats. This publication is for the use of property owners and managers, crime prevention specialists, law enforcement and security professionals, risk managers, lighting specifiers, contractors, homeowners, and those responsible for the protection of critical infrastructure who are concerned about security and the detection and prevention of crime and terrorism.

2.2 What is *Crime*?

The classical definition of *crime*[10] used in common law involves violations of established written criminal statutes published by a government. (For more information on crime, categories of crime, and foreseeability of crime, refer to **Annex C**.)

In this Guide, crime, its prevention, and the application of lighting to help in the efforts to minimize criminal activity are considered in a less technical manner

to increase the document's accessibility. Lighting designers, architects and other professionals may also wish to consult more-technical design publications as to how these guidelines can best be implemented. Each site will of course present its own challenges, and the IES offers a wide range of technical support tools to assist in these inquiries.

This publication contains material useful in determining when crime is an issue for a facility and therefore in need of specific security lighting consideration. It also provides discussion of basic security principles; crime prevention concepts; light level criteria for a variety of applications; a protocol for evaluating current lighting levels; a security survey and crime search methodology; and other recommendations. Suggestions are given for exterior and interior security lighting practices for the reasonable protection of persons and property. This document encourages the concept of *best security practice*, which also takes into account the following design issues for lighting:

- Economics, including installation, maintenance, and lifecycle costs
- Energy conservation and minimizing maintenance requirements
- Environmental issues such as light pollution, light trespass, and the adverse effects of light on animals and plants
- Local community needs, practices, and standards
- Protection of national critical infrastructure and key resources

Minimum guidelines for the secure movement of persons and equipment and for performing specific tasks can be found in other IES publications.

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

- Facilitate the visual ability of those performing security or enforcement functions
- Provide a clear view of an area from a distance, and enable anyone moving in or immediately around it to be easily seen and recognized
- Remove potential hiding places
- Permit facial identification at a distance of at least 9.1 m (30 ft), and create the perception that those in the area are identifiable
- Complement or enable other security devices
- Through fear of detection, deter persons from committing crimes or terroristic acts
- Aid in the apprehension of criminals, combatants, and terroristic suspects

2.3 Measurements and Criteria Used in This Guide

The primary measurement references throughout this publication use Système International (SI, or metric) units, with United States Customary System (USCS, formerly called English or Imperial) equivalent units immediately following in parentheses. For example, 1.5 meters and its USCS equivalent of 5 feet are displayed as *1.5 m (5.0 ft)*, while 108 lux and its footcandle equivalent are displayed as *108 lx (10 fc)*. These and other conversions are rounded to the nearest one-tenth and are approximate, but are considered sufficiently accurate in this context. For more detailed and accurate definitions, refer to ANSI/ IES RP-16-10, *Nomenclature and Definitions for Illuminating Engineering*, and *The Lighting Handbook*, 10th ed. (IES 2011). (Note: *The Lighting Handbook*, 10th ed., states that a lux-footcandle conversion of 10 lux to 1 footcandle is acceptable unless specifically noted otherwise. In this Guide, the conversion used is 10.76 lux = 1 footcandle.)

3.0 UNDERSTANDING "WHEN SECURITY IS AN ISSUE"

In considering whether to implement the recommendations in this Guide, it is important to recognize that *security* is not always a particular concern for the lighting design. Not all properties, centers of activity, or gathering places require special consideration or enhanced security. It is not acceptable to merely say or accept without reason that . . . *security is always an issue*. Rather, it is critical for those responsible for risk management and crime prevention to perform due diligence[11] to determine what the actual risk is and plan countermeasures accordingly. Clarification and tools for performing due diligence are provided throughout this document. Law enforcement, security staff, designers, management professionals, and facility owners should consider *security an issue* when one or more of the following conditions exist or can be expected to exist:

- The persons and/or property being secured present a desirable target to would-be criminals or terrorists.

- There are especially vulnerable members of society on the property, such as high-profile leaders, the elderly, children, or the physically or mentally challenged.

- The property is a critical security or defense infrastructure, such as key government facilities, bridges, airports, checkpoints, and border installations, as determined by emergency planners.

- The property has a history of relevant crime or significant increases in relevant crime.

- Relevant crime in the surrounding area is high in comparison with other adjoining neighborhoods.

- Results of a physical security survey or threat analysis indicate a meaningful threat to security.

- Conditions have changed, exposing persons to new security hazards or increased risk. This includes changes to adjacent properties (e.g., re-lighting) that make the subject property look poorly lighted or otherwise more vulnerable to attack.

- There are obvious physical signs of destructive behavior near or on the property, such as graffiti, broken windows, trash buildup, gang activity, vagrants, trespassing, or loitering.

- There are recurring reasonable resident or customer complaints or concerns about security or fear of crime.

- The property is a high profile or troublesome enterprise or activity, such as a bar, nightclub, gambling hall, or other potential high-activity gathering spot.

- It is a restricted-access area, such as found in some industrial or government infrastructures.

When it is determined that *security is an issue*, reasonable and necessary measures should be incorporated to enhance security and safety conditions at the site in response to the perceived threat. Each site will have its own set of unique conditions, but the following considerations serve as a starting point:

- Are there mission and objective statements regarding the security and safety of individuals, physical assets, and intellectual property, and are these current, well established, and in practice?

- Are there adequate post orders [job descriptions] for those tasked with carrying out security responsibilities and duties?

- Are policies and procedures for protection of assets up to date, and do these documents address relevant issues?

- Have tenants or those who occupy or use the space been advised of the potential threat level or hazard?

- Have tenants or those who occupy or use the space been advised of methods of deterrence and proper actions to take in the event of an incident?

- Have public and private law enforcement agencies been notified of the condition, and did this notification include a request for assistance or additional services?

- Has a security assessment, survey, or Crime Prevention Through Environmental Design (CPTED)[12] review been performed or updated since it was determined that *security is an issue*?

- Do changes in procedures, staffing levels, and/or security elements need to be addressed?

- Do illumination systems, light levels, uniformity ratios, glare control, and maintenance schedules meet recommended practices, standards, and code requirements?

If there is a history of violence against persons on a property, then it is likely that crime 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, damaged fences, or broken light fixtures or windows, a reasonable person could conclude that the site is not secure, and those responsible need to take action. Likewise, ongoing complaints from users of the property, changing conditions, or the introduction of a high-risk business into the area, may either indicate or elevate the risk of crime and could pose a threat to both property and persons. Of particular concern are high-risk businesses where the controller of the property has determined through research, prior events, or the nature of the business that users of the space are at increased risk after hours. The security professional and/or lighting designer should take note of this and plan accordingly. (See **Section 4.7 Risk Management and Quality Assurance** for more-detailed information.)

When operations are conducted at night or during instances of poor visibility, illumination levels may need to increase, both in quantity and in quality, to aid in the protection of persons and property, and light quality (color, glare, uniformity) may need to improve as well. An increase in the quantity of light alone is rarely sufficient. It is important to understand that increased light quantity does *not* equate to better lighting; the *quality* of the light is usually more important than the quantity. Increased glare from higher light levels does not mean better visual effectiveness, especially when security is an issue.

Conversely, if conditions improve, it is reasonable to reduce the level of security to a point commensurate with the perceived threat. In such cases, a test phase should be conducted and evaluated, with a defined set of achievement goals. A test period of six months to a year may be practical, preferably extending through both winter and summer, with monthly evaluation increments for comparison.

Good lighting alone cannot guarantee security. Where crime occurs in daylight hours, it will likely also occur at night. Good security lighting integrated into a balanced security plan, however, can play a critical role in reducing or displacing crime and can help make other security elements more effective.

4.0 BASIC PRINCIPLES OF SECURITY AND SECURITY LIGHTING

Security lighting is installed to help protect people and property from criminal and terroristic activities, and to create a perception of a reasonably secure environment. Throughout this publication we discuss planning, installations, and actions that are designed to deter both criminal and terroristic activities. In the context of deterrence, criminal and terroristic acts are distinguished only by how the would-be offenders are managed if caught or captured. If the alleged offender is prosecuted in the criminal courts, it is a *criminal* act. If the suspect is captured operating in a military or paramilitary group, or in a foreign country, the person may be classified as an *enemy combatant* or *terrorist*. When applying the principles of security lighting, the final classification of the offender is a negligible factor.

To understand the principles of *security lighting*, it is necessary to consider key security tenets.

4.1 Responsibility

In North America, the burden of security and safety is generally the responsibility of 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, making them a resource for the lighting professional in determining *whether crime is an issue* for a given property. Casual visitors, invitees, licensees, and 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 to influence the environment.

4.2 Anticipating the Threat

A helpful approach for 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 to increase the level of means or resources necessary for the criminal to attack the target and escape. Security lighting's principle effect on crime is to affect *behavior* of would-be criminals. In most IES documents, light is a tool to produce adequate visibility of a particular task. Security lighting may also increase visibility, but the main intended effect of security lighting is to change or improve behavior in the lighted environment. When opportunity is limited and a large amount of time and resources are required to complete a criminal act and escape, criminal motivation declines.

4.3 Time

Time is the criminal's enemy. The longer a criminal act takes in planning, execution, and escape, the more likely it is that the criminal will be captured. Police officers and crime prevention specialists know that most common criminals are both opportunistic and lazy. They will often choose a property that requires the least amount of stealth, equipment, and planning.

4.4 Target Hardening

Coordinated security elements make the target harder to attack. 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 from task to task but often include management controls, perimeter protection, 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.

4.5 Fight or Flight

The basic decision made by persons when threatened is often called *fight or flight*. In other words, "Do I defend myself or try to evade that which threatens me?" Fleeing danger is not always an option, due to circumstances. *Fight* may be the physical act of defense or a call for help. For police, security officers, or intended victim, it may mean some form of physical defense for serious threats. *Flight*, on the other hand, may mean moving to a secure place or getting out of the way of a presumed threat. Properly installed and maintained lighting can play an important role in helping people make this basic decision in an accurate and timely manner.

4.6 Security Elements

Security elements can be *active* or *passive* deterrents.

Passive elements include those security features that, by themselves, 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, open areas, warning signs, safes, and exterior or interior illumination systems.

Active elements have the capacity to interact with persons or generate a response to a criminal's actions. The most common *active* deterrent is a patrol officer. The effectiveness and response of uniformed individuals making patrol rounds is often hard to predict, and may thereby cause a would-be criminal to reconsider. Other widely used *active* technologies include interactive alarm systems, card or coded entry devices, closed-circuit television [CCTV], metal detectors, and trained animals such as dogs.

Security lighting is often passive in application; however, motion-sensor controlled lighting is one common exception to this rule. By applying both passive and active elements to some security lighting applications, the designer can create fear in the mind of the would-be criminal for being observed or detected.

4.7 Risk Management and Quality Assurance

While it is possible to measure light levels precisely through instrumentation, *risk* and *security* are relative terms and cannot be measured on an absolute scale. Circumstances fall somewhere on a continuum between absolute risk and absolute security. There are few situations where property or risk managers can predict with absolute certainty either a negative or a positive outcome. What may be an acceptable risk to one property owner or manager may be unacceptable to another. This determination is often influenced as much by intuitive perception as by systematic analysis. Other factors, including business clientele, management philosophy, and legal environment, are also important considerations in determining whether circumstances are risky or secure. Unfortunately, we too often make that determination in hindsight after adverse events occur.

Risk is an estimate of the potential loss of an asset based on the probability and magnitude of undesirable events. *Risk* encompasses a combination of factors, including conditions and behaviors that affect threat frequency and potential adverse results. *Risk assessment* is the process of comparing current hazards, threats, vulnerabilities and control, and determining whether the current level of risk is acceptable. Cost-effective business decisions regarding appropriate investment in countermeasures can only be reached based on an objective analysis of the circumstances. Ignoring or under-investing in security may lead to unacceptable results, while over-investing may divert funds from other important initiatives.

Property managers and business owners have a duty to implement reasonable security countermeasures to protect customers, visitors, and employees from criminal activity. The reasonableness of countermeasures is related to the nature and use of the property and to the criminal activity within the surrounding area. The decision to implement countermeasures such as improved lighting should be made with performance expectations in mind. Lighting is one of the few security countermeasures for which an objective guideline is available based upon the type of facility, use, or operation. The performance expectations for other countermeasures are often subjective, inconsistent, and based largely upon the property manager's perception. When

evaluating risk, fiscal considerations will come into play at some point. For the management team in charge of the facility, this becomes a particularly heavy burden when the protection of human life is the prime consideration. High-impact exposure professionals, such as those involved after an oil spill or terrorist attack, as well as risk management and loss prevention professionals should be at the core of the decision-making process for every project.[63] In addition to reducing risk, security countermeasures also result in improved operational efficiencies. This is especially true when long-lived energy efficient light sources are used. The ultimate goal is to identify a few inexpensive countermeasures that will simultaneously reduce many risk factors and result in a positive return on investment for the property owner.

A structured assessment facilitates developing a rational plan that will make the best use of financial and human resources. Risk assessments should demonstrate that the property manager adequately evaluated the threat of criminal activity to the operation. Property and risk managers should identify the most serious realistic threats as the basis for evaluation, and mitigation efforts should be implemented to reduce risk factors related to those threats. A process for determining, quantifying, and documenting risk factors and the ability to explain the decisions made to reach optimum investment are critical. The level of rigor or complexity will vary depending on the scope and type of operation. The mere absence of a documented risk assessment may be used as evidence of negligence in a civil lawsuit resulting from an adverse incident. It is important for the property manager to determine that implementing certain procedures or modifications would reduce one or more risk factors. It would not be reasonable to expect property managers to invest in countermeasures that would not significantly reduce risk factors.

Risk assessment depends upon data that, while not complex, may be difficult to characterize. Criminal activity data available from various sources is often the basis for establishing whether crimes taking place on a property were foreseeable; the property owner could be found negligent if criminal activity was foreseeable and the property owner failed to implement reasonable countermeasures. Law enforcement and crime prevention resources differ significantly from community to community. Some have elaborate Computer Aided Dispatch systems and are cooperative in sharing call reports and complaints on a property-specific basis, while other agencies have scant resources. Even when available, official crime statistic reports may not reflect the true picture. Criminal activity may be unreported to law enforcement, or there may be political or economic pressures on law enforcement agencies to report less criminal activity than what actually occurs. Depending on the agency command structure, there may be crime prevention officers available to discuss criminal activity. It may be prudent for property managers to meet with patrol officers assigned to their area, preferably those assigned to the area at night, when security lighting may be an issue. A risk assessment should therefore include not only official crime reports but also discussions with law enforcement officers and adjacent neighbors to understand the nature of crime in the area.

Security is an issue, and future criminal activity may be foreseeable, if the property is a type often associated with criminal activity or located in an area with past criminal activity. Reasonable countermeasures for at-risk properties are typically more stringent than for properties where security historically has not been an issue. One often-overlooked issue is defining the property boundary lines where the property manager's responsibility begins and ends. The risk assessment should include a thorough understanding of the exact boundaries and the responsible party for security, including maintaining the security lighting system. (For more information on conducting a physical security survey, refer to **Annex A**.)

In cases involving leased or rented space, the responsibility and ultimate liability for maintaining security countermeasures can be modified within the terms of the property lease agreement. It is important for all parties involved to understand their responsibilities regarding security issues. Leases and insurance contracts should define responsible parties in order to ensure that liability coverage is in place.

A quality assurance program that evaluates system performance is very important. In the case of security lighting, measurements should initially be taken to ensure that the lighting meets predetermined performance criteria, and then taken periodically thereafter to confirm that performance criteria continue to be satisfied. Risk-assessment evolutions should occur on a predetermined cycle in order to determine whether countermeasures are effective in lowering the risk of criminal activity. Without an initial benchmark and periodic quality control assessments, it is difficult to verify whether crime prevention efforts are meeting objectives. Lighting tends to deteriorate over time due to a number of reasons explained later in this guideline. Failure to maintain the security lighting system could allow risk factors to increase, leading to a higher potential for adverse incidents and liability

exposure. If deficiencies in the lighting occur, the individual or entity responsible should be notified in writing, and documentation of repairs should be made. Documentation such as work orders, work completion records, and follow-up records will make it more difficult to establish that the property manager was negligent in maintaining the property.

4.8 Planning Security Lighting Applications

To achieve the objectives of security lighting, attention should be given to the amount and uniformity of light, shadowing from obstructions, surface reflectance and contrast, glare, light source color characteristics, interaction with electronic surveillance systems, and the effects on the surrounding area.

Lighting can be a major deterrent to criminal acts during hours of decreased daylight. Properly installed security lighting can be cost effective, easy to operate, and dependable. Rational criminals choose to avoid detection and, given a choice, will avoid lighted areas at night. The extent and type of lighting used as part of a balanced security system is determined by several different factors, as explained in **Sections 4.8.1** through **4.8.4**.

4.8.1 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 prior to altering lighting or other security elements at the site. Such an analysis is usually performed annually, and the security profile of the property and adjacent properties is adjusted accordingly. If an unoccupied site is being developed, 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 becomes a reality, it may be possible to reallocate valuable resources. On a property where a history of relevant crime exists, *security is an issue*. Lighting designers should explicitly exclude this scope of work from their contracts or seek professional assistance from a security lighting specialist. (For more information on the analysis of crime, and what crime is relevant, see **Annex C**.)

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

4.8.3 Degree of Obstruction. Landscape design, fences and other obstructions, and building configurations should not retard detection and identification of unauthorized persons on the premises. The lighting should be designed to minimize areas of relative darkness so that the activities of people allowed on the site can be observed.

4.8.4 Ambient Luminance (Brightness) of the Surrounding Area. Security elements on a given site can have environmental impacts or affect the security elements on adjoining sites. If light levels are lower or not as uniform on one site compared to an adjoining site, the more poorly illuminated site may be more attractive to criminal activity. Based on centuries of experience, it is well understood among law enforcement professionals that criminals capable of making rational choices look for the weakest link or the darkest area in order to improve their chances of success.

Stray light from a security installation can be referred to as *light trespass* by neighbors. There also can be possible safety effects on nearby roads and railroads due to stray light or over-lighting. When signal lights are in use to control traffic on roads, railroads, or rivers, or at sea, the lighting designer should take into consideration the hazards of disability glare. There can be environmental impacts on nocturnal animals, migratory birds, and nesting sea turtles. The design team needs to consult local lighting ordinances prior to beginning design work. Mounting height restrictions, source type, wattage limitations, shielding, and other local requirements need to be considered when starting the design. When local lighting ordinances and restrictions make it difficult to design lighting adequate to the security threat, seeking a variance to the code is recommended. (See **Annex E** for more information on municipal ordinances.)

5.0 VISIBILITY CONCERNS IN SECURITY APPLICATIONS

Fear of crime is elevated at night, when darkness compromises vision. Lighting enables the visual system and is thus critical to perceptions of security. For security purposes, the important lighting criteria are illuminance, uniformity, glare, color rendering, and shadows. The definitions and discussion in this guideline are simplified. For more-detailed definitions, the designer should refer to ANSI/IES RP-16-10, *Nomenclature and Definitions for Illuminating Engineering*, and *The Lighting Handbook*, 10th ed. (IES 2011).

5.1 Eye Adaptation

Our eyes are constantly adjusting to the light levels of our surroundings. The process of adaptation takes the visual system through three distinct operating states: photopic vision, mesopic vision, and scotopic vision, in order from bright to dark. Photopic vision occurs at luminances higher than approximately 3 candelas per square meter (cd/m²), which corresponds to an illuminance of approximately 27 lx (2.5 fc) in a concrete parking structure with an average reflectance of approximately 35 percent (*Luminance* is the amount of light coming from a surface, and it is measured in candelas per square meter [cd/m²].) Scotopic vision occurs at luminances less than approximately 0.001 cd/m², which under these same assumed conditions corresponds to an illuminance of approximately 0.009 lx (0.0008 fc). Mesopic vision is in between the photopic and scotopic states. (For additional details, please refer to *The Lighting Handbook*, 10th ed. [IES 2011]).

5.2 The Effect of Light Source Color Characteristics on Visibility

The relative sensitivity of the human eye to any given wavelength depends on the amount of energy present at all wavelengths in the visible portion of the electromagnetic spectrum (between 380 and 760 nanometers [nm]; see **Figure 2**). The relative spectral sensitivities of the eye at the two extremes of visual adaptation—photopic and scotopic are illustrated in **Figure 3**. Photopic visual adaptation (peak sensitivity at 555 nm) occurs at medium and high light levels, typical with interior lighting and with exteriors during the day, when the eye uses only the cones to process light. Scotopic visual adaptation

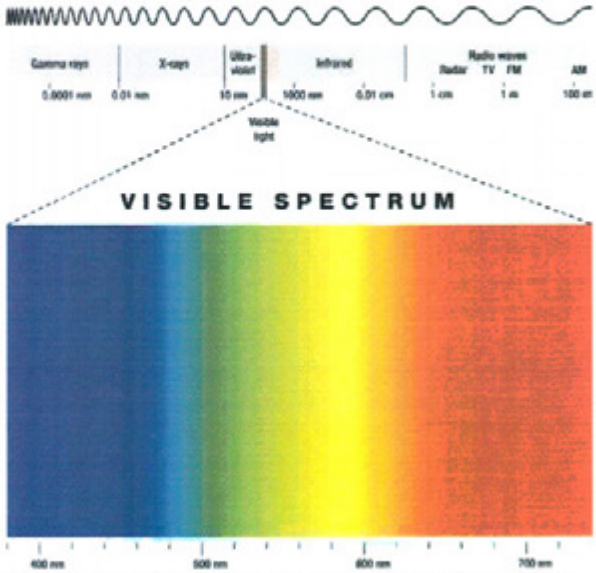


Figure 2. Electromagnetic spectrum. (©iStockphoto)

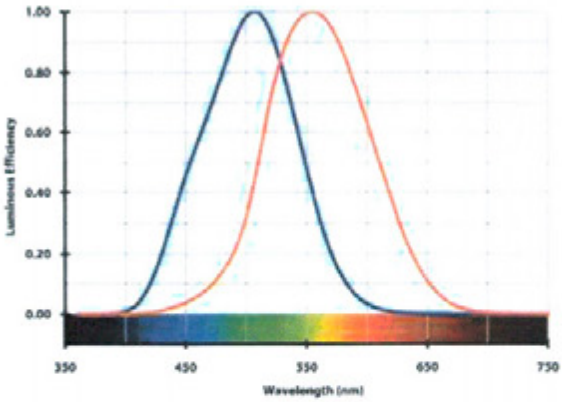


Figure 3. CIE Luminous Efficiency Functions of Wavelength. (©IES, *The Lighting Handbook*, 10th ed., 2011)

(peak sensitivity at 507 nm) occurs at very low light levels, roughly corresponding to starlight, when the eye uses only the rods to process light.

Exterior lighting systems typically produce light levels somewhere in between, resulting in mesopic visual adaptation, whereby a combination of both cones and rods supports vision. However, adaptation is usually much closer to photopic than to scotopic, and the effect of mesopic multipliers (see **Section 5.2.2**) on photopic calculations may be negligible in many applications. (For more detail regarding these terms and their relevance to any given lighting project, refer to IES TM-12-12, *Spectral Effects of Lighting on Visual Performance at Mesopic Lighting Levels*.)

5.2.1 Mesopic Factors. The term *mesopic factors* refers to a characteristic of light sources, where those with high scotopic/photopic (S/P) ratios can be adjusted numerically to indicate increased visibility represented by higher illuminance values. These mesopic factors are a function of the interaction of the S/P ratios of the light source and the adaptation luminance of the viewer. Different parts of the retina adapt to the luminance of the corresponding portion of the visual field. The factor (or multiplier) is inversely proportional to the adaptation luminance and becomes unity at photopic adaptation levels. Furthermore, mesopic factors do not affect the average illuminance in a linear manner; the lowest illuminance in the field of view is most affected, and the point of maximum illuminance may not be affected at all. Because of the contributions of vehicle headlamps, the IES Roadway Lighting Committee does not recommend use of these factors for applications where vehicle speeds are above 40 kilometers per hour (25 miles per hour). Multipliers for adjusting recommended photopic illuminance target values are provided graphically in **Figure 4**. Additionally, the graph in **Figure 5**

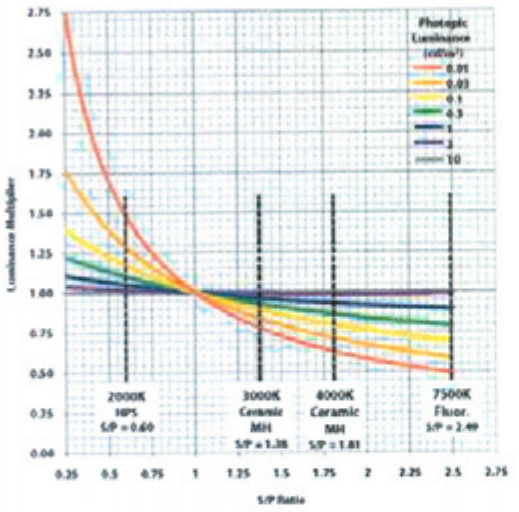


Figure 4. Mesopic multipliers, used to adjust recommended photopic illuminance target values for mesopic adaptations. (©Illuminating Engineering Society, *The Lighting Handbook*, 10th ed., 2011)

provides details regarding frequency of detection. (For more information on mesopic factors, refer to *The Lighting Handbook*, 10th ed. (IES 2011), Section 2.4.3 Mesopic Vision, and IES TM-12-12, *Spectral Effects of Lighting on Visual Performance at Mesopic Lighting Levels*.)

5.2.2 Color Rendering Capability. In addition to determining the luminous efficacy of a light source, color characteristics are important in security lighting applications for identification purposes. For example, although the luminous efficacy of low pressure sodium (LPS) is higher than that of most other light sources, the light produced is monochromatic yellow. As a result, only objects having at least moderate reflectance at the LPS peak wavelength, such as yellows and light neutrals, can be clearly visible under LPS light; all other objects appear dim and muted in color. In such conditions, identification of suspects based on hair color, skin tone, clothing color, or vehicle color is difficult. Light source color rendering capability is equally as important as lumens, footcandles, and other light level metrics. (For guidance with the evaluation of light source color characteristics, refer to **Section 7.1**.)

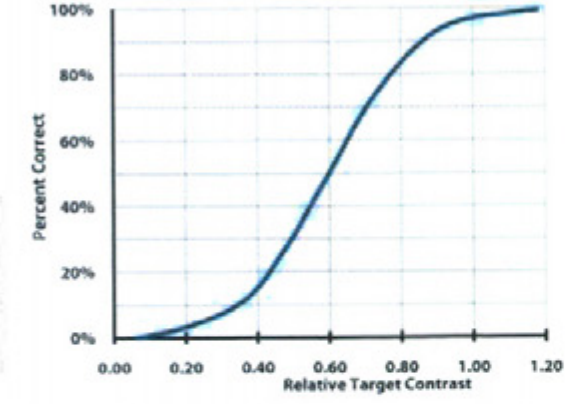


Figure 5. Frequency of Detection. As luminance contrast is increased, the number of times a luminous disc is correctly detected, relative to the number of times it is presented, increases. By convention, a performance of 50 percent is threshold, and the contrast that produces the condition is threshold contrast. (©Illuminating Engineering Society, *The Lighting Handbook*, 10th ed., 2011)

5.3 Age Factors

The human eye has highest acuity, contrast sensitivity, and overall light sensitivity when young. Older eyes generally need larger visual task size, better contrast of task against background, and/or higher illumination as they age (see **Figure 6**). For purposes of simplicity, and averaging of these factors, IES has adopted illuminance recommendations for three age groups: under 25 years old, 25 to 65 years, and over 65 years.[45] In 2011, the average lifespan in the US was 77.9 years, with many people working and actively engaged beyond 65 years of age. As a practical matter, few security lighting applications (see **Section 8**) can exclude the consideration of over-65 users at a given facility. Designers should be particularly concerned about loss of visual acuity for sites such as hospitals, multifamily residences, elderly care facilities, parks, and shopping facilities.

5.4 Illuminance

Only a portion of the light output from a luminaire, measured in lumens, actually reaches the target surface(s). Illuminance is the density of light falling onto a surface. The primary units of measurement

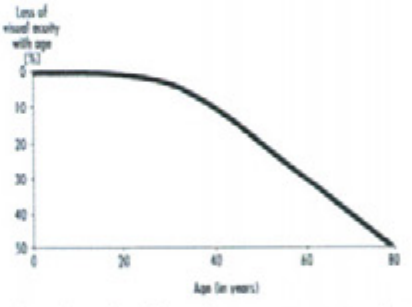


Figure 6. As the visual system ages, a number of changes in its structure and capabilities occur. These include loss of focusing power, reduction in lens transparency, lens yellowing, and decrease in maximum pupil size.[3]

for illuminance are lux (lx, lumens per square meter) and footcandles (fc, lumens per square foot). Lighting levels are measured using an illuminance meter (often referred to as a light meter, footcandle meter, or lux meter). Illuminance criteria for a variety of applications where security is an issue are located in **Section 8.2.**

5.4.1 Horizontal Illuminance. Most measurements or discussions about security lighting refer to horizontal illuminance. These measurements are taken with the detector oriented such that the white dome or disc of the detector faces straight upward. Unless otherwise stated, horizontal illuminance is measured at ground level. It should be noted that many seemingly level surfaces, such as roads, parking lots, and landscaped areas, are not necessarily level and may contain slight grades for drainage. As a practical matter, however, these surfaces are often considered horizontal unless the grade is particularly steep. (For more information on horizontal illuminance and taking measurements, refer to **Annex B.**)

5.4.2 Vertical Illuminance. Lighting that allows identification of faces is an important aspect of security lighting. Security lighting design should provide enough quality lighting (of adequate quantity) to positively identify a face as familiar or unfamiliar, and body language as either threatening or nonthreatening, at a distance of not less than 9.1 m (30 ft) from the viewer.

Vertical illuminance is usually measured with the detector 1.5 m (5.0 ft) above ground level, oriented such that the white dome or disc faces the horizon. Vertical lighting measurements are usually taken in several directions representative of typical facial orientation and observation, and these values should not be averaged. Some vertical illuminance measurements may not be meaningful, such as those taken facing outward from a property line (oriented away from any luminaires located on the property) or directly under a luminaire.

If the background illuminances (behind the face) are more than four times the illuminance on the face, the image will likely be in silhouette and the face unrecognizable. In large, unobstructed areas, the horizontal plane can be considered the background; the actual directional background may be walls, sky domes, or other surfaces. For example, if the average horizontal illuminance in an area is 108 lx (10 fc), vertical illuminance at the face should be no less than 27 lx (2.5 fc) at any point in the area in order to enable facial recognition. (For more information on taking vertical lighting measurements, see **Annex B.**)

5.4.3 Uniformity of Horizontal Illuminance. *Uniformity* refers to the evenness of the illuminance. The most common uniformity ratios are average-to-minimum and maximum-to-minimum, generally referring to horizontal illuminance. Shadows reduce uniformity of lighting and impair security. When the lighting contrast is great (thereby creating strong shadows), there could be a reduced perception of security. In addition, shadows make it difficult for users of property and equipment to maintain quality surveillance, by creating areas where would-be perpetrators can hide. Good lighting design can eliminate shadows caused by fixed obstructions or by gaps in lighting system coverage. Shadows caused by moving objects, such as intermittently parked vehicles, present greater challenges but need to be considered in the design. See **Figure 7**, for example.

Uniformity increases the perception of security and helps to remove potential hiding places (e.g., see **Figure 8**). *When security is an issue*, the horizontal illuminance uniformity ratio should not exceed 6:1 average-to-minimum, and some applications may require even better uniformity, as per **Section 8.2**. When determining uniformity ratios in parking lots, the areas evaluated should be temporarily clear of vehicles.

5.5 Glare

A functional definition of glare is, *a ratio of foreground intensity to background intensity, taking the colors and brightness of each into consideration.* The two types of glare of greatest relevance for personnel are discomfort glare and disability glare. Discomfort glare merits consideration since it can cause visual fatigue for personnel. Disability glare is light scattering in the eye, resulting in a "veil" of light, which reduces contrast (and visibility), therefore making it easily quantified.

Figure 7. Uniform lighting in areas where pedestrians interact with moving vehicles may provide better visibility. (Provided courtesy of Magnaray® International Division)

Figure 8. Uniformly spaced poles and luminaires provide lighting at each crane assembly area in this cargo terminal. (Photo courtesy of Holophane)

Glare, when properly controlled, can actually be harnessed for use in some security lighting applications by concealing targets behind outward-directed glare sources, which simultaneously reveal and hinder intruders.

5.6 Light Pollution

The term *light pollution* covers all adverse off-site effects of an exterior lighting system, including light trespass and sky glow. Lighting pollution from exterior lighting systems should be minimized to the greatest extent practical, to satisfy any applicable local ordinances.

5.6.1 Light Trespass. Light trespass, also known as spill light, is light that strays onto adjacent property. This can cause nuisance glare even when resulting illuminance levels are low. There are several methods used to control light trespass: reducing luminaire mounting height, increasing pole setback from property lines, and/or using optical designs that restrict high-angle luminous intensity. Conversely, spill light received from luminaires on an adjoining property generally should not be relied upon unless proper maintenance of such nearby systems can be ensured.

5.6.2 Sky Glow. Although not specifically a security lighting issue, *sky glow* considerations will be involved in overall facility design based on good practices and possibly local ordinances. Light emitted directly above the horizontal, reflected from the ground, or reflected from objects on the ground contributes to sky glow, which impedes views of the nighttime sky. Uplight may be greatly reduced by specifying luminaires emitting zero or minimal direct uplight, by producing light levels no higher than actually needed, and by reducing light levels during any periods of reduced need.

5.6.3 Community Responsive Design. In addition to meeting the security demands of the protected area, security lighting needs to be appropriate in relationship to the surrounding community and environment. To the extent practical, security lighting

designs should minimize light trespass and sky glow. In addition to surveying existing neighborhood lighting applications, designers should consult any local lighting ordinances. (For more on local government codes and requirements, Lighting Zones, and the *Joint IDA/IES Model Lighting Ordinance [MLO]*, see **Annex F**.)

6.0 SECURITY ZONES

It is helpful to consider the various functional areas and operational needs of the facility, when assessing an existing site or planning a risk containment program for a developing design. The design team should consider such factors as times of use, movement of persons within the facility, physical and staff resources, and vulnerable or potentially "hot" spots.

Security zones are established *when security is an issue* and there is a need to provide security protection for persons, property, or critical infrastructure. Security zones are not exterior Lighting Zones (LZs), as defined in the *Model Lighting Ordinance*. Whereas exterior LZs are derived from the surrounding site development, security zones are designed around vulnerabilities and target-hardening practices. The project will typically contain various security zones within the area project. The security zone lighting plan should accommodate variations in terrain, climate, obstructions, and integration and support to other security resources, while being mindful of who and/or what is being protected.

When planning or evaluating security lighting, designers will find it useful to divide the facility into zones such as perimeter, pedestrian, building, vehicle, storage, equipment, and restricted areas. During the planning process, designers may title and plan for various other zones for evaluation of specific security lighting, as the project requires. Each zone may require consideration of a differing set of vulnerability and response factors.

6.1 Perimeter Zone

Lighting to enhance perimeter fencing or open areas may be installed for either esthetic or security reasons. *When security is an issue,* the perimeter illumination can perform any or all of the following functions: enhance observation (passive deterrent); enhance the ability of walking or stationary security personnel (active deterrent); and support the effectiveness of closed circuit television (CCTV) monitors. In situations where exterior perimeter protection is a critical element of the overall security design, designers should consider the recommendations in **Section 8.2.2**.

6.2 Pedestrian and Vehicle Movement Zone

Pedestrian and vehicle movement areas require increased visibility and different quality considerations than other zones. In parking lots, where both people and vehicle movements interact, pole mounted light sources are the more common solution. Relatively low fixture mounting heights require reduced pole spacing (more poles) and/or increased luminous intensity at the higher angles approaching 90 degrees from nadir.[14] Floodlights aimed at higher angles can create direct glare and light trespass, and therefore should be carefully placed and oriented. Paths for pedestrian traffic only require fixtures on a pedestrian scale, for delineating paths and connecting the site with buildings.

Pedestrian path zones define foot traffic patterns and establish a sense of welcome and security. Luminaires that support path lighting are typically bollards or landscape-style luminaires. Bollards are typically at a height of 0.6 to 1.1 m (24 to 42 in.), with spacing based on luminaire photometry and applicable criteria. Due to their location in the visual field, these luminaires typically cannot produce adequate facial illumination without also producing glare. Therefore, a different lighting approach or supplemental illumination from pole- or wall-mounted luminaires may be preferred. Paths are particularly important in health care facilities, with 24-hour operations assisting in guiding people throughout the site.

6.3 Building Zone

Lighting the building façade can be a security lighting technique, reinforcing general perceptions of environmental brightness. For optimal placement and spacing of lighting fixtures, luminaire photometry should be reviewed. When using security lighting techniques, consideration should be taken during the design to ensure that light levels and source color quality and glare are adequate for facial recognition and optimized for security cameras to obtain a clear, accurate video.

Building security design should include consideration of access through the roof, as this is a common point of entry due to the general lack of security for rooftops and the fact that visibility of the roof is difficult from the ground. In those instances where the roof is used as a helicopter landing pad or there is a high degree of risk, there should be a security and safety lighting scheme to match the tasks

and perceived vulnerabilities. In such instances, redundant sensor-controlled lights and entry alarms can increase energy savings.

6.4 Vehicle, Storage, and Equipment Zones

Large storage yards, especially those containing items supporting critical infrastructure, or bonded or valuable cargo, can be especially vexing for the designer to apply acceptable security lighting techniques. Complete removal of shadows and dark spots is difficult or unrealistic in areas where items are stored close together. Solutions commonly involve elevated placement of luminaires and closer spacing, along with the use of linear-profile luminaires, (e.g., linear LED or fluorescent) to decrease shadows.

6.5 Restricted Zones

There may be critical areas within the complex where access is restricted or surveillance of the area is more predominant. These zones may be a whole structure or an interior portion of a building. The restricted area will typically have its own perimeter and controlled access point. The first consideration in planning security for restricted zones is whether to highlight or blend in. For example, restricted areas within an office building may simply have a room number on a reinforced entry door and a card reader for access. In these cases, additional specific security lighting may not be needed or advisable. Other operational areas may have a guard station, signage indicating the nature of the occupied space, or other security features that may require enhanced lighting.

7.0 LIGHTING EQUIPMENT

Proper selection and application of lighting equipment makes a difference between a security lighting installation that deters crime and one that actually aids criminals. Careful selection and appropriate placement and orientation of lighting fixtures will ensure that the lighting levels are appropriate with limited glare, minimal energy use, and reliable operation. A well-designed lighting system will not detract from daytime or nighttime esthetics. It is important, however, not to judge decorative luminaires solely on their daytime appearance. Pole-mounted "lantern" style luminaires (see **Figure 9**, for example) can be equally attractive during the day or night. Care should always be exercised when choosing decorative luminaires, which may produce glare and light trespass.

Figure 9. Pole-mounted "lantern" style luminaires used in an urban setting, creating an upscale, turn-of-the-century theme for this street, home to numerous upscale businesses and stores.
(Photo courtesy of OSS – Law Enforcement Advisors®)

Of greater significance are nighttime performance issues such as light distribution, color rendering, control of glare, and light trespass. Since glare and distribution can be critical factors in security lighting applications, the BUG rating for the specific luminaire (see **Figure 10**) should be consulted to aid in proper luminaire selection for each application.

The proper installation and maintenance of lighting fixtures is crucial and, if exposed to weather, the luminaires should have Ingress Protection (IP)[66] ratings suitable to the environment, for protection from solid objects, liquids (usually water), and mechanical impacts. Most outdoor lighting should be IP54, and for vandal-resistant applications fixtures should be IP65 or higher. Units with higher IP ratings (IP65+) usually cost more but are needed where high-pressure wash-downs occur frequently and where units are required to be dustproof. For a listing of qualifying laboratories in the United States, refer to the Occupational Safety and Health Administration (OSHA) website: http://www.osha.gov/dts/otpca/nrtl/.

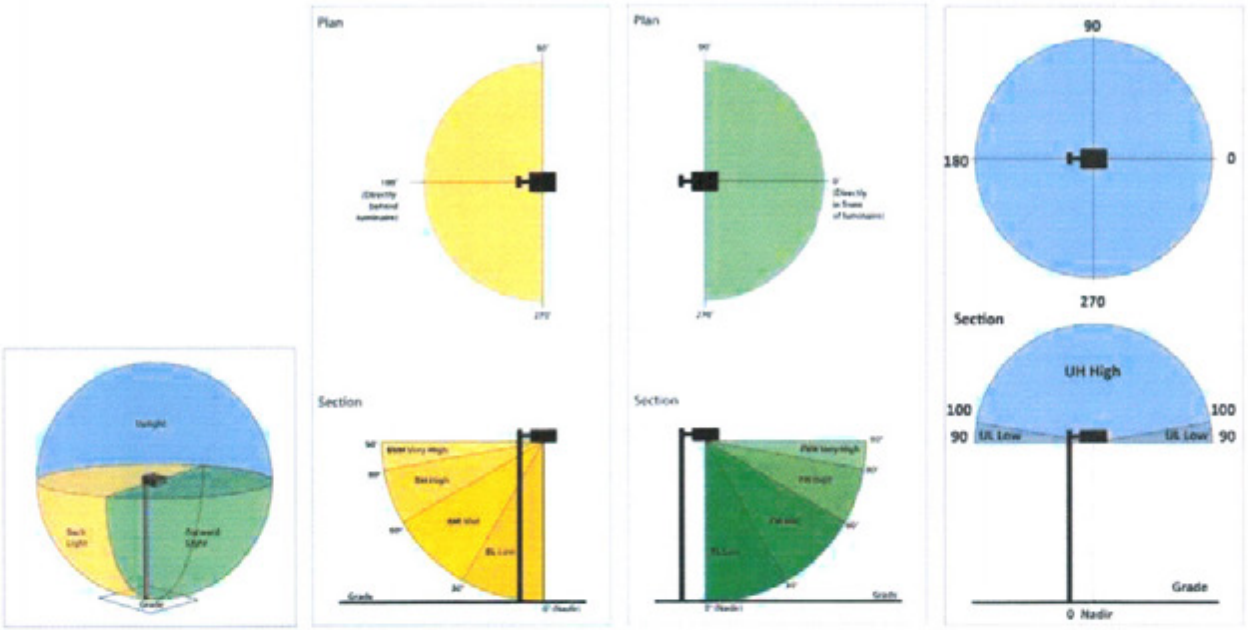


Figure 10. The Luminaire Classification System for Outdoor Luminaires (LCS) uses Backlight, Uplight, and Glare (BUG) ratings to describe light distribution and optical control of outdoor luminaires by the number of lumens in particular zones. (©IES TM-15-11, *Luminaire Classification System for Outdoor Luminaires*)

Depending on the needs of the application, **Table 1** and **2** can be used as a preliminary guide for light source selection, but they are not intended to be a comprehensive list of all light sources. Light source manufacturers' data should be consulted for more specific and comprehensive information. Performance metrics are discussed in the sections that follow.

7.1 Light Source Color

Similar to the figures in **Section 5.2** illustrating the sensitivity of the human eye to different wavelengths, the color characteristics of a light source can be calculated using its spectral power distribution (SPD), which shows the relative amounts of energy at various wavelengths across the visible portion of the spectrum. The SPD of any particular light source should be available from the manufacturer.

To facilitate product evaluation and comparisons, the complex SPD data is used to calculate simpler and more readily understood metrics such as correlated color temperature (CCT) and color rendering index (CRI).

7.1.1 Correlated Color Temperature. Light sources used for illumination can be divided into three categories of color description: "*warm*" (orange-white), "neutral" (white), and "*cool*" (bluish-white) in appearance. Correlated color temperature (CCT) is the metric used to characterize this color characteristic, using the thermodynamic temperature unit, the kelvin (K). The value is determined by finding the temperature at which a theoretical black body radiator (similar to the tungsten filament in a common incandescent light bulb) must be heated to emit light of a color which best corresponds (correlates) to the color of the light source. Most "warm" appearance light sources have nominal CCT at or below 3000K, "cool" appearance light sources typically have nominal CCT at or above 4000K, and neutral white light sources occupy the region between (see **Figure 11**).

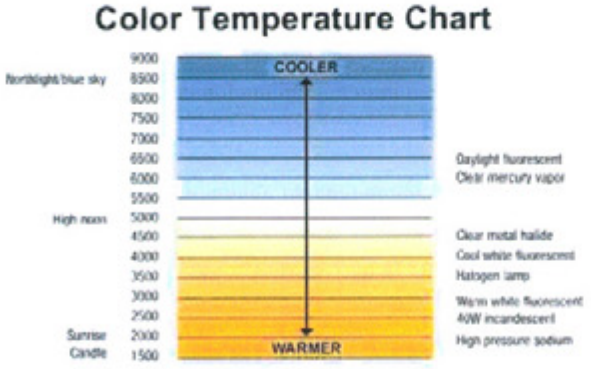


Figure 11. The correlated color temperature scale. The color appearance of various light sources defined in terms of correlated color temperature (CCT), measured in kelvins (K). (Illustration courtesy of Osram Sylvania.)

Table 1. Generalized Characteristics of Various Light Sources. (©IES, DG-10-12, *Choosing Light Sources for General Lighting*, and *The Lighting Handbook*, 10th Edition, 2011)

Source	Efficacy, Lm/W	Average Rated Life, Hours	Color Rendering, CRI	CCT (K) Range	SPD Effects, Colors Enhanced	SPD Effects, Colors Dulled	Starting, Warm-up Time (minutes)	Dimming Range (% Light Output)
Incandescent	up to 20	750–5,000	97–100	2500–2800	red, orange, yellow	violet, blue	0	100–0
Halogen	up to 22	up to 6,000	98–100	2650–3150	red, orange, yellow	violet, blue	0	100–0
Light Emitting Diode (LED)	80+ *	up to 50,000	80+ *	2700–8000	all *	varies**	0	100–0
Organic LED (OLED)	TBD	TBD	TBD	variable	TBD	TBD	0	TBD
Linear Fluorescent	65–104	up to 60,000	70–90 (tri-phosphor)	2700–8000	all	none	0	100–1
Compact Fluorescent	46–87	6000 - 15,000	82–92	2700–6500	all	none	0	100–1
Induction Fluorescent	70–90	50,000 - 100,000	80	2700–6500	all	none	0	100–1
Mercury Vapor	40–60	up to 24,000+	15–50	3200–6800	violet, blue, green	red	<10	100–10
High Pressure Sodium	70–140	up to 40,000	22–30	1900–2100	yellow	violet, blue, red	<5	100–50
Quartz Metal Halide	64–110	up to 20,000	62–75	3200–4500	violet, blue, green	red	<10	100–50
Ceramic Metal Halide	80–120	up to 30,000	Up to 95	2800–4500	all	none	<10	100–50
Low Pressure Sodium	up to 180	14,000-18,000	-44 (negative 44)	1700	yellow	all but yellow	<10	N.A.

Table Notes:

* Phosphor-conversion white LEDs

** Combined-RGB LEDs

Table 2. Comparison of Various Light Source Characteristics
(©IES, DG-10-12, *Choosing Light Sources for General Lighting*)

SOURCE TYPE

Light Source Characteristic	High Pressure Sodium	Metal Halide (pulse-start)	Induction (electrodeless)	Fluorescent	Compact Fluorescent	Low Pressure Sodium	Light Emitting Diode (LED)
System Efficacy (Acceptable Performance per Watt)	moderate to high	moderate	moderate	moderate	moderate	moderate	high
Efficacy (Lumens/Watt)	high to very high	moderate to high	moderate	moderate to high	moderate	high to very high	high
Rated Life	long	moderate long	very long	long	long	moderate	long to very long
Lumen Maintenance	good	fair to good	fair	fair to good	good	good	good
Optical Control	good	good	poor	poor	fair	poor	very good
Color Rendition	poor to fair	good to very good	good	fair to very good	very good	poor	very good
Brightness	high to very high	high to very high	low	low	low	moderate	high
Operating Position Limits	none	some	some	none	none	some	none
Compactness	fair to good	fair to good	fair	poor to fair	fair to good	poor	very good
Starting Time (to full output)	slow	slow	fast	fast to instant	fast	very slow	instant
Temperature Sensitive?	no	no	yes	yes (@low temp)*	yes (@low temp)		yes (@ high temp)
Parking Lots	acceptable	acceptable	poor	poor	poor	poor	acceptable
Garages	acceptable	acceptable	acceptable	acceptable	acceptable	poor	acceptable

Dimmability*	Bi-Level	Bi-level	Yes	Yes	Yes	no	Yes
Controls Friendly**	no	no	yes	i.s.= no r.s.= yes	yes	no	yes

* Given dimming power supplies
** Motion sensors, daylight sensors, etc.

A complimentary metric, D_{uv} was introduced as a means of ensuring that the differences in CCT between light sources of the same type or batch are within a prescribed limit. Such color variation is exhibited by some metal halide lamps based on older technologies. Being a newer metric, D_{uv} is reported more frequently for Light Emitting Diode (LED) products than for other light source technologies, but it is applicable to any source type. D_{uv} values should generally be kept as low as possible, in accordance with ANSI standards. LED technology shows much promise for the lighting industry in general, and security applications in particular. However, as with other developing technologies, not all of the benefits or shortcomings have been thoroughly examined.[16] For more information on color metrics, including a newly developed method for evaluating color rendition, see IES TM-30-15, *IES Method for Evaluating Light Source Color Rendition*.

7.1.2 Color Rendering Index. How do the colors of surfaces and objects appear under a light source? Do colors look the same at night as they do during the day? It is as important to be able to *differentiate* between the colors of two adjacent items (such as a person's clothes next to a bush) as it is to be able to *describe* the color of a possible suspect's clothes or vehicle.

The color rendering index (CRI) metric essentially measures the average degree of color shift that objects undergo when illuminated by a particular light source, as compared with the same objects when lighted by a "perfect" reference source of equal CCT and 100 CRI. The higher the CRI, the better the color rendering ability of the light source. Research has shown that almost any nominally white light source with a CRI of 80 or higher allows more accurate and confident color identification at the illuminances used in public spaces at night. Low pressure sodium (LPS) lamps do not allow accurate color identification under any illuminance level.

The "special" color rendering index for strong red colors, denoted R_9, has recently increased in usage and is useful as a supplement to CRI. For example, some of the newer LED products have a high CRI but do a poor job of revealing red colors. This can occur when other colors are rendered exceptionally well, thereby compensating for the deficiency in red when the averaged CRI is calculated. Due to nuances in the calculation method, an R_9 value greater than zero (not negative) is considered adequate for appropriate facial recognition and video surveillance systems.

7.2 Luminaire Mounting Heights

Taller poles typically result in greater areas of coverage, and thus fewer poles required for a given area. Higher-mounted luminaires are also less prone to vandalism. In many localities, however, pole height is restricted as a means of reducing light trespass. When lower mounting heights are used, more poles and lower-output luminaires will likely be required to maintain adequate uniformity without increased glare (see **Figure 12**).

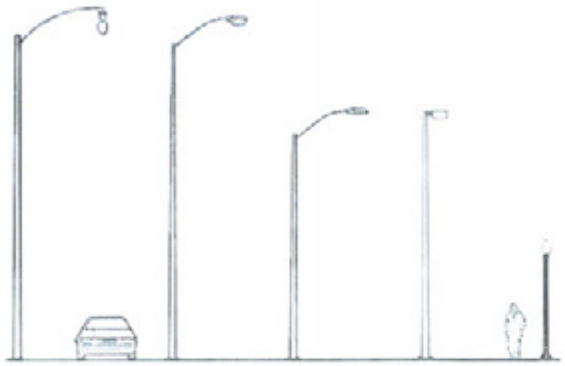


Figure 12. A typical family of luminaires exemplifying various pole heights and luminaire configurations. (Illustration courtesy of Clanton and Associates, Inc.)

7.3 Lighting Controls

Many lighting ordinances require a reduction in light levels at certain times of the evening or during periods of reduced activity. Establishment of such curfews is a logical method to reduce both energy use and light pollution. However, the lighting designer should first evaluate security requirements to determine how, when, or whether curfew-related restrictions should be relaxed or modified. For example, retail employees may be at greater risk than customers may, since employees usually arrive earlier and depart later, when fewer people are present. Lighting levels and on/off switching can be controlled through vacancy, motion, or dimming controls. These options could enhance security functions.

The least expensive means of reducing light levels and energy usage is to turn off selected lighting fixtures. However, the resulting gaps in coverage greatly reduce uniformity. Dimming offers an attractive alternative since all luminaires remain energized and uniformity remains; however, special ballasts or drivers are required, and these increase initial cost.

For non-residential applications, security lighting fixtures are usually controlled automatically. An exception would be in a guardhouse application where light is needed only occasionally for undercarriage or periodic inspections. Types of automatic controls include time-based controls, photo controls, and motion-based controls. The various automatic controls can operate individually

or in combination to control a single luminaire or a group of luminaires.

7.3.1 Time-Based Controls. Time-based controls, often referred to as timeclocks or time switches, range in complexity and functionality but generally lack real-time feedback from the illuminated areas they control. A preset schedule does not take into account conditions such as passing storms. The better products are programmable so that on/off times can vary with the seasons and can allow dimming of luminaires during periods of reduced need. Also called "astronomic" timeclocks or switches, these controls are programmable for latitudinal differences. Other, more sophisticated devices contact a satellite for time updates. All of these products should have a battery backup to maintain operation and preprogramming in the event of a power failure.

7.3.2 Photo Controls. Often referred to as *photocells*, photo controls can control either individual luminaires (usually integral to the luminaire) or groups of luminaires by means of a relay or contactor panel. Photo controls can automatically turn the lighting fixtures on and off during dark periods, even during the day. With photo controls, lighting fixtures can be combined with time-based controls, thereby reducing lighting at times of reduced need. Photo controls that control multiple luminaires are usually placed in the darkest portion of the area controlled. In addition, they should be placed where they are only influenced by daylight, not by other light sources, such as the luminaire(s) they are controlling. *When security is an issue,* photocells should be located so that a flashlight cannot be used to interfere with their operation. "Smart" photocells are capable of monitoring from dusk to dawn and shutting off a percentage of lighting fixtures each night throughout the year. Various programs and photocell-based controls are able to dim the lights at hard time settings, and turn lights off at "half-dawn."

7.3.3 Motion-Based Controls. Motion detectors are generally employed to switch light sources on and off or to dim units. Incandescent and fluorescent lamps can be cycled on and off without noticeable delays in warm-up or restrike; frequent switching can greatly reduce their rated lifetime (total hours of operation), but this effect can be offset by corresponding increases in calendar life (days before replacement). By contrast, the delays associated with warm-up and restrike of HID light sources render these sources incompatible with simple on/off motion sensor controls. LED products, however, will only tend to benefit from frequent switching because this does not typically affect their performance and does increase their calendar life. In many applications, it may not be acceptable to simply extinguish luminaires, due to reductions in uniformity. Dimming controls are typically more expensive but preferable in terms of security.

Motion detectors can be effective in introducing an element of surprise. When used to control luminaires intended to produce unexpected light or glare for intruders, this same light alerts personnel and directs their attention to the location of the threat. Motion detectors can be especially effective when used in pairs as "traps." A motion detector trap is used in confined areas, such as spaces between buildings or between 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.

Most commercially available electronic motion detectors contain an optical, microwave, or acoustic sensor, and in many cases a transmitter for illumination. However, a passive sensor only senses a signal emitted by the moving object itself. Changes in the optical, microwave, or acoustic field in the device's proximity are interpreted by the electronics, based on passive infrared, microwave, ultrasonic, or tomographic motion detection, or by video camera motion software. Most inexpensive motion detectors can detect up to distances of at least 5 meters (16 feet). Specialized systems are more expensive but have much longer ranges. Tomographic motion detection systems can cover much larger areas because the radio waves are at frequencies that penetrate most walls and obstructions and can be detected from multiple locations, not just at the location of the transmitter.

7.4 Maintenance and Depreciation

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

The recommended light levels in this guide are based on measured lux (footcandle) levels over time, which

are generally referred to as *maintained* light levels. All manufactured light sources degrade over time, giving off less light as time passes. When designing a new lighting system, calculations should apply an appropriate depreciation multiplier (combined light loss factor) for a particular light source, luminaire, and application. In critical security lighting applications, coverage patterns should overlap so that no area is dependent on a single luminaire. This can be most efficiently accomplished by using no fewer than two luminaires per pole, each having identical distributions, such that failure of one luminaire results in no more than a 50-percent reduction. Alternatively, it may be economical to install light sources with a higher rated initial lumen output and adjust the power level over time as the lamp ages, to maintain the desired illuminance. Designers need to weigh options carefully, considering that if energy compensation techniques are implemented, power use will need to increase, which could shorten system life.

Some outdoor luminaires experience rates of light loss far in excess of what the light source manufacturers originally predicted.[64] For example, some manufacturers optimistically rate the life of their light sources based on laboratory conditions, without regard for "in situ" operating conditions, experienced when installed in a luminaire. Without proper thermal management, excessive heat can have adverse effects on light source output, efficacy, and life. (For additional information, refer to IES DG-4-14, *Design Guide for Roadway Lighting Maintenance*.)

7.4.1 Light Source Replacement. The rated life of most light sources is defined as the number of hours of operation until 50 percent of the light sources have expired, with LED sources being a notable exception. Two IES documents—ANSI/IES LM-80-15, *Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Array and Modules,* and IES TM-21-11, *Projecting Long Term Maintenance of LED Light Sources*—describe approved methods of testing solid-state sources such as LEDs to ensure that lumen maintenance meets expectations for LED lighting. LM-80-15 describes testing protocols for LED manufacturers, while TM-21-11 describes lumen maintenance extrapolation methods. Failed light sources and luminaires performing below par should be replaced as soon as practical. When installations require special lift equipment to service the luminaires, consideration should be given to replacing all of the light sources on the pole at the same time to avoid extra labor and equipment costs. Light sources should be replaced at or before the manufacturer's published rated life, since the light output typically cannot be predicted after this point. A maintenance program that simply waits until the light source has failed (spot relamping) or is cycling on and off is not recommended. In lieu of a specific existing plan, the facility manager or owner should consider group relamping, whereby all luminaires of a given type are replaced simultaneously at 70 percent of rated life, as recommended in IES DG-4-14, *Design Guide for Roadway Lighting Maintenance*.

7.4.2 Cleaning. Regardless of the quality of the equipment, insects and dirt will eventually collect in enclosed luminaires. At a minimum, the luminaire, especially the lens and other optical components, should be cleaned at the time of relamping. *When security is an issue,* cleaning may be required more frequently to maintain equipment within the most effective operating tolerances.

7.4.3 Pruning. Trees and shrubbery that would otherwise block light output from security luminaires should be pruned at least annually to avoid creating shadowy areas. Where practical, low branches and bushes should be trimmed to improve sight lines. Vegetation growth over a number of years should be anticipated, depending on the local climate and growth patterns. Good coordination and planning will reduce the adverse effects of vegetation growth and the long-term cost of landscape maintenance. (For more information on the effects of vegetation on security lighting and other crime prevention tools, refer to **Annex D.**)

8.0 SECURITY LIGHTING APPLICATIONS

8.1 General

It must be emphasized here that the recommended lighting levels and uniformity standards for each of the applications described in this section apply *when security is an issue.* In addition, the recommended criteria are for *horizontal* illuminance unless otherwise noted. In addition, illumination quality (uniformity) ratios are calculated and displayed as *average-to-minimum* unless specifically noted. Notable exceptions are some uniformity ratios adopted by the US Government for specific applications and stated as *maximum-to-minimum.* (For guidance on measuring horizontal and vertical illuminance and calculating illumination uniformity ratios, see the protocol in **Annex A.**)

8.1.1 To Light or Not to Light. Not all security challenges and environments warrant the same criteria for lighting. For example, lighting a secure

area may advertise the presence of something worth attacking and hence may attract criminals or vandals that are not familiar with the area or target. In some applications, maintaining a lower lighting profile may be a better approach. Examples of applications *not to light* might include pumping stations in rural areas, isolated telephone relay enclosures, or tactical facilities conducting no-light operations. 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:

- Risk analysis of criminal or terrorist attack
- Corresponding countermeasures
- Economy of force[18]

If the risk of attack 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. When uncertain whether to light or not, the designer should consider employing sensory or timer controls for installed security light sources, in addition to other security measures. Such a sensor supported lighting system is particularly effective when integrated with distance monitoring sensors that constantly interrogate the integrity of the property and report violations.

8.2 Specific Application

In some instances, the designer may need to refer to several applications for a more well-rounded view of the applicable guidelines. For example, a major retail complex may have one or more automatic teller machines, parking facilities, or restaurants on premises. In such cases, the designer should review each specific application.

In security applications *when security is an issue*, a color rendering index (CRI) of 80 or higher is appropriate. (See **Section 7.1.2 Color Rendering Index** for more information.)

Note: When municipal codes or state, provincial or federal energy requirements do not allow the quantity of illumination recommended in this Guide, a variance in that code should be requested from the code making body, with proof that "Security is an Issue." (For more information, see **Annex E**.)

8.2.1 Homeland Security and Critical Infrastructure. The efforts to protect critical infrastructure[19] and bolster homeland security[20] extend from law enforcement and security agencies of the federal government to local governments and private sectors of the economy. For example, an oil refinery is a political, economic, and military target, and damage to such a facility has serious ramifications for workers, local communities, and the security of a nation. To be effective, the protection of critical infrastructure and homeland security require a partnership between both the private and public sectors. The scope of these protection efforts includes:

- Emergency preparedness and response including volunteer medical, police, emergency management, and fire personnel
- Corporate, domestic, and international intelligence activities

  Critical infrastructure and perimeter protection
- Border security, including land, maritime, and country borders
- Transportation security, including aviation, maritime, and rail
- Economic viability
- Bio-defense
- Detection of radioactive and radiological materials
- Research on next-generation security technologies

8.2.1.1 Bridges and Tunnels. Railway and vehicle bridges over navigable waterways and tunnels are critical infrastructure and require special considerations when designing security lighting. Since the events of September 11, 2001, local governments and the federal authorities have worked to protect these vital transportation arteries.

The US Coast Guard (USCG) regulates navigation lighting for overwater bridges in the US.[21] In considering the terroristic or criminal threat to a particular bridge, it is important for the lighting designer to consider that the threat can be waterborne, from a land approach, or both. In most instances, facade lighting is effective when integrated with visual observation and security monitoring plans and systems. Local governments operating bridges in the US should coordinate final designs with the USCG.

Threats to traffic tunnels for both railway and motor vehicles include both tunnel interior and exterior entrances. Blockage of a tunnel creates critical incidents for local governments and may seriously affect traffic flow, evacuation routes in case of an emergency, and movement of critical materials. Lighting designs for tunnels should support monitoring systems. Façade lighting on the exterior of the tunnel should be designed to limit hiding spaces without creating glare and to alert oncoming traffic to the entrance. (For more information on the illumination of tunnels, refer to IES RP-22-11, *Tunnel Lighting*.)

8.2.1.2 Critical Checkpoints and Inspection Stations. *When security is issue*, facility control points and guardhouses for controlled access should meet the recommendations specified in **Section 8.2.4.2**, as a minimum, with the following additional requirements[22]:

- Minimum exterior lighting of 22 lx (2.0 fc) with an average-to-minimum ratio of 3:1 out to a distance of 15 m (50 ft) along the roadway, and 0.15 m (6.0 in.) from the surface.
- Where practical, the approach road and pathways beyond a distance of 15 m (50 ft) should illuminated at a minimum of 11 lx (1.0 fc) with an average-to-minimum ratio of 4:1 out to a distance of at least 27 m (30 yards). (See **Figure 13**, for example.)
- Use glare-protected fixtures to minimize exposure of enforcement personnel working around the checkpoint gatehouse.
- Interior lighting within the stations should be diffused and designed with dimming controls to aid with night vision and additional security to the occupants. (See **Figure 14**, for example.) The use of a night light unit with a red lens should be considered.
- The lighting system should be connected to a standby power source located within the restricted area.

While the IES does not normally recommend designing lighting systems with disability glare, this technique is used in special security lighting applications to aid in controlling approaches to high security facilities and checkpoints. The use of glare renders approaching intruders outside the protected area highly visible to guardians inside the perimeter, while masking the officers and other features from outside observers. In such an application, luminaires are often mounted at or near eye level and aimed outward from the secure area. Typical applications of this principle might include sensitive weapons storage facilities, prisons, and detention facilities. Such designs have a high probability of producing light trespass and sky glow. Therefore, they should only be considered in those instances where security is a *very high* priority.

Figure 13. Driveway approach and canopy at the guardhouse provide uniform light for checking vehicles. (Photo courtesy of OSS – Law Enforcement Advisors®)

Figure 14. A well-balanced lighting system between the interior of the guardhouse and the exterior surveillance lighting. Note that the guard station is not staffed and the guardroom is lighted for effect (to give the appearance of human presence (Photo courtesy of OSS – Law Enforcement Advisors®)

8.2.1.3 Less Critical Visual Inspection Perimeter Sites. Sites relying on live officer visual surveillance without other sensors should have lighting levels ranging from 2 lux (0.2 fc) near the boundaries and perimeter fencing, increasing to 22 lux (2.0 fc) at entry points. The

inner containment area should have illuminance values ranging from 2 lux (0.2 fc) to 5 lux (0.5 fc), using the higher values for more-sensitive areas within the contained area. The illumination plan should be designed to fit the security and safety objectives of the site. Evaluation measurements are taken on a horizontal plane at ground level, and on the vertical planes, facing in the relevant directions, at 0.9 m (3 ft).

8.2.1.4 Perimeter Fences and Barriers. The purpose of lighting security perimeters is to define boundaries, deter or slow trespass, and enable enforcement staff or surveillance equipment to detect intruders. Perimeter barriers come in many different forms, from masonry walls to barrier vegetation. The placement and height of poles depends in large measure on the security level, desirability of seeing through the barriers, and whether one or both sides of the barrier are under active surveillance or patrol. If both sides of a perimeter are under surveillance, luminaires positioned over the top to reduce shadowed areas at the base of the barrier are often effective (see **Figure 15**).

The lighting will be more effective if the fence material is of a low-reflectance color. If unpainted galvanized chain link is used, special care is required in aiming of the luminaires to reduce direct and indirect glare. (For information on perimeter security lighting installed to support critical infrastructure and homeland security, see **Section 8.2.1.**)

In addition to security lighting considerations, it is critical that designers consider areas adjacent to the protected property. Glare and light pollution control are an important part of being a good neighbor.

No part of the illumination or surveillance infrastructure should be outside of the perimeter or otherwise vulnerable to surreptitious attack. A comprehensive system includes backup emergency power sources for lighting, surveillance, and monitoring equipment.

8.2.1.5 CCTV Assessment Lighting: Sensor Equipped Fence[23]**.** Sensitive homeland security sites are equipped with

Figure 15. If a view through the barrier is desirable, a set of pole-mounted fixtures set back inside the secured perimeter is effective. (Photo provided courtesy of Magnaray® International Division)

quality redundant lighting and monitoring systems. Illumination provided for active[24] closed circuit television (CCTV) monitoring from the same or a remote location should conform to NFPA 70[25] and IEEE C2.[26] The lighting configurations recommended therein provide sufficient light for optimum CCTV assessment of each zone.

CCTV monitored fencing that is designed in accordance with TI 811-6, *Manual, Lighting Fixtures Standard Drawing,* Series 40-06-04,[27] and this publication supports the requirements of the site security design. The area surrounding the fence is uniformly illuminated with a minimum of 22 lx (2.0 fc) and a *maximum-to-minimum* ratio not to exceed 6:1. (Note: These illuminance values and uniformity ratio are a US government standard, as well.) The area illuminated around the entire perimeter includes coverage that is approximately 3.0 m (10 ft) wide on the inside of the fence and approximately 7.6 m (25 ft) wide on the exterior of the fence. The facility monitoring station is equipped with monitoring and override features that allow remote control of key lights by security staff. A photocell switch controls the on-and-off function of the system. The sensory switch turns the lights on at or below 32 lx (3.0 fc), and off at 22 to 108 lx (2.0 to 10 fc). A time-delay prevents accidental switching from transient light sources.[31]

Rather than randomly activating the luminaires or setting a timer, installed intrusion detection system (IDS)[32] sensors detect an intruder and turn on the lights. Such an active lighting system provides an active deterrent value at lower cost. This type of system meets high standards for preventing false alarms and nuisance triggering.

8.2.1.6 Government Parking Facilities. Surface parking lots at government or government-supported industrial complexes where there are high vehicle movement levels require 22 lx (2.0 fc) minimum on the pavement, with an average-to-minimum ratio of 3:1. Medium-use parking areas require 11 lx (1.0 fc) minimum on the pavement, with an average-to-minimum ratio of 3:1.

8.2.1.7 Lobby Security Screening and Search Areas. Courthouses, airports, and building-lobby screening areas where greeters or officers conduct physical and electronic screening of persons and their possessions require lighting that will aid screeners in their tasks and provide a psychological deterrent for individuals desiring entry. Designs should provide supplemental task and desk lighting to illuminate inspection areas, writing tasks, and reading tasks, while limiting glare around screening monitors. Generally, for paper tasks and offices with computer monitor displays, illumination should fall between 215 lx (20 fc) and 538 lx (50 fc) for both normal and heightened-security designs. If LCD monitors are in use, higher illumination levels are required for the same viewing tasks: up to 785 lx (73 fc).

8.2.1.8 Maintenance and Testing of Critical Infrastructure. Installed systems and policies require periodic testing and evaluation. Testing and quality assurance programs should include these steps, at a minimum:

- Review written policies that govern maintenance and use of security lighting and surveillance systems, and question enforcement personnel on their use. Ask staff to demonstrate activation and reporting requirements.
- Conduct a functional test of all secondary source back-up lighting and surveillance systems at 30-day intervals for not less than 30 seconds.
- Conduct an annual test on each back-up lighting and surveillance system for not less than 1.5 hours.
- Ensure that equipment is 100 percent operational for the duration of each test. If not, complete repairs within 15 days.
- Document each test and any corrective action taken.

8.2.2 Law Enforcement, Fire, and Emergency Response Facilities. Public emergency response facilities are by their very nature places that require a high quality of outdoor lighting in conjunction with other security and safety design and operational considerations.

8.2.2.1 Law Enforcement Agencies. The operation centers of law enforcement agencies are unique in modern society in that they are places of both dread and safety at the same time, depending on the perceptions of the visitor. At these places, law enforcement

officers, arrestees, witnesses, and victims coexist. Exterior illumination should be adequate to:

- Provide a reasonably secure haven for the public seeking refuge and assistance
- Aid in conflict avoidance between the public and detainees
- Move prisoners securely from place to place
- Conduct detailed vehicle and equipment searches
- Load, unload, and handle firearms, special munitions, and equipment
- Safely move emergency vehicles
- Aid in deterring and detecting escape from custody
- Detect and deter terroristic attacks

Lighting that enables recognition of faces is critically important to determining who belongs in the space and who does not, who is perceived as secure and who may present a danger, and what their intentions are. Emergency vehicle and pedestrian movement areas within 30.5 m (100 ft) of building entrances should have an average maintained illuminance of at least 86 lx (8.0 fc) from the surface to 1.5 m (5.0 ft) above the surface, with an average-to-minimum uniformity ratio of 3:1. This includes entrances, interiors, and exits of sally ports,[33] and emergency vehicle parking and inspection areas. General parking areas farther than 30.5 m (100 ft) from these emergency facilities should have an average maintained illuminance of 54 lx (5.0 fc) on all parking and walking surfaces, with an average-to-minimum uniformity ratio not greater than 4:1.

Police agencies operating temporary lock-ups, or holding facilities, and country jails should consider the lighting recommendations contained in the latest *Jail Design Guide*,[28] published by the National Institute of Corrections. Throughout this design guide, there is an emphasis on officers' being able to manage the quality and quantity of light provided to detainees during both daylight and nighttime activities from secured control stations. Some luminaires may remain on or dimmed during sleeping hours, within a range of 9 to 16 lux (0.8 to 1.5 fc) to facilitate officer observation, especially in medical, mental health, and administrative and disciplinary segregation units.[2]

8.2.2.2 Fire Stations and Emergency Response Facilities. Fire stations are places where long periods of apparent inactivity can change with a single call or signal to rapid personnel and vehicle movement. The station may be staffed on a 24-hour-a-day basis, or may be a gathering point for community volunteers. Staged equipment and personnel often consist of firefighting, bomb disposal, rescue, and emergency medical units. In the case of a local volunteer station, the movement is no less intense and dangerous, as volunteers arrive, equip themselves, and rapidly depart. In such emergencies, quality of sight and sound should be superior to those of the surrounding areas. It is an acceptable practice for station exterior illumination to be minimized during non-emergency conditions to match the surrounding community standard. During preparation and response to an emergency call for service, parking and station exit areas should be illuminated with a maintained illuminance of 54 lx (5.0 fc) with an average-to-minimum uniformity ratio not greater than 3:1. Five minutes after all responding personnel and equipment have departed and the building is secured, the illumination can return to a stand-by mode until emergency units return.

8.2.2.3 Hospitals and Trauma Centers. Emergency medical and trauma facilities are, by their very nature, places that require a high quality of outdoor lighting where visibility at night is a critical life safety issue.

8.2.2.3.1 Medical Offices & Clinics. Medical offices and clinics, both private and public, are typically open in the early morning and late evening hours to accommodate patients. As these medical facilities often serve a wide variety of patients with serious medical impairments, including the very young and elderly, after-hours path lighting needs special attention. Pathways, parking areas, and entry areas should have average maintained illuminance of 32 lx (3.0 fc), with an average-to-minimum uniformity ratio of 4:1.

8.2.2.3.2 Hospitals. Hospitals are around-the-clock operations, where the secure movement of staff, visitors, and patients is

critical to the provision of quality care. One of the primary concerns of hospital staff and patients is personal safety. Pathways and parking areas that are used after dark should have average maintained illuminance of 32 lx (3.0 fc), with an average-to-minimum uniformity ratio not greater than 4:1. (For parking garage guidelines, see **Section 8.2.7**.) Special attention should be given to the location of late-night employee parking and illumination of the paths between the hospital and the parking facility. *When security is an issue*, pathway and parking facility illumination should be augmented with active presence or surveillance by staff during shift changes.

8.2.2.3.3 Emergency Departments and Trauma Centers. Emergency room and trauma centers receive critically ill or injured patients at all hours and by all modes of transportation, including private and law enforcement vehicles, walk-ins, and air ambulance. Most major trauma centers also have on-site landing facilities for air ambulance services. Entrances to emergency departments are even more critical, given the rising violence in and around emergency medical treatment facilities. Exterior illumination for trauma entrances should be adequate to:

- Provide reasonably secure havens for patients seeking assistance
- Aid in conflict avoidance between the public and emergency vehicles
- Load, unload, perform triage, and safely move patients from vehicles to treatment areas
- Continue medical treatment of patients around ambulances and ambulance bays
- Aid law enforcement and security personnel in identifying threats to the safety and security of the emergency department patients, visitors, and staff
- Provide external triage, treatment, and decontamination areas in the event of natural or other disaster, if the capacity of the interior facilities is exceeded
- Allow an effective transition from the working area inside an ambulance into the interior trauma theater

Lighting control for entrances should be a variety of active and passive means. They should allow for quick response by enforcement officers to prevent unauthorized access and should provide a secure environment for the delivery of patient care and confidentiality (see **Figure 16**). An average maintained illuminance of at least 86 lx (8.0 fc) is required from ground level to 1.5 m (5.0 ft) above ground level, with an average-to-minimum uniformity ratio not greater than 3:1, on and within 18 m (60 ft) of all emergency vehicle and emergency pedestrian movement areas immediately adjacent to the emergency department. General parking areas within 30.4 m (100 ft) of these emergency facilities should have an average maintained illuminance of 54 lx (5.0 fc) on all parking and walking surfaces, with an average-to-minimum uniformity ratio not greater than 3:1.

8.2.2.3.4 Trauma Center Helipads. Most Level I and Level II Trauma Centers have on-campus landing facilities for air ambulance operations. It is critical that these be:

- Clearly defined landing areas
- Free from obstructions
- Well illuminated
- In compliance with aviation lighting standards

Aircraft landing areas have clearly defined limitations on lighting pole height to prevent

Figure 16. 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 OSS – Law Enforcement Advisors®)

interference with safe aircraft operation. Care should be taken to ensure that surrounding structures or devices, including temporary objects, do not have the potential to interfere with secure flight operations and are clearly marked for both day and night operations. In addition, air safety equipment (windsocks, anemometers) should be clearly illuminated for night flight operations without interfering with pilot vision.

For safety and security recommendations and standards for heliport design, the designer should refer to Advisory FAA Circular 150/5390-2B. The Advisory Circular (AC) provides general design guidance, and does not mandate required practices. Anyone constructing, modifying, or evaluating a heliport should determine all site-specific requirements and consult with a local FAA representative. Accordingly, the heliport should include at least one touchdown and lift-off area (TLOF) centered in a final approach and takeoff area (FATO), a peripheral safety area, and two or more approach and departure paths. For night operations, the TLOF, FATO, taxiways, taxi routes, and windsock should be illuminated at levels and uniformity equal to or above the surrounding areas. Other useful visual aids include floodlights, taxiway lights, landing direction lights, a heliport identification beacon, and a heliport approach path indicator (CHAPI). The recommended CHAPI power system is single-phase 120/240 volts for VFR[34] and 6.6-ampere series circuits for IFR.[35] Obstruction lights should be installed where required to mark objects in close proximity to the approach and departure paths.

8.2.3 Storage Yards, Industrial Parks, and Terminals. Area lighting for storage yards, industrial parks, and truck and rail terminals is often supported with floodlighting or other luminaires mounted on poles 9.1 m (30 ft) or more in height (see **Figure 17**, for example). The recommended average illuminance on the surface of large open storage areas is 5 to 22 lx (0.5 to 2.0 fc) with an average-to-minimum illuminance uniformity ratio of 6:1 or better. Luminaire spacing will depend on the output, mounting height, and distribution of the luminaires. In instances where unacceptable material losses have been sustained or *where security is an issue,* the average maintained illuminance levels should be at least 11 lx (1.0 fc) with an average-to-minimum uniformity ratio not greater than of 6:1, in combination with an active surveillance system.

If the area contains large numbers of obstructions to visibility (as in container terminals or rail yards), a design utilizing more multiple-source locations and higher mounting heights can reduce shadows. It is 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-reflectance colors on buildings and light-colored paving will enhance the efficiency and uniformity of the lighting system.

When security is an issue, roadside truck terminals and fueling stations that are open to the public require additional considerations. Fueling-area canopies, stores, restaurants, and exterior areas should meet the guidelines in **Section 8.2.6**. In areas set aside exclusively for truck parking and rest areas, the average maintained illuminance levels should be at least 22 lx (2.0 fc) with an average-to-minimum uniformity ratio not greater than of 4:1, in combination with an active surveillance system. In truck park arrangements, shadows between large trucks are of serious concern. This can be addressed by multiple high-mast luminaires and other design considerations.

8.2.4 Commercial Offices and Other Non-retail Buildings. Office buildings come in many shapes and sizes and serve a myriad of purposes. It is common for designers to lay out the design of a building only to find that months into the leasing process the facility has a mix of tenants, all with differing security and safety and access needs. Designers planning initial or upgrade illumination need to consider the nature of the tenants. Some tenants who are subject to special security needs include:

Figure 17. Area lighting for storage yards, industrial parks, and truck and rail terminals, often supported with floodlighting or luminaires mounted on poles. (Photo courtesy of Acuity Brands)

- Controversial political or religious groups
- US government agencies
- Medical clinics
- Bars and clubs

Designers and officer building managers that have federal, state, provincial, or local-government tenants should refer to **Section 8.2.4.1;** for facilities that provide emergency clinic services, they should refer to **Section 8.2.2**; and for office buildings that have a bar or club on-premises they should refer to **Section 8.2.10**. Office buildings often have a variety of tenants, managers and designers should review the security lighting applications contained throughout **Section 8.2**.

8.2.4.1 Government Use Office Buildings. The U.S. General Services Administration (GSA) provides security for many general-use federal buildings. Lighting guidelines and other operational requirements are published and inspected by the GSA agency in coordination with the tenant agencies. Some of the buildings are government owned, while others are privately owned and leased in whole or in part by the government. *When security is an issue*, federal office buildings managed in whole or in part by the GSA utilize the services of the Federal Protective Service (FPS) to plan, manage, and inspect security maintained at each building complex. In each case, FPS coordinates with tenants to incorporate their varying needs. Although the FPS security standards are not made public, the service does draw from the guideline published by IES in general, and recommendations of the IES Security Lighting Committee in particular. Lighting and security designers responding to GSA general office procurements should review the guidelines contained in **Section 8.2.1** and seek release of any published applicable standards from the FPS through the contracting officer.

In Canada, the protection of government buildings is entrusted to the Royal Canadian Mounted Police (RCMP). The RCMP, in addition to managing national government buildings, publishes and maintains the *Physical Security Guide*, G1-005.[65] During the development of IESNA G-1-03, the previous version of this Guide, crime prevention officers of the IES Security Lighting Committee coordinated with the RCMP on their guidelines. The RCMP publication was last updated in January 2000 and contains minimum illumination guidelines. These guidelines include as Minimum Safeguards:

- Provide general illumination of the entire perimeter of the building, driveways, and parking lots, to a target level of 25 lux, 20 lux minimum (2.3 fc, 1.9 fc minimum).
- Lighting sources may be street lighting, yard lighting or building-mounted lighting, or combinations of all three.
- Maximum contrast of darkest to brightest illumination is a ratio of 1:10 (i.e., if darkest is 25 lux [2.3 fc], then highest level should not exceed 250 lux [23 fc]).
- Where the building abuts the property line, with private property on the other side, that private property should not be illuminated if its owner so requests.

In addition, the following measures are also recommended:

- Solar-activated light sources to compensate for summer and winter hours, especially if video equipment is used
- Security lighting, in order to obtain increased light intensity or a specialized color spectrum, or both, for identification or for closed-circuit video equipment applications
- Illumination of the additional portions of the site to 25 lux (2.3 fc)
- Illumination at the site fence line
- Low-reflection fence; e.g., coated with dark, non-reflective material
- Lighting at staff entrances and exits used after hours to a minimum of 50 lux (4.6 fc), but not more than 200 lux (18.6 fc)
- Wall-mounted light fixtures (3 m to 4 m [10 ft to 13 ft] high), shining on light wall surfaces, so that a person moving on the site would cast a large, long shadow
- Tamper-resistant lighting fixtures
- Security lighting positioned to prevent deep shadows from the building or vegetation, so an intruder could be noticed
- When using video cameras, providing a minimum of 50 lux (4.6 fc) reflected light. Consult a lighting engineer when using color

video cameras for correct light sources and their appropriate color rendition index.

- If color rendition is a requirement, ensure the correct type of lighting is used.

8.2.4.2 Business Checkpoints and Inspection Stations. Security personnel charged with stopping and inspecting people, identification, and vehicles, often control access roads to secured areas. These security posts at access points range from a single officer staffing a booth to border stations that simultaneously inspect multiple lanes of traffic. The intensity of inspections ranges from token check or wave-through to challenges and detailed searches, depending on the perceived threat. In the latter instance, the entrance or inspection points are equipped with multiple, redundant luminaires so that the loss of any one luminaire will not seriously degrade the lighting available to the officers for effective task performance. For critical applications, backup power for the primary illumination system or an independent secondary system with instant-on capabilities is required.

Officer tasks may include detailed inspection of all sides of the vehicles, license plates, personal identification cards, and vehicle contents, including the driver, occupants, and cargo. In such instances, horizontal as well as vertical illuminance support officers in completing required tasks without the need for auxiliary hand-held devices such as flashlights. In high-security areas, selected luminaires are usually mounted at or below pavement level to facilitate inspection of vehicle undersides. (See **Figure 18** for an example of a low-mounted lighting system.) Having a bright concrete or more-reflective road surface to increase the reflected light will aid the inspection process. Lamp installations that are at or below grade need to be balanced with the lighting that is provided above the surface.

Illuminance at ground level for inspection areas should be an average of 108 lx (10 fc) or twice that of the immediate surrounding areas, whichever is the greater, and an average-to-minimum uniformity ratio not greater than 3:1. The same values should be at 1.5 m (5.0 ft) and at the midpoint of the vehicle window(s) being inspected. When inspections are for various types of vehicles, the lighting should be consistent throughout the range of vehicles anticipated. Good color rendering light sources, with a CRI of 80 or higher, should also be employed so that officers can easily discern the color of clothing, documents, goods, and vehicles.

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 officer or soldier. 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 (see **Figure 19**); painting the inside of the gatehouse in dark colors; and

Figure 18. An example of luminaires deliberately mounted approximately 0.46 m (18 in.) A.F.G. (above finished grade), where security is a high priority. (Image provided courtesy of Magnaray International Division)

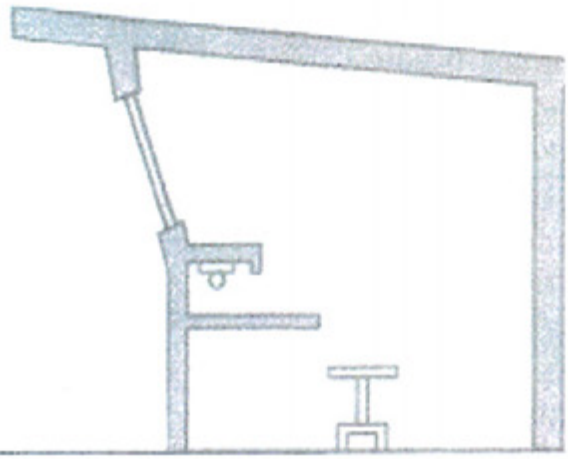


Figure 19. Tilted glass limits view of the interior of the guardhouse. (©Illuminating Engineering Society)

ensuring that illumination can be dimmed, will all help limit the view into the gatehouse

In installations where entrances are monitored solely by CCTV or electronic devices, illuminance at the checkpoint may be lower than at sites staffed by security personnel. However, it is important that the illuminance be at levels consistent with the manufacturer's surveillance equipment requirements. (For information on checkpoints and sections operated in support of critical infrastructure and homeland security, see **Section 8.2.1.2**.)

8.2.4.3 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, illuminated points of entry may include unauthorized access points such as ladders to the roof and skylights, back doors, and loading docks. Luminaires set in the ground, mounted on the building or under the eaves, or mounted on poles are effective options. While ground-mounted floodlights may provide uniform illuminance, they are relatively easy to disable. The average-to-minimum illuminance uniformity ratio should be in the range of 8:1 to 6:1, depending on the acceptability of loss.

8.2.4.4 Building Interiors. Security lighting for the interiors of buildings depends on the methods of providing security. 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 hallways and work areas should be consistent so that officers are not subjected to changing patterns of light. Unoccupied buildings supported by continuous patrol officer rounds should average 22 lx (2.0 fc) or better, with an average-to-minimum uniformity ratio of 6:1. As an alternative, areas of the building can be completely darkened if patrolling officers are provided with a system that activates sectioned light sources as patrol rounds are performed. Regardless of the illumination levels provided, patrol officers should always carry supplemental lighting devices such as flashlights when patrolling inside and outside enclosed structures at least 1 hour before and after dusk. If the building is monitored automatically using electronic surveillance devices, enough light should be provided to operate the equipment within recommended tolerances. If sensor control systems are installed that do not require light, it is appropriate to design the system to be dark when secure, and illuminated once trespass has been detected.

8.2.5 Automated Teller Machines and After-Hours Depositories

8.2.5.1 Background. Automated Teller Machines (ATM) and After-Hours Depositories (AHDs) are installed in many types of locations, which create a variety of security considerations. While user safety for customers, employees, and servicing personnel is a primary concern for the financial services industry, regulatory criteria, marketability, and area crime statistics[36] all impact site selection and the security provided. The financial industry and some state and local jurisdictions have responded with internal policies, recommendations, standards, and laws to make ATMs and AHDs safer and more secure.

8.2.5.2 Installation. There are many security elements to consider for after-hours external banking devices (ATMs and AHDs). These include but are not limited to location, lighting, potential areas of concealment, visibility, and a host of other physical security concerns.[37] The most common installation types are external walk-up, drive-up, and vestibule[38] and interior installations (see **Figure 20**).

The many types of installations and configurations bring with them security related

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 OSS – Law Enforcement Advisors[39])

issues where cash or other transactions occur in public venues. ATM and AHD Installations can be in attended or unattended locations. Attended device installations are those that have employees available to provide a presence and varying degrees of supervision at or near the transaction point. This is most often the case where ATM or AHD units are located inside financial institutions, supermarkets, stores, hospitality sites, and convenience stores. Generally, unattended ATMs and ADHs place the customers at greater risk of attack. However, the quality of attendant training and job description is important to consider. It is common for the ATM or AHD to be installed in a location where the attendant has a job description that does not include customer support or oversight of the ATM or AHD.

Some states and local jurisdictions have enacted statutes and ordinances that specify minimum-security standards for automated financial transaction points. These regulations place heavy emphasis on the importance of security lighting in helping to deter crime against customers. In some jurisdictions, state and local regulations may conflict or are difficult to apply. Designers should research these regulations and codes, consult with local authorities, and incorporate these standards into the design.

Security is an issue when designing for most ATM or AHD installations due to the nature of the device. In such instances, it is paramount that designers and operators provide in-depth security and not rely on any single security element or program. Especially in exterior designs, it is important to allow for redundancy so that the loss of any one luminaire will not degrade the lighting design below the minimum requirement.

8.2.5.3 Exterior Unattended Installations. In cases where there are no controlling state or local minimum standards, the designer should consider the following lighting best practices and additional security design concepts for exterior-access installations:

- A minimum of 323 lx (30 fc) at any preparation counter or stand within 3.0 m (10 ft) of the ATM or AHD, with an average-to-minimum ratio of 3:1.

- A minimum illuminance of 108 lx (10 fc) at the face of the ATM or AHD, as measured horizontally in an arc greater than or equal to 180 degrees[39] centered on the face of the device, at ground level and at a height of 1.5 m (5.0 ft), and measured out to a distance of 1.5 m (5.0 ft), with an average-to-minimum ratio of 3:1 within the arc.

- Extending the arc beyond 1.5 m (5.0 ft) out to a total distance of 18 m (60 ft), including any vestibule area, a minimum of 32 lx (3.0 fc) as measured at ground level and a height of 1.5 m (5.0 ft), with an average-to-minimum ratio of 4:1.

- 22 lx (2.0 fc) minimum with an average-to-minimum ratio of 4:1 at ground level and at 1.5 m (5.0 ft) along pedestrian walkways leading to the nearest parking lot or curbside.

- For a stand-alone ATM or AHD (an ATM that is a walk-up or drive-up and is *not* mounted through the wall of another structure or building), the areas on all four sides of the structure need to be illuminated, creating 360 degrees of coverage. In addition to applying the guidelines above for the transaction side of the structure, the remaining three sides are illuminated in an arc extending out to 18 m (60 ft) with a minimum of 32 lx (3.0 fc) as measured at ground level and at a height of 1.5 m (5.0 ft), with an average-to-minimum ratio of 4:1.

- Supporting parking spaces should have a minimum of 32 lx (3.0 fc), consistent with the guidelines for parking lots, as discussed in **Section 8.2.8**.

- After-hours vestibule lighting should be designed in such a way that glare does not generally prevent users from seeing inside the vestibule from the outside as they approach from the surrounding access ways, and does not generally prevent users who are inside the vestibule from seeing the surrounding area outside.

- Users should have an unobstructed view of all accessible areas of the after-hours vestibule from the exterior of the vestibule. If necessary, this requirement can be met by supplementary security devices such as mirrors, camera and monitors, fencing, and barriers.

- Illuminance at the machine and the surrounding area should provide good-to-

excellent definition of facial features at a distance up to 9.1 m (30 ft).

- Illuminance levels should support all CCTV camera operating requirements.

- Users should have a reasonably unobstructed view from the face of the unit out to a distance of 15 m (50 ft) in all unobstructed directions, and potential areas of concealment should be eliminated. If necessary, this requirement can be met by supplementary security devices such as mirrors, active CCTV monitoring camera and monitors, fencing, and barriers.

- Luminaires installed below 3.7 m (12 ft) should be should be tamper-resistant.

A post-installation assessment is strongly recommended, in accordance with the protocol provided in **Annex B**. The final design should not produce glare in the eyes of the customers or others in the area.

8.2.5.4 Exterior Vestibule Installations. Interior ATMs and AHDs come in an ever-widening variety of installations and applications. It is common to find these devices in convenience stores, supermarkets, gas stations, hospitality centers, airports, malls. Some ATMs are attended, while others are simply placed in an interior location where observers or passersby provide intermittent presence. The degree, quality and frequency of attendance should be taken into account when considering security and security lighting design. Attended device installations are those that have employees available to provide a presence and varying degrees of supervision at or near the transaction point.

Generally, unattended ATMs and ADHs place the customers at greater risk of attack. However, the quality of attendant training and job descriptions are important to consider. It is common for the ATM or AHD to be installed in a location where the attendant has a job description that does not include customer support or oversight of the ATM or AHD. At a minimum, interior ATMs and AHDs should meet the following guidelines:

- 108 lx (10 fc) minimum at the face of the ATM, and a minimum of 323 lx (30 fc) at any preparation counter or stand within 3.0 m (10 ft) of the ATM.

- Interior lighting within 3.0 m (10 ft) of the device should be raised to 108 lx (10 fc) with an average-to-minimum ratio of 3:1. These conditions can be found in bars, restaurants, and hallways where subdued lighting is applied for effect.

8.2.6 Parking Lots. When security is not an issue, recommended practices for lighting parking lots and garages are available in IES RP-20-14, *Lighting for Parking Facilities*. Walkways and bikeways within the public right of way are covered in ANSI/IES RP-8-14, *Roadway Lighting*. Other walkways and bicycle paths issues are covered in IES DG-5-94, *Lighting for Walkways and Class 1 Bikeways*. *When security is an issue*, the recommended security and safety illuminance for open parking facilities should be at least a maintained average of 32 lx (3.0 fc) on the pavement and to a height of 1.5 m (5.0 ft). A uniformity ratio not greater than 4:1, average-to-minimum, should be maintained throughout the hardstand. Sidewalks, footpaths, and grounds around or supporting open parking lots should be illuminated to no less than 6 lx (0.6 fc), with an average-to-minimum uniformity ratio no greater than 4:1 (see **Figure 21,** for example). (For information on illumination of parking lots serving sensitive controlled spaces, homeland security operations, or the military, see **Section 8.2.1.6**.) For security purposes, exterior lighting should have a high CRI (80 or higher). At this level, guests are better able to differentiate colors. This is also important for surveillance cameras, which record facial and vehicle colors accurately with this CRI recommendation.

New designs in exterior wall packs, floodlights, pole-mounted fixtures, and parking garage luminaires are all available with multiple lighting technologies

Figure 21. Well-shielded 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 OSS – Law Enforcement Advisors®)

that allow for instant-on features. (For an example of an instant-on application for a perimeter fence, see **Figure 22**.) Some fixtures come equipped with individual occupancy sensing controls that control multi-level ballasts. Individually selected fixtures can dim down to reduced power usage (40 percent to 70 percent of full power) when no activity is present, to conserve energy. When the fixture's built-in occupancy sensor picks up activity or a thermal signature, the ballast instantly goes to full power for a pre-set duration. With no activity detected, the fixture returns to its dimmed down state at reduced power. This configuration works well with security cameras and guards who monitor security systems. As the lighting level increases, each lighting fixture takes on the role of a sentry, letting trespassers know they have been detected. Security personnel who survey monitors can easily determine that an event triggered an occupancy sensor and caused a fixture to switch to full power in a specific area. These types of lighting technology are available with light sources in a range or CCTs with high CRIs and instant on technology, including fluorescent, induction, and LED.

8.2.7 Parking Garages. The security threat to unescorted people and unsecured property in covered parking garages can be very high. Isolated floors, numerous places to hide, lack of unobstructed surveillance, and limited escape routes often combine to create this condition. *When security is an issue* in multilevel parking facilities, the recommended minimum illuminance is an average of 65 lx (6.0 fc) on the pavement, with approximately the same values measured at 1.5 m (5.0 ft) above the pavement, and with an average-to-minimum uniformity ratio not greater than 4:1. (See **Figure 23** for an example of good uniformity.) These illuminance levels are maintained whenever access is allowed to the parking areas. It is important for glare to be avoided in such installations. Structural elements afford concealment of luminaires. When coupled with a low ceiling, the designer may be challenged to provide uniform lighting in the space, especially between parked cars.

Back-up generators or battery-operated lighting is necessary in parking space areas, stairwells, elevators, and exit ramps when the public is allowed access. In locations where people gather, such as at elevators and stairs, a higher illuminance average of 108 lx (10 fc) should be provided in a 9.1-m (30-ft) radius from the center of the gathering point, with an average-to-minimum uniformity ratio not greater than 4:1. A well-lighted stairwell reduces apprehension and facilitates observation of other people in the space (**Figure 24**).

Figure 23. Multiple structural elements coupled with a low ceiling can make it difficult to achieve uniformity, especially between parked cars. In this example, the designer was successful. (Photo courtesy of Larry Leetzow)

Figure 22. 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 24. This well-lighted stairwell will create a greater sense of safety and security for those who use it. (Photo courtesy of OSS – Law Enforcement Advisors®)

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 secure movement and easy detection of hazards and threats out to a distance of at least 9.1 m (30 ft).

Illumination levels at entrances and exits should aid in the eye adaptation when going from the structure into the street or vice versa. This type of lighting design is *transitional lighting*. Lighting should have sufficient uniformity to avoid shadows and glare

Retroreflective material should be considered for wall signs, common walkways, gathering points, and hazardous areas. Location signs (level and bay indicators) are useful on columns that face the aisles. 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 aid pedestrians in locating vehicles and exits faster, reduce exposure to criminal hazards, and encourage a feeling of wellbeing and of being in control of one's surroundings.

Energy conservation practices often include limiting access to unused upper levels and reducing or turning out light sources on these levels. Restricted access and egress during late-night hours and days not used, combined with a reduction or no-lights condition, can save energy and luminaire maintenance costs. Instant-start light sources (sensor controlled lighting) can be utilized to aid in controlling the lighting levels.[43] Such applications should include a "clear the building first" program and signage for users.

In both open and multi-layered parking facilities management should define a security plan that includes maintenance of critical infrastructure. This certainly includes lighting maintenance when there are operations after dark. As part of this plan, management, security, or maintenance personnel should check nightly for light sources that are out or not performing within the manufacturer's tolerances while walking the grounds nightly. Repairs or replacement should be made within 48 hours of a major deficiency being noted. One way to reduce the cost of recurring maintenance is to service and change luminaires on a regular, predetermined maintenance schedule.

8.2.8 Public and Natural Parks. For purposes of security lighting design, parks are generally divided into four categories: Urban, Suburban, Nature, and Natural.

8.2.8.1 Parks and Public Spaces. 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 other areas where identification at a distance is impaired, properly installed lighting should enable a fight-or-flight decision to be made at a distance of at least 9.1 m (30 ft), by illuminating potential hiding places, movement paths, and escape routes along paths. This is of particular importance in parks and open public areas, where other security and safety amenities are usually not present.

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 use of the park
- Hours of public access
- Local cultural values
- Traffic patterns and access
- Patrol frequency
- Light pollution and light trespass

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 32 lx (3.0 fc) on the pavement, with an average-to-minimum uniformity ratio not greater than 4:1.

In locations where loitering and criminal attacks are likely to occur, illuminated levels should be at least 11 lx (1.0 fc) horizontal at ground level and to a height above ground of 1.5 m (5.0 ft), with an average-to-minimum uniformity ratio not greater than 4:1. Glare should always be avoided.

When security is an issue, park trails and walkways open to the public at night need to be illuminated to at least 6 lx (0.6 fc) at grade and at 1.5 m (5.0 ft) above grade along the axis of the walkway, along the length of the trail. Both sides of the pathway should have illumination out to a distance of 9.1 m (30 ft), with an average-to-minimum ratio of 4:1. Where trails are situated in woods, landscaped areas, or broken terrain, lighting should blend with the environment whenever practical. Creative combinations of light sources and mounting devices can

assist in these applications. Glare and sky glow need to be taken under consideration and controlled.

8.2.8.2 Nature and Parks. Parks primarily set aside for the enjoyment of natural habitat emphasize maximum use of natural features while minimizing the impact of built-up structures. Exceptions to this general rule are parks that have installed parking, rest areas, restaurants, hotels, and laundry facilities. In such instances, park officials should refer to the park guidelines above, and to other applicable parts of **Section of 8.2**, with an eye toward limiting the area covered for safety and security lighting. Limiting glare and sky glow is particularly desirable.

8.2.9 Retail Stores and Centers. Many retail centers and superstores today are high volume operations, well in excess of 9,300 m^2 (100,000 ft^2), offering a vast array of services while attracting thousands of customers a day. Many operate 24 hours a day or late into the night, and parking lots for these facilities are large and often congested. A large percentage of violent crime at retail facilities occurs in parking lots where customers and employees are often isolated and vulnerable. The size and complexity of the store or center does not seem to matter to would-be attackers. Proper illumination is a critical component of the overall security plan for retailers.

When Security is an issue, illuminance levels should be at least 32 lx (3.0 fc) on the pavement, with an average-to-minimum uniformity ratio not greater than not greater than 4:1 in parking lots, including parking and support areas used by employees and vendors. To conserve energy and provide additional security for stores with a late-night or 24-hour operation, additional illumination should be provided closer to the entrances where customers will be parking during these low-activity, high-vulnerability hours. Illuminance in this area should be at least an average of 54 lx (5.0 fc) on the pavement, with a uniformity ratio not greater than 4:1 average-to-minimum. The size of the area provided with this additional illumination is determined based on projected customer count during these hours, and on the history of crime on the property and in the neighborhood. In such a design, the light sources not within the 54-lx (5.0-fc) zone can be cycled off or provided with instant-strike sensors. In such an arrangement, the customer is encouraged to park closer to the store; visibility by fellow customers and store personnel is improved, and the customer has less distance to travel. If security is an issue, illuminance in the area of delivery docks, outdoor trash compactors, and recycling bins in the back of the store should be at least an average of 32 lx (3.0 fc) on the pavement, with a uniformity ratio not greater than 4:1 average-to-minimum. This will provide adequate performance and security lighting for delivery personnel as well as for employees needing to work or move about in these areas.

Considering the complexity of many retail centers, designers and crime prevention specialists should survey the various businesses located in the center regarding their individual security lighting needs. A review of the other specific applications addressed in **Section 8.2** will help in this effort. For example, if automatic teller machines are located on the property, the designer should refer to **Section 8.2.5**; for restaurants and eating establishments, **Section 8.2.10**.

Approach roadways to the complex and rear areas of stores should be illuminated based on IES RP-8-14, *Roadway Lighting,* and IES RP-20-14, *Lighting for Parking Facilities - Revised.*

8.2.10 Restaurants and Eating Establishments. Local and franchise restaurants are typically late-night operations, and many are 24-hour operations. Neighborhood establishments often rely on patrol officer patrons for intermittent security presence inside their establishments while consuming discounted menu items. In addition to the presence of uniformed customers, these officers can be valuable resource against local criminal activity. Others, such as national chains, have developed system-wide security plans, policies and training, while regularly tracking and reacting to reported crime statistics. For the various categories, patron and employee security is a high priority. For facilities allowing consumption of alcoholic beverages on site, the designer should consider the guidelines provided in **Section 8.2.19**.

The effectiveness of syndicated restaurants that are initially not a part of the neighborhood fabric depends heavily on quality site selection, tested plot and facility design, operational and security policies, staff training, and integration of layers of security. Critical among these security features is *security lighting.* Areas of meaningful security concern to managers are customer drive-thru or take-out windows, general parking, refuse disposal areas, and places where employees perform tasks outside the building after dark.

Customers are especially vulnerable to attack on "blind" sides of the restaurant and at the drive-thru lane or take-out lane, particularly when patrons are transacting business at the payment or order window(s). Customer attention is on 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 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's personnel have a 180-degree view from building wall to building wall. Store security mirrors are also an effective deterrent to unobserved approaches (see, for example, **Figure 25**).

When security is an issue, the average maintained illuminance for the area within 9.1 m (30 ft) of the exterior service window(s) is 65 lux (6.0 fc) on the pavement, and equal illuminance levels at 0.9 m (3.0 ft) and 1.5 m (5.0 ft) above the pavement, with 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 32 lx (3.0 fc), at grade, with an average-to-minimum uniformity ratio not greater than 4:1. Lighting that is mounted on the building above the take-out or drive-up window allows good observation by the employee; however, glare for the patrons in their cars should be avoided (see, for example, **Figure 26**).

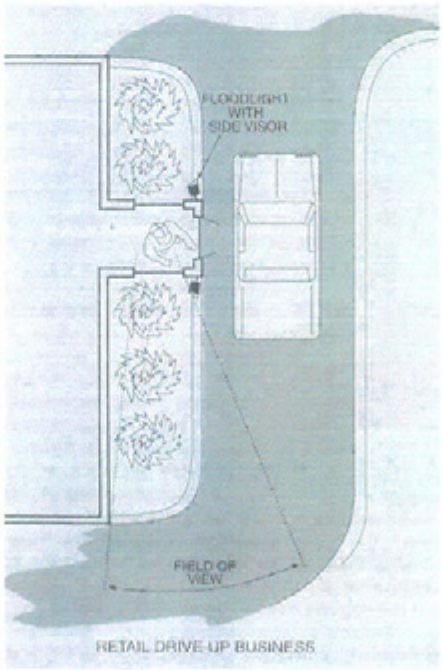


Figure 25. In this design, light is emitted from the floodlights to project down the lane and parallel to the car to enable detection of intruders from the rear corner of the building. (Illustration courtesy of Occupational Safety Systems, Inc.)

Figure 26. In this example, 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-colored surfaces reflect light onto the driveway for easy wayfinding.
(Photo courtesy of OSS – Law Enforcement Advisors®)

Most municipalities and franchised companies require refuse disposal areas to be enclosed. Although effective for visual and sanitary reasons, these requirements increase the security risk to employees servicing these storage facilities. Simply lighting this area is not effective alone, due to visual obstruction, and the design of the facility or written procedures need to address critical security concerns after hours. However, the illumination of the refuse area, both inside and outside of the enclosure should be consistent with the rest of the general parking areas.

8.2.11 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, alcoholic beverages, gasoline, and proximity to major thoroughfares combine to make these types of retail outlets susceptible to both planned and impulsive aggravated robbery[44] and other violent crimes. In recent years, the gas-convenience store concept has expanded customer service to include wide selections of packaged and in-house prepared foods, automatic teller machines, and the sale of beer and liquor. Some have shared, franchised restaurant facilities, with drive-up and counter service.

When security is an issue, the average maintained illuminance should be at least 65 lux (6.0 fc) on the pavement and at 1.5 m (5.0 ft), with an average-to-minimum uniformity ration of 4:1 or better. These recommended values apply to storefront entrances, open areas between the gas pump canopy and the store, air and water stations, outdoor telephones, and other exterior customer use areas (see **Figure 27**). The canopies over gas pumps should be

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

illuminated at 215 to 323 lux (20 to 30 fc), with a 3:1 average-to-minimum ratio. Control of glare for roadside establishments is always a major issue; it needs to be evaluated on site and from the roadway as observed from approaching vehicles.

Appropriate horizontal and vertical illuminance can 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. Store interior merchandise lighting should follow the recommendations contained in IES RP-2-01, *Lighting Merchandising Areas*. 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**, for example). The design team should work to eliminate a condition where windows act as a mirror, making it difficult for clerks and customers to view the lot and pump areas. Tilting or coating store window glass can also avoid this condition, as can controlling the reflectance values of objects reflected in the window. For example, dark-colored merchandise does not usually present an image reflected in the glass; however, mostly *white* merchandise can be more of a design challenge. Covering windows with opaque sales promotion material that blocks the view through the windows should be discouraged. Clerks should also be clearly visible to outside customers. For locations that have franchised restaurant facilities with drive-up and counter service, the designer should also refer to the guidelines in **Section 8.2.10**.

Figure 28. The in-store clerk has a clear view of the pump island outside. (Photo courtesy of OSS – Law Enforcement Advisors®)

Figure 29. A well-lighted entrance to a dormitory building ensures 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.
(Provided courtesy of OSS — Law Enforcement Advisors®)

8.2.12 Single-Family and Duplex Residences. Most often, illumination of exterior doors (see **Figure 29**) is for the identification of callers, for safety, and for more routine tasks such as finding keys quickly and locating lock keyways. Light from luminaires installed beside the door aid in face recognition through peephole security viewers or door windows. If a luminaire is mounted overhead, it should not be located directly above or behind where the visitor would normally be standing. The minimum vertical illuminance for security lighting at exterior doorways should be no less than 11 lx (1.0 fc), measured 1.5 m (5.0 ft) above the doorway threshold or at the midpoint elevation of the viewing device or door window, and out to a radius of at least 3.0 m (10 ft). If background illumination exceeds 34 lx (3.2 fc), the facial illumination should be no less than one-fourth of the background; otherwise, the face becomes silhouetted and is indistinguishable.

Most residential lighting fixtures at the entrance door are controlled by a toggle switch inside the residence; however, sensor-controlled light fixtures that activate upon approach are highly recommended. As visitors approach, the sensor-controlled light will turn on, and the caller perceives 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 fixture 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 toward approach paths can be an effective deterrent. Floodlights facing the street need to be adjusted so that vehicle or pedestrian traffic on adjoining roads does not trigger the system. Very careful design and installation are 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 (e.g., see **Figure 30**).

Plant and landscaping materials can have uplighting to eliminate shadows or hiding spaces and for esthetics (see **Figure 31**).

Figure 30. Top visors that limit glare and wasted uplight are recommended. (©Illuminating Engineering Society)

Figure 31. 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.)

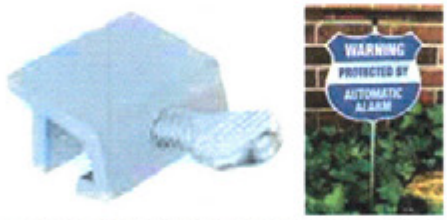
The interior of the home should have several timer switches that operate light sources throughout the hours of normal use. The timing pattern should be adjusted to the behavioral patterns of the residents. The homeowner should not wait until going out of town to establish this practice. Neighbors should be educated about the light patterns. For long life and energy savings, compact fluorescents and LEDs provide an ideal light source type for these timer-controlled table light sources. Light sources should be located in a bedroom, a 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 secure lighting pattern. This serviceable pattern is most effective when it flows from the exterior approach into the relative safety of their favorite secure haven in the home. Timer controls, infrared sensors, or photocells can effectively augment established patterns.

Many local law enforcement agencies will conduct a crime prevention survey for local residents. In some states, completion of a crime prevention survey with corresponding low-cost upgrades will entitle the homeowner to meaningful reductions in their annual cost of insurance. The use of trained crime prevention professionals is also an option. In addition to other recommendations, these assessments may include such additional security options as:

- Sensor-controlled light sources for frequently used movement areas
- Secondary track locks on all windows and sliding glass doors (e.g., **Figure 32a**)
- Deadbolt locks on all doors in addition to doorknob locks
- Pin locks for sliding glass doors
- Central-station alarm monitoring of intrusion, panic, and fire
- Signage for such programs as Operation Identification,[46] Crimewatch,[47] yard and window alarm signs (e.g., **Figure 32b**)
- A trained dog at the residence
- Defensive weapons such as oleoresin capsicum (pepper spray) or a firearm

For emergency conditions when the resident is under a perceived direct threat, such as a potential repeat of a violent confrontation, consideration should be given to securing a peace bond[48] or restraining order[49] from a local, state, or provincial court. Such action, in conjunction with a detailed assessment of the residence and workplace can be very helpful. As a part of upgrades, additional sensor-controlled lights may be installed on each side of the residence so that any night approach will trigger illumination.

If the resident opts to keep a firearm in the residence for protection, child access should always be



Figures 32a, 32b. Window locks (e.g., left image) and signage can be simple and relatively inexpensive security devices. (Images courtesy of OSS – Law Enforcement Advisors®)

controlled, and a state or nationally approved *carry law* or *refuse to be a victim* course should be taken. Training with firearms in low-light conditions is also recommended. Further, the residents should consider storing a portable flashlight near their defensive firearm for emergencies. The defensive firearm acquisition, retention, training, and carrying course should include study of the possession and carry laws for the state where the resident lives and travels. In addition, security lighting and other defensive measures that will limit the likelihood of having to rely on such force should be installed.

Designers working on security projects for predominately single-family home communities will find important detail regarding street lighting in IES DG-21-15, *Design Guide for Residential Street Lighting*.

8.2.13 Multi-family Residences and Dormitories. Multi-family residences 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. Owners and managers of multi-family facilities should consider this when planning the security of their properties. Special attention should be given to vandalism, graffiti, and local crime statistics reported by residents, security agencies, and law enforcement agencies. This 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.

8.2.13.1 Common Areas. Common areas such as hallways, stairways, entrances, and assembly areas have critical safety and security considerations of their own. Lighting that enables recognition of faces is essential to determine who belongs in the space and who does not, who may be perceived as secure and who may present a danger. An average maintained illuminance of at least 32 lx (3.0 fc) should be provided from ground or floor level to 1.5 m (5.0 ft), with an average-to-minimum uniformity ratio of 4:1. If the residential complex shares a common, open or enclosed, mailbox area, the space should be uniformly illuminated to an average of 108 lx (10 fc) at floor level and at 1.5 m (5.0 ft) above the floor, with an average-to-minimum uniformity ratio not greater than 3:1.

8.2.13.2 Other Interior 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. Design consideration to locate and illuminate probable hiding or seclusion areas where perpetrators can prey on tenants approaching or exiting these areas is important. This includes spaces under stairways, unsecured storage lockers, vending areas, roof access wells, and furnace and maintenance rooms. Transitional lighting should be provided for all exits.

8.2.13.3 Individual-Residence Controls. Individual residences should have, as a minimum, an individual luminaire by every entry door, 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. Luminaires installed on one or both sides of the exterior door aid in face recognition through the peephole, security viewer, or door window. If the luminaires are mounted overhead, they should not be located directly above or behind where the person would normally be standing. The minimum vertical illuminance for security lighting at exterior doorways should be no less than 9 lx (0.8 fc), measured 1.5 m (5.0 ft) above the doorway threshold or at the midpoint elevation of the viewing device or door window, out to a radius of at least 3.0 m (10 ft). If the background illumination exceeds 34 lx (3.2 fc), the facial illumination should be no less than ¼ that of the background; otherwise, the face becomes silhouetted and is indistinguishable.

8.2.13.4 Parking Areas. *When security is an issue*, lighting for parking structures or open parking areas should be consistent with recommendations contained in **Section 8.2.6** and **Section 8.2.7**. In low-risk conditions, the lighting should be in accordance with the recommendations contained in IES RP-20-14-Revised, *Lighting for Parking Facilities*.

8.2.13.6 Maintenance Considerations. Maintenance of luminaires for a multi-family residential complex is a particularly vexing problem. Stocking the number and variety of light sources 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 personnel should 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 patrol a property, this inspection process should be performed daily as the officer makes rounds, and should be reported on his daily activity log or other forms. In addition, if battery-operated lights are used, spare batteries and light sources should be available.

8.2.14 Senior Living Multi-resident Facilities. 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. ANSI/IES RP-28-16, *Lighting and the Visual Environment for Seniors and the Low Vision Population,* includes specific recommendations for senior citizens and those who may be sight-impaired. Some of the key recommendations in this publication that pertain exterior illumination include:

- Parking garage entrance: An average maintained illuminance of 538 lux (50 fc) during the day and 161 lux (15 fc) at night
- Exterior walkways: An average maintained illuminance of 54 lux (5.0 fc), with an average-to-minimum uniformity ratio of 3:1
- Designers should also ensure that these recommended illumination levels are maintained levels with an average-to-minimum uniformity ratio of 4:1.

Parking garages may offer a seeing problem for older drivers and pedestrians. Seniors' ability to adapt to rapid and/or extreme changes in luminous intensity diminishes with age. They typically drive more during the day than at night because they are more sensitive to glare, such as from oncoming headlights. Most parking garages have very low illuminance levels as compared with daytime exterior 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 to illumination level changes.

Glare and contrast levels are important to seniors. Their sensitivity to glare from exposed point sources is extreme. Bare light sources and luminaires whose surface brightness exceeds 850 cd/m² should be well shielded. Contrast is one of the most important visual cues for older people. Doors, handrails and obstructions should have good contrast with their backgrounds.

When security is an issue, the recommended security and safety illuminance for open parking facilities for senior living is average of 65 lx (6.0 fc) on the pavement and to a 1.5-m (5.0-ft) height above ground level, with an average-to-minimum uniformity ratio not greater than 3:1 maintained throughout the hardstand. Sidewalks, footpaths, and grounds around or supporting parking lots should be illuminated to an average of 54 lx (5.0 fc), with an average-to-minimum uniformity ratio not greater than 3:1. For multi-level interior parking garages designed for the elderly, the recommended minimum is an average of 129 lx (12 fc) on the pavement, with approximately the same values measured at 0.9 and 1.5 m (3.0 and 5.0 ft) above the pavement, and with an average-to-minimum uniformity ratio not greater than 3:1. Back-up generators or battery-operated lighting is necessary in all public access locations, such as parking space areas, stairwells, elevators, and exit ramps. In locations where residents gather, such as at elevators and stairs, lighting levels should be increased to an average of 215 lx (20 fc) in a 9.1-m (30-ft) radius from the center of the gathering point, with an average-to-minimum uniformity ratio not greater than 4:1.

8.2.15 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. *When security is an issue*, parking facilities should be illuminated to at least an average of 32 lx (3.0 fc) on the pavement, with an average-to-minimum uniformity ratio of 4:1 or better. Sidewalks, footpaths, and surrounding grounds supporting mass movement of persons should be illuminated to an average maintained illuminance of 11 lx (1.0 fc) from the ground up to 1.5 m (5.0 ft), with an average-to-minimum uniformity ratio of 4:1.

8.2.16 Educational Institutions and Schools. The traditional role, hours of service, and occupancy rates of community schools and institutions of higher learning are changing. In the past, most educational facilities were primarily used only during daylight hours and only nine months out of the year.

Figure 33. Lighting for vehicular and pedestrian traffic facilitates surveillance when security issues are a high priority on campus. Compare and contrast with the dark side of the building, which was not considered in the lighting design. (Photo courtesy of OSS – Law Enforcement Advisors®)

There are now sporting events, evening classes, community meetings, and organizational activities, all of which may meet during the evening hours. *When security is an issue*, exterior parking facilities (e.g., see **Figure 33**) should be illuminated to at least an average maintained illuminance of 32 lx (3.0 fc) on the pavement, with an average-to-minimum uniformity ratio of 4:1. Sidewalks, footpaths, and grounds supporting movement of persons (e.g., see **Figures 34 and 35**) should be illuminated to at least an average maintained illuminance of 11 lux (1.0 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 all participants have departed campus grounds.

Campus facilities providing after-hour field events should review and consider the guidance provided in **Section 8.2.18**.

During periods of inactivity, some rural and suburban school administrators choose to use a *blackout* method of lighting these facilities to protect buildings and contents. In the *blackout* mode, buildings and

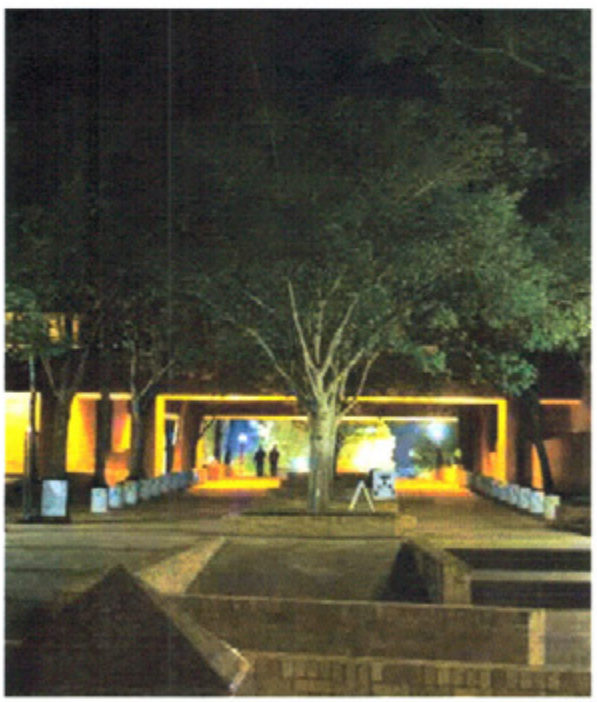


Figure 34. Clearly defined walkways through a campus ensure safe passage for visitors and students. (Photo courtesy of OSS – Law Enforcement Advisors®)

Figure 35. Transition areas between buildings. (Photo courtesy of OSS – Law Enforcement Advisors®)

grounds are deliberately left without any activated illumination. In this approach, patrol officers are aided in detecting individuals using hand-held lighting devices when on the grounds. In addition, energy is conserved and the property is less visible to unknowing passersby. When planning this approach, the designer should consider using a system that allows patrol officers to turn on selective lights when responding to alarm signals or otherwise having determined that the integrity of the facility is being violated. In addition, a layered approach to security that integrates at least two electronic monitoring processes—e.g., sensor-activated lights and door, window, and interior contacts—should be considered. Ideally, access roads and pathways are closed off afterhours as well.

Colleges and universities in the US that receive federal funds are now required to publish their crime and certain disciplinary offense statistics through a uniform reporting system known as the Clery Act. The Act also requires institutions of higher learning to notify students and staff of immediate threats affecting the school, students, or staff. Such warnings are made immediately following confirmation of the emergency and are generally sent in the form of emails, text messages to cell phones, and automated phone call announcements to pre-registered numbers provided by students and staff. (For more information on the *Clery Act* and *foreseeability of crime*, refer to **Annex B**.) Designers and stakeholders responsible for campus security should refer to reported Clery data when planning new facilities or upgrading existing facilities. This review should include lighting design that that can support mass evacuations in case of an on-campus emergency.

Campuses with dormitories or offsite fraternity or sorority houses should review and consider implementation of the guidance provided in **Sections 8.2.6, 8.2.7,** and **8.2.13**.

8.2.17 Vehicle Display and Sales Lots. Many lots will have planned average illumination on the surface of the lot of 215 lx (20 fc) or more. Because vehicle color is important to the potential customer, fixtures and light sources are selected with a maximum color range. It is common for vehicle display lots to have more than $10 million in inventory displayed at any one time. This amount climbs dramatically when you consider inventories of heavy equipment and lots for over-the-road trucks. Given the amount of inventory combined with the need for high-volume sales, it is little wonder that vehicle sales businesses often benefit from

major code variances,[53] where lighting codes exist. There is some security lighting consideration in all of the illumination that is highlighting the displayed vehicles and striking the surface of the lot.

Dealers often do not fence their lots and do not restrict access to the vehicles after normal business hours. Perimeter security is limited in many cases to guard rails and ditches that do necessitate a minimum amount of criminal ingenuity in order to steal a displayed vehicle. Despite these vulnerabilities, not all display lots are guarded by trained security personnel. Clearly, *security is an issue* for dealers, and many vehicle retailers could benefit from a detailed physical security assessment (see **Annex A**). Beyond what is current marketing practice for many dealers, a full color spectrum illumination pattern producing 86 to 108 lx (8.0 to 10 fc) with an average-to-minimum ration of 3:1 is recommended for reasonable security, when combined with other *active* security measures.

8.2.18 Sporting and Concert Events. When evaluating security lighting at a location with a sporting or concert facility, and the playing field is included in the analysis process, it is recommended that the assessment team refer to IES RP-6-15, *Sports and Recreational Area Lighting. When security is an issue,* pathways, wayfinding, and parking areas should have average maintained illuminance of 32 lx (3.0 fc), with an average-to-minimum uniformity ratio not greater than 4:1. For additional parking garage guidelines, refer to **Section 8.2.7**. Designers should consider the illumination on the field and in the viewing areas, exit ways and tunnels, and parking areas to allow for an orderly eye adjustment from the brighter lights of the field to the parking lot or public transportation areas.

8.2.19 Taverns, Bars, and Clubs. Businesses open to the public, and social clubs that serve alcoholic beverages, are governed by owner practices, dram shop[56] regulations, and state laws. In many localities, public laws and ordinances consider it a privilege, not a right, to serve alcoholic beverages on a business premises. Clubs' interiors need to be intimate. However, designers and operators should not choose intimacy over safety and security; a balanced approach should be used. By their very nature, taverns, bars, and social clubs serving alcoholic beverages are establishments *where security is an issue.*

General parking areas, sidewalks, footpaths, play areas, and areas adjacent to the structure, should be illuminated to at least an average maintained illuminance of 32 lux (3.0 fc) at grade, with an average-to-minimum uniformity ratio not greater than 4:1. The entrance to the facility should be illuminated for security, safety, and identification of customers. Often the entrance is serviced by a door attendant or greeter assigned the task of determining age, sobriety, and the likelihood that the person is carrying a weapon. Illumination for this purpose, if outside the entry door, should be at least an average maintained illuminance of 86 lux (8.0 fc), with an average-to-minimum ratio of 3:1. In cases where door attendants are only provided during special events, portable lighting that meets these guidelines is acceptable. In those instances where admittance is tightly controlled and crowds or outside lines form, illumination along the pathway where the line is required to form should be at least 54 lux (5.0 fc), with an average-to-minimum ratio of 4:1 for a distance 6.1 m (20 ft) beyond the end of the line of patrons. The door attendant or a designee should make evening rounds before darkness to check exterior lighting and report any needed corrections. If an ATM is located on the premises, management personnel should refer to and follow the guidelines provided in **Section 8.2.5**.

ANNEX A – PHYSICAL SECURITY SURVEY

A physical security survey may go by many names, depending on the person or agency performing the task. It may also be known as a security audit, security risk assessment, vulnerability or criticality analysis, or need assessment. The assessment request may designate a specific area of concern or be general in its tasking. No facility can be provided with protection plans without a logical process to evaluate risks to life and property and, as applicable, implementation of appropriate countermeasures.

A survey team might include the following members: the facility manager, security director, security consultant, architect, lighting designer, a representative from any security and/or safety committees, and a representative of a contract security company or police department who is employed on the site. In the case of health care institutions, it is wise to include a clinical representative, or patient care professional.

The purpose of any physical security survey is to gauge the risks, the vulnerabilities at a particular site, and the effectiveness of existing security (policies and procedures, hardware and personnel performance) in addressing those risks. The outcome may include a series of recommended short-term, intermediate, and long-term improvements, 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 security risks involved. The role of lighting is a critical component in a risk analysis, and the lighting system should be evaluated in conjunction with any other planned physical security measures. The assessment team should remember that many criminals prefer to work in the dark.

A.1 Factors to Consider

In determining the vulnerability level, as much objective information as possible should be gathered about the location and its surroundings. A site visit should take place both during the day and at night. Illuminance readings should 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
- Whether there signs of gang activity such as graffiti on walls or equipment boxes
- The current site use, population, or zoning (if any)
- Ways in which the intended and unintended uses of surrounding properties can affect the vulnerabilities or risk of the property being assessed

A.2 Space

Safety and security are enhanced when people can see each other within a 9.1m. (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, ignore, or defend against the other person, if necessary. Confined areas and areas that restrict the ability of people to see ahead 9.1m (30 ft) increase the ability of would-be attackers to surprise potential victims. Lighting can play a key role in the defense principle of allowing individuals to see potential threats and identify escape routes at greater distances, and potentially deter would be attackers due to the probability of being discovered before or during the commission of the crime.

A.3 Open Sight Lines

Elements of *hardscape* (buildings, retaining walls, sidewalk) and *softscape* (trees, bushes, plant materials), all have an effect on the lighting design. Areas that have no hard corners, hiding places, or obstructions to lines of sight, and which use low-level landscaping, have a tree canopy trimmed to at least 2.1m (7 ft) above the ground, and are well maintained enhance feelings of personal security. 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 compromise the most elaborate lighting designs.

A.4 Patrol Response Time

In designing a safety and security program, the lighting designer needs to consider how lighting can enhance the visual effectiveness of the on-site patrol force. Relevant questions may include:

- How often is this area 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 glare that will limit the ability of the patrol to see into areas in spite of illumination?
- How easy is it for emergency personnel to identify buildings and locations on the site from the streets?
- How can lighting enhance or inhibit 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 to five minutes or less. Internal facility or base security personnel often have quicker response times, due to shorter distances of travel, greater familiarity with the property, and a smaller population to serve. Operations utilizing security patrols may designate maximum response times, and it is wise to periodically test those response times. The lighting designer may need to consider this time factor in the final design package, such as active sensor controlled interactive video or

voice response. For example, a small plant or office building in a rural county may need more active and passive protection at the site, as rapid response is simply not practical.

A.5 Supplemental Security Design

Increasingly, security strategies include the use of electronic surveillance to supplement the onsite surveillance by both public police and private security. Electronic security, including closed-circuit television (CCTV), may provide continuous monitoring capabilities that are not as efficient as security patrols. In many instances, CCTV systems are not continuously monitored but rather recorded for playback after an incident has occurred and been made known to authorities or management. In either application, lighting is a critical part of an electronic security surveillance design that is integrated into the overall security design. Although cameras capable of operating under infrared and low-level lighting are available, the quality of video images used for identification, response, and investigation is enhanced by ensuring that adequate lighting exists. Where CCTV is utilized, lighting designers should consider the camera manufacturer's recommendations and limitations.

A.6 Survey Process

The survey process includes several steps. Surveys should be conducted as needed (and especially after a serious incident) on built properties; surveys are often conducted when new construction or renovation of an existing property takes place.

A.7 Survey Tools

The tools the survey team will need include:

- Laptop, tablet, or 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
- Small flashlight
- Digital camera to aid memory recall
- Distance measuring device (e.g., tape, wheel roller, or laser)

Two people are optimum for most assessments and taking light measurements. The survey team should not ignore considerations for personal protection, especially in locations that are considered moderate-to-high risk areas. An assessment template or survey guideline needs to be created that ensures that all critical areas are included in the assessment. A lighting survey for senior citizen housing, for example, should include assessment of the lighting on both sides of the property lines, at the bus stops, at parking lot entrances, in the 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 inside the elevators, in front of the mailboxes, inside and outside the emergency exits, and in the stairwells and corridors.

A.8 Recording Light Values

Illuminance measurements should be noted in the survey plan. (For details on taking and recording photometric readings, refer to **Annex B**.)

A.9 Technical Specifications

As part of the survey process, technical specifications of lamps, luminaires, locations, aiming angles, mounting heights, and controls should be examined to see whether existing conditions require change. Important lighting equipment considerations include:

- Quantity of light (lumen output of each luminaire)
- Spatial distribution of light (zonal lumens, beam angles)
- Spectral distribution of light (color attributes of the lighting)
- Temporal distribution of light (flicker)
- Maintenance requirements
- Optional accessories; e.g., external shields or louvers

A.10 Use of Light Values

Light measurements should be performed in a manner facilitating comparison with predicted values and applicable criteria. *When security is an issue,*

**Light meters should be calibrated (and periodically recalibrated) according to manufacturer's recommendations. Refer to IES *LM-50-13, IES Approved Method for Photometric Measurement of Roadway and Street Lighting Installations*, for appropriate field measurement procedures.

measurement of light values on properties allowing public access should be performed and recorded on a recurring basis.

A.11 Additional Factors of Lighting

In addition to taking objective light meter readings and evaluating technical specifications, subjective aspects should be considered. It is wise to consider the advice of non-technical personnel, representing both sexes and a range of ages, 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 create a sense of fear or security? Are the shadows harsh, creating very dark areas, or are they soft, permitting one to look into the shadows easily?

A.12 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 intruder's face will appear in silhouette. Conversely, neighboring property management or civil authorities may complain of spill light. Ambient light that spills over onto neighboring properties or into the wrong internal area(s) can be controlled with 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 personnel 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. Glare, however, in the wrong areas can limit the ability to see a perpetrator. Just as glare can hinder the trespasser, it can also hinder the police officer or security officer who is patrolling from the perimeter. If glare is used within a facility, it should 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.

A.13 Special Needs

In addition to the security requirements already discussed, the visual needs of senior citizens should be considered. Older eyes have special needs. (For more information on security lighting for the elderly and sight challenged individuals, refer to **Section 8.2.14 Senior Living Multi-residence Facilities** and to ANSI/IES RP-28-16, *Lighting and the Visual Environment for Seniors and the Low Vision Population.*)

A.14 Structuring the Assessment

Assessments should be as thorough and visually graphic as possible. **Figures A1 and A2** show examples of lighting maps that were designed based on a lighting assessment in a northeastern US community. The crime data is for the year 2000, and results are indicated using icons. For each building development, lighting values were taken in footcandles and plotted on the site maps.

A.15 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 estimated or quoted cost involved for each. Qualified lighting professionals can provide the necessary data.

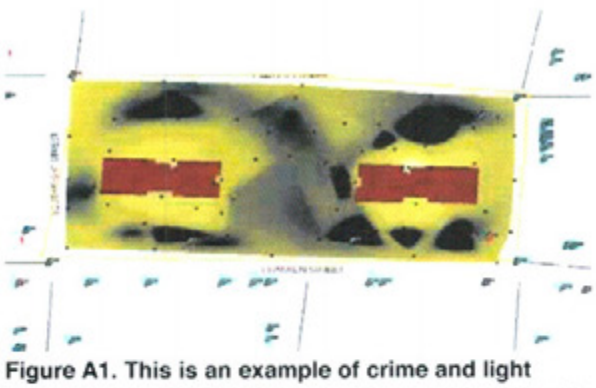


Figure A1. This is an example of crime and light mapping used for crime assessment associated with high-rise buildings for the elderly. Black dots are the locations where readings were taken around the property, while the light blue pistol symbols indicate where a reported crime occurred on or adjacent to the property over a given period. The red "human" figures represent where an individual was injured during a criminal event. (Provided courtesy of SPARTA Consulting Corporation)

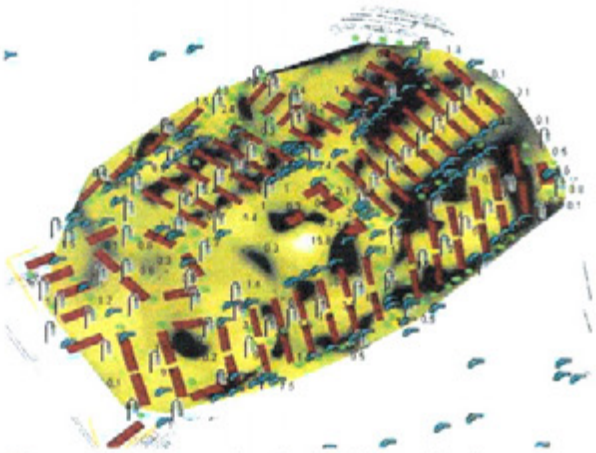


Figure A2. An example of a lighting and crime assessment in and around a multi-family housing complex, using a light map associated with an apartment complex. Locations of light poles and of crime are shown, as well as location of trees. Numbers indicate the location of the light reading, with the value in footcandles. (Image provided courtesy of SPARTA Consulting Corporation)

ANNEX B – TAKING SECURITY ILLUMINATION MEASUREMENTS: A WORKING PROTOCOL

B.1 Background

Taking lighting measurements in the field for security purposes is often quite different in practice and purpose from taking measurements for other kinds of lighting applications. Security lighting recordings are often performed by police officers investigating a crime scene. They may also be performed by a security officer or maintenance personnel making rounds, property managers, or a security consultant reviewing a site for regulatory compliance or evaluating an incident location. As a result, the recordings need to be conducted efficiently, consistently, with minimal calculations, and with the use of practical equipment accessible to the public.

The guidelines in this Annex are written especially for police officers, security personnel, risk managers, maintenance personnel, accident reconstructionists, property and facility operators, and non-lighting professionals.

Depending on the reason(s) for the assessment, evaluation of the lamps and maintenance schedules may be appropriate. Both can have a meaningful impact on the results. If the lamps are new, the results are typically higher than the original design called for, and if older, the rated results will be below the design illuminance. Dirty lenses, faulty wiring, and misaligned lamps can all influence results.

For the purposes of conducting site lighting assessments in a professional capacity, the process should be well documented, such as presented in this document, or a methodology that can stand the test of peer review or litigation should be developed and documented.

B.2 Preparing for the Evaluation

Preparation, planning and study are essential for security lighting surveys. First, if possible a typical night should be selected. The important thing is to document existing conditions and, when practical, qualify observed conditions, such as levels under *moonlight* or *sky glow*. An average night, hypothetically, will have a sky with half cloud cover, a mid-phase moon, no rain, no snow cover, and no light trespass from a nearby sporting event. In other words, reasonable, but not perfect conditions are optimal. However, many exposures are open to the public during all hours, and weather conditions and light readings should be taken under representative times and conditions. Site safety and hazards should be determined prior to the survey to ensure personnel safety during the evaluation procedure. This is of particular concern in high-crime locations or those with or recent criminal incidents.

A consistent methodology and procedural application is essential. In today's litigious environment, with 24-hour service and many points of exposure in public places, *point-in-time* surveys have become a means for service owners and operators to assess ongoing compliance and safety. *Point-in-time survey* is a term utilized to point out that site conditions and surroundings are continuously subject to evaluation and change. Luminaire performance, off-premise issues, foliage, air temperature, humidity, power fluctuations, controls, site personnel, and other factors can and do play a role. Some of these elements may be beyond the control of the owner or manager of the site. This needs to be taken into account when assessing the quality of the survey. If readings have to be taken under adverse conditions such as snow cover because of the time of year, these conditions should be noted in the assessment.

B.3 Taking Measurements

The following is a systematic approach to taking security and safety lighting measurements for people and property, *when security is an issue*:

- **Step 1: Regulations, entity standards and/or recommended practices.** The first step

in conducting any type of lighting evaluation is to determine whether there are any specific defined parameters or recommended practices regulating the type of environment to be evaluated. These standards and practices could influence the type of light sources and luminaires required, the placement of luminaires, the measurements that should be taken, the scope of the evaluation, or any number of other factors.

- **Step 2: Select the equipment.** Measuring security lighting is not generally an expensive proposition. An illuminance meter, often referred to simply as a light meter (see, for example, **Figure B1**), is the first requirement. The meter should be cosine- and color-corrected, with range, resolution, and accuracy as described in IES LM-50-13.*** Measurement results should be displayed in either lux or footcandles. Typically, these meters can have a sensor remotely attached to the body by a cord accessory. Meters of this type are produced by a variety of manufacturers, and can be purchased commercially from an industrial meter or instrument shop or an electrical supply house.

  For accurate and consistent results, the meter should be initially calibrated and later recalibrated as recommended by the manufacturer. It is recommended that meter maintenance be documented.

  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; a flashlight; a fisheye level, sometimes called a bull-eye or gradient level; a plot plan or sketch; and recording materials. As a helpful hint, the fisheye level should be attached to the light meter sensor in such a manner that it does not interfere with the sensor head. This will aid in keeping the meter level, if the placement or slope of the terrain is in doubt.

Figure B1. Typical Illuminance Meter. (Provided courtesy of OSS – Law Enforcement Advisors®)

- **Step 3: 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 or satellite imagery and a compass, and the plan or sketch marked accordingly. This will be useful later when describing results, and identifying objects. It is also helpful to evaluate and describe the property in relationship to frontage and side roads and other nearby landmarks.

- **Step 4: Layout of the area to be measured.** Regulations, recommended practices and design considerations may affect the measurement technique, regardless of site layout. The type of area to be measured can help determine a measuring or sampling methodology. Areas that are clearly defined, standard shapes with uniform luminaire placement, such as parking lots, can often be sampled using a straight-line technique that covers a representative section or sections of an area. To take a correct sample, a line or lines should be selected within the area to be sampled that include a good range of what appears to be the best and the worst lighting conditions. The best place to start looking for the lowest values is near the perimeter, between the most widely spaced poles, or directly beneath luminaires. Sampling with a light meter is always recommended to evaluate the results of the visual estimation. Once a line is established, sample measurements can be taken along the line at regular intervals or at predetermined points, depending upon the objectives of the evaluation.

  If measuring an irregular or poorly defined area, such as a curving sidewalk, an exposed ATM or night depository in an outside area, or a crime scene, a determination should be made about where and how many readings will be taken. The number and location of the sample measurement points will be determined by the layout, size, and shape of the area, the spacing of the lights, and the degree of precision desired, and possibly by regulations or recommended

***Refer to IES LM-50-13, *IES Approved Method for Photometric Measurement of Roadway and Street Lighting Installations*.

practices. Taking sample measurements along a line that follows a walkway or sidewalk at a predetermined spacing, or laying out a grid pattern of readings over a crime scene, might also be appropriate ways to sample. For example, to check the security lighting at a large gatehouse entrance that is 27.4 meters (90 feet) across, measurements might be taken at intervals of 1.5 m (5 ft) in a grid pattern. Sample points could be flagged using small cones or chalk. For larger areas, such as supermarket or mall parking lots, the sample points could be spaced at larger intervals, but should be taken in intervals of at most one-half the mounting height. 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 4.8 m (16 ft) on each side of the path to ensure visibility into the areas near where people walk or travel. In addition, readings should be taken on both sides of fences and perimeters of the property, if possible. On the outer side of the perimeter, light trespass should be evaluated.

- **Step 5: Determine height and plane.** Depending on the environment to be evaluated, readings should be taken at ground or floor level with the sensor leveled horizontally. If facial recognition is the primary concern at a location, readings should be taken at 1.5 m (5 ft), or other determined heights above ground level, with the meter in the vertical position (see **Figures B2, B3, B4**). These readings may also need to be

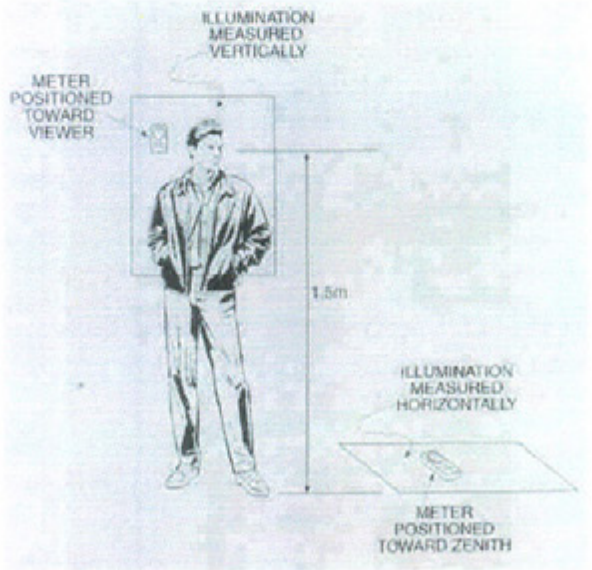


Figure B2. Meter position for measuring horizontal and vertical illuminance. (Provided courtesy of OSS – Law Enforcement Advisors®)

Figure B3. Recording meter reading at point 1, 1.5-meter (5-ft) level. (Provided courtesy of OSS – Law Enforcement Advisors®)

Figure B4. Recording meter reading at point 1, ground level. (Provided courtesy of OSS – Law Enforcement Advisors®)

taken with the sensor positioned on a vertical plane aimed at a light source or camera. In the case of ATM machines, a state statute or local code may require a measurement at 0.9 m (3 ft) above ground level, or similar requirement at the height of an ATM transaction face. In reviewing state or local requirements, one may find non-scientific terms or terms that do not apply to illuminance measurements, such as *footcandlepower, candlelux,* or *candlepower.* When this occurs, it is necessary to seek clarification.

Practical field experience shows that measurements taken above ground are usually comparable to or higher than those taken at ground level. Typically, if the measurement position is moved from ground level to some height above ground, the amount of spill light is reduced, thereby slightly increasing the value average. However, uniformity may worsen, as dark spots get darker and the bright spots get brighter. These above-ground readings could be taken at the same points or locations as ground-level readings. Once the secondary height is determined, the operator should use a tape measure or ruler to locate the proper mounting height for the light meter sensor. Mounting the sensor on a fixed object such as a tripod or other device helps to ensure a consistent sample height. Again, consideration needs to be given to any regulations or recommended practices.

- **Step 6: Taking light reading samples.** No matter what level, plane, or pattern in which readings are taken, it is important to keep the following in mind when taking sample readings:

  - The meter should be set to read the correct units of measure and the proper range of measurement.

  - Awareness of the sensor location and position are critical; tilting the sensor or changing the location of the sensor can greatly affect the result.

  - Allowing the meter time to accurately read and settle in on a reading value is important.

  - The operator should be sure not to block light from reaching the sensor or otherwise cause shadows that might influence the reading. A good practice is to move away from the meter sensor as far as practical, while still being able to read the meter display. This can be achieved using a long cable accessory to connect the sensor head to the meter housing (see **Figure B4**).

  - Results should be recorded in a systematic way, such that each location and value can be easily demonstrated and recreated if necessary. Notes associated with individual reading points may be necessary, depending on the scope of the evaluation.

  - Depending on the nature of the evaluation, it might be necessary to establish a system for verifying the repeatability of the light measurements at regular intervals during the evaluation. This can be accomplished using a control test point on site, as long as the environmental conditions remain constant. Selected control test points should be allowed to stabilize (warm up) before testing.

  - It may be necessary to take readings in multiple patterns or planes, in order to properly evaluate the area of concern.

- **Step 7: Calculating the results.** With the results recorded, the summary data can then be determined. Consideration needs to be given to any regulations or recommended practices.

  For applications requiring an average, all of the horizontal readings in a given area should be added together, and then divided by the number of readings taken. The result will be the average illuminance in lux (footcandles) for the area where readings were taken. For averages, it is important that samples be taken at uniform intervals throughout the area or throughout a representative sample of the area. Extrapolations can be accurate only if the site is illuminated throughout with the same equipment, at the same spacing, and with the same number of burning hours on all the lamps. For sites with a mix of lighting designs or luminaires, each of the differing lighting schemes should be evaluated individually.

  Meeting an *average-to-minimum ratio* is another common criterion for lighting applications. This is usually expressed as a ratio to unity; e.g., an average of ten and a minimum of two will be expressed as 5:1. The *minimum* in the calculation is the lowest fc (lux) reading recorded. For example, using the gatehouse scenario, imagine that the average fc (lux) was 39.8 lx (3.7 fc), and the

lowest fc (lux) reading was 15.1 lx (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 known and can be compared to the recommended criteria.

In some situations, readings should meet a minimum-level criterion rather than an average. As with meeting the average criterion, it is important that samples be taken at uniform intervals throughout the area. Calculating results is as simple as comparing each reading to the standard.

- **Step 8: Vertical illuminance readings.** Lighting that allows identification of faces is 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), at security checkpoints, or for security camera applications. The light meter is held in a vertical position at an average facial height of 1.5 m (5.0 ft) above ground level to determine the incident light on a face. However, in which compass direction should this vertically positioned meter be pointed? For some applications, the answer is simple: for peephole viewing, the meter should face the peephole; for checkpoints, the directions facing the officer when viewing people passing through the checkpoint should be considered. Open and semi-open areas present no such easy determination. In evaluating a site post-incident, readings should be taken in directions as seen by witnesses. An accepted method for determining vertical illuminance readings when no set direction of vision is established is by recording four values in the four cardinal directions (north, east, south, and west). Depending on the location, the four readings may be at wide variance to one another. However, *each* should be sufficient for facial identification, depending on the measured difference between background and foreground illumination. If the background illuminance (behind the face) is more than four times the illuminance on the face, the image will likely be in silhouette. Thus, if the background illuminance is 108 lux (10 fc), the facial illuminance should be above 27 lux (2.5 fc) for 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 to determine that a potential threat exists and decide whether to continue along a path or avoid the area to reduce risk. Cameras will require different amounts of light in order to function properly.

- **Step 9: Determining opportunities for improvement:** Before leaving the site, it is important to 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, or standards, and/or in response to a perceived threat. Such testing and the results are best utilized when part of an overall security effort or inquiry. The survey team should determine what other security issues or questionable practices might apply. 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. Advantageous environmental conditions or security practices may also need to be included in the evaluation. For properties open to the public, security lighting surveys should be performed at least annually. It is important to consider seasonal foliage variables and extreme temperature changes, as this may result in the need for more frequent evaluations. A comparison to neighboring or nearby properties with similar security risks or concerns can be helpful. The lighting on the test property could appear to be comparatively weak. If comparable or neighboring sites have more-robust lighting, or if relighting has occurred at one or more of these properties, the test site might appear attractive as a crime site to persons seeking to stay out of the better-lighted sites nearby. Lighting maintenance inspections for servicing or replacement of luminaires should be performed consistently at regular intervals. These are best performed at night. Frequency of inspections may be determined based on site history, foreseeability of activity and other levels of risk.

ANNEX C – CRIME ANALYSIS AND THE FORESEEABILITY OF CRIME

C.1 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 has occurred on or around the site is instrumental in establishing *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. The study of *foreseeability* is usually the threshold question before the various civil courts when determining whether a designer or property owner has acted reasonably in response to a perceived threat to personal safety or asset protection. *Important:* Lighting designers who are not comfortable with research of crime statistics may want to consult with a crime prevention specialist to perform these analytical tasks, or should explicitly exclude security lighting from their scope of work.

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*, unless overridden by other combined factors. (For more information on when security is an issue, refer to **Section 4.0 Understanding "When 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 (e.g., **Figures C1** and **C2**). In a post-event analysis****, some state courts have mandated an analysis of a specific distance out from the property (e.g., 1 mile, 2 miles, a police beat). Other than in a post-event situation, generally the property itself and the neighborhood (generally 0.8 kilometers [approx. 0.5 miles] radius) may be appropriate. In conducting the first analysis, going back at least two full years should be considered.

****Refer to IES LM-50-13 or IES LM-64.

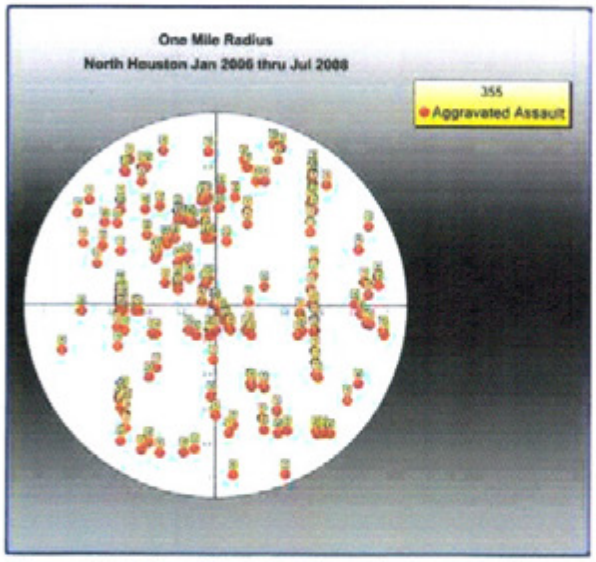


Figure C1. Crime chart showing crimes occurring within a 0.6-km (one-mile) radius of a specific location. (Provided courtesy of OSS – Law Enforcement Advisors®)

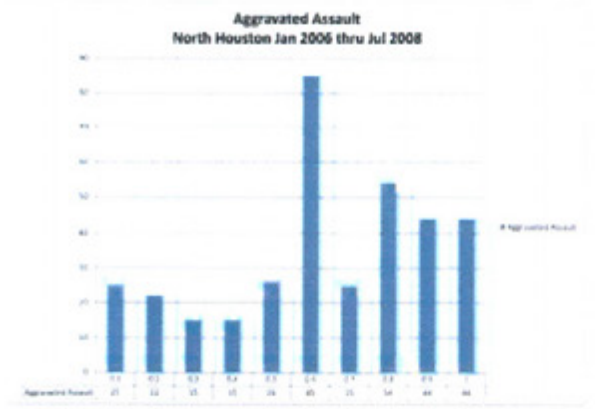


Figure C2. Crime bar chart showing the number of aggravated assaults occurring within a 0.6-km (one-mile) radius of a specific location over a 2 ½ year period. (Provided courtesy of OSS – Law Enforcement Advisors®)

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 capabilities 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.

Due to the inherent vulnerabilities of youth, institutions of higher education are required to report certain offenses through a uniform reporting system under the Clery Act[13] (see **Section C.3.2**). The Act mandates that colleges and schools that received any form of federal financial support are required to report crime statistic data relating to specific offenses detailed in the Act. Such reports are required to be reported to the US Department of Education on or before October 1 of each year and are to be made public to students, staff, and the general public. This collected and reported data can be very helpful when educators and construction, law enforcement, and security professionals are designing new or upgrading existing operations, or for parents and students when choosing a college or university. Accessing this data is easy and can be done by contacting the US Department of Education at http://ope.ed.gov/security/. The reported crime data is also required to be posted on the education institution's website. Unfortunately for those interested in similar data for kindergarten through high school, there is no similar reporting program. As such, researchers need to contact school administrators or local law enforcement for this data.

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 local enforcement agencies can be a meaningful aid from government sources to individual employees, supervisors, and managers when security lighting design is 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.

C.2 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 enforcement agency, such as a police or sheriff's department. The most common form of data collection is through the 9-1-1 emergency operator systems and agency dispatcher logs. (Note: 911 calls do include cell phones, special communications, TTY, etc.) 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 usually not corrected by the responding officer(s) upon arrival or after an initial investigation. For example, a call for service may be recorded as an *assault,* but 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. In relying on *police call reports* as the sole source of criminal activity, these factors should be taken into consideration. The advantage of a call report analysis is that that data is usually readily available, acquired at low cost, timely, and more readily understandable by laypersons than more complicated data.

Police Incident Report: Sometimes referred to as an *offense report,* an *incident report* is originated by the original responding law enforcement officer after arriving at the scene, completing some inquiry, and determining that a violation of the law probably occurred. The reports are usually assigned control numbers, and are logged 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.

C.3 Uniform Crime Reporting (UCR) Program

This is a cooperative crime statistics gathering effort by the United States and Canada. The program began in 1930 in the United States and was subsequently adopted by Canada with some modifications. Reporting by local, state or provincial, and federal law enforcement agencies in both countries is on a voluntary basis. UCR data covers approximately 97percent of the United States population living in *Metropolitan Statistical Areas* (MSAs),[30] and 89 percent of the population residing in smaller communities, cities, and rural counties. Canada receives a similar response in its data collection effort. Some law enforcement agencies do not report UCR data to the national government for a variety of reasons, namely for budgetary or staffing reasons. Mexico does not have a UCR or similar statistical information 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.

C.3.1 Index Crimes[40]. This category includes the most serious crimes as defined, collected, and reported to the United States federal government, and utilized by most other agencies within the UCR program[41]:

- Murder and non-negligent manslaughter
- Rape[42]
- Robbery
- Aggravated assault
- Burglary
- Larceny theft
- Motor vehicle (auto) theft
- Arson[50]

All crime occurring on property may be relevant, 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. The legal definitions of 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.

C.3.2 The Jeanne Clery Disclosure of Campus Security Policy and Campus Crime Statistics Act[13]. Originally enacted by the Congress in 1990 as the Crime Awareness and Campus Security Act of 1990, the Jeanne Clery Act requires all public and private institutions of postsecondary education participating in federal student aid programs to disclose certain timely and annual information about campus crime and security policies. Annual reports to the US Department of Education are to be submitted by the schools no later than October 1 of each year. These reports contain three years of crime statistic data and policy statements on sexual assault, the law enforcement authority of the campus police or security, and where students should go to report crimes.

Statistics may be gathered from campus police or security, local law enforcement, and other school officials who have significant responsibility for student and campus activities.[51] Crimes are reported in seven major categories, which include:

- Criminal Homicide, including:
  - Murder
  - Non-negligent Manslaughter
  - Negligent Manslaughter
- Sex Offences, including:
  - Forcible Sex Offenses (includes rape)
  - Non-forcible Sex Offenses
- Robbery
- Aggravated Assault
- Burglary
- Motor Vehicle Theft
- Arson

The report may also indicate whether any of the reported incidents, or other crime involving bodily injury, was a hate crime. If resulting in arrest or disciplinary referral, schools are also required to report liquor law violations, drug law violations, and illegal weapons possessions. Statistics may also be broken down geographically, illustrating whether they occurred:

- On campus
- In residential facilities for students on campus
- On non-campus buildings
- On public property

A more extensive public crime log is also required under Clery, ensuring that schools that maintain a police or security department disclose in that public crime log … *any crime that occurred on campus…or within the patrol jurisdiction of the campus police or the campus security department and is reported to the campus police or security department.* This is to include the nature, date, time, and general location of each crime as well as its disposition, if known.

The Clery Act also requires schools to provide immediate notification to students and employees to warn against an immediate threat to students and staff. Warnings are issued without any delay following confirmation of an emergency. School policies regarding such warnings are also to be reported with the other statistical and policy data.

C.3.3 Factors Effecting Crime Reporting[52]. The level of crime reported to police or a security department is dependent on numerous variables.

- 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.
- Some incidents are falsely reported to the police as crimes and may not be removed from the crime data.
- Public attitude toward law enforcement causes underreporting of crime, perhaps by as much as 56.9 percent of serious crimes.
- Size, population, and demographic composition of an area may result in many calls for service not being investigated and recorded as incidents.
- Economic status and unemployment rate in an area tend to influence the types of crime that are reported.
- The stability of the population, i.e., the 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.
- Climate may create variations in crime patterns over a short period.
- The level of crime reported may also be affected by standards, practices, and the 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 the third bullet item above. Members of society do not report all crime to police. According to the US *National Crime Victimization Survey (NCVS)*, 2008,[54] only 41.9 percent of all crimes were reported to police. Crimes of violence were reported only 47.1 percent of the time, and only 40.3 percent of property crimes were reported. As to *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. A review of crime statistics as reported by the Bureau of Justice Statistics shows that these figures do not meaningfully change from year to year. To find national data for the last reporting period, contact the Bureau of Justice Statistics online.

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 because they tend to use the police as mediators and authority figures in disputes more than other groups.

The local police, constable, or sheriff's 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. Some of the collection possibilities include:

- **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 the exact address, and compared to other similarly divided areas, or to the city as a whole. Data that is derived from arbitrary sizing such as *"1 square-mile 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 websites that provide a breakdown of city or county crime into subdivisions that can be compared.

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

- **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 or provinces, this information can be another important indicator regarding the allocation of security resources.

- **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 Internet at www.statcan.ca . In Mexico, the contact is the Department de Justicia, in Mexico City. By contacting the United States Department of Justice, Office of Justice Program, and Bureau of Justice Statistics at 800-732-3277, one can access data on the various states and on national crime in the US. 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.

- **International.** During the 1990s, 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.*[55] 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.

C.3.4 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 or property crime (crimes directed against persons or property, respectively) 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: *What is likely to happen on this property in the future?* Also, *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 the crime at the site has been considered, the crime in the patrol beat, city, and/or county should be examined. 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 national and state or provincial 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. When regular users of the property are informed, they are placed on notice and can participate in solutions, while taking necessary personal precautions. Findings should not be concealed from perceived stakeholders.

ANNEX D – 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, pronounced *sep-ted*).

Crime prevention is defined as the anticipation, recognition, and appraisal of a crime risk and the initiation of some action to remove or reduce it. This annex is designed to help design professionals, police personnel, and anyone involved in or concerned with development of a site or area. The concepts and strategies of CPTED are discussed, and illustrations are provided to enhance various applications of CPTED. The principles are site specific.

The concepts and strategies of CPTED can be applied in both existing and new development. Ideally, CPTED concepts should be applied during the design phase to more fully benefit from the applications, as well as to avoid costly changes later.

CPTED 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 (see **Figure D1**). 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 reaction-oriented, approaches to crime. CPTED best works with various elements of the community being involved in a continual process of improvement.

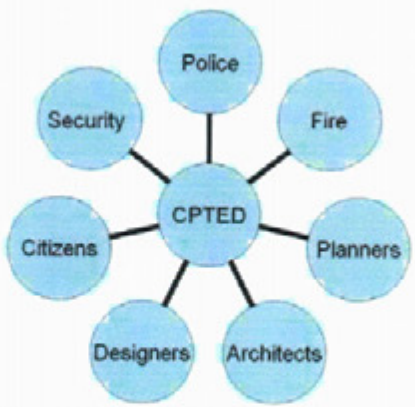


Figure D1. CPTED holistic approach.

CPTED has become increasingly recognized as a cost effective approach in the design or redesign of an environment to reduce the opportunity for crime and the fear of crime through natural, mechanical, and procedural means.

D.1 Summary of CPTED

CPTED and the concepts of safe design have had several significant influences over the years. As early as the 1960s, Jane Jacobs discussed the interaction of the physical environment with its inhabitants, and how important this is in the life and vitality of a street or neighborhood, in *The Death and Life of Great American Cities*. She wrote:

. . . the basis for community security is a strong sense of social cohesion and a feeling of control over one's home turf. . . . The first thing to understand is that the public peace . . . is not kept primarily by the police, as necessary as police are. It is kept by an intricate, almost unconscious network of voluntary controls and standards among the people themselves . . . No amount of police can enforce civilization where the normal, casual enforcement of it has broken down.

In 1969, architect and urban planner Oscar Newman coined the expression *defensible space* when he began his works and study of public housing and its layout, in association with residents' perception of safety and their victimization. In 1975, he continued to write on the subject with *Design Guidelines for Creating Defensible Space,* where the purpose of defensible space was to enable residents to become the critical force in providing thir own security.

C. Ray Jeffery, a criminologist from Florida State University, coined the term "CPTED" and studied the relationship between the built environment and the incidence of crime. In 1982, James Wilson and George Kelling wrote *Broken Windows*. Their theory states that maintaining and monitoring urban environments to prevent small crimes, such as vandalism, public drinking, and toll-jumping, helps to create an atmosphere of order and lawfulness, thereby preventing more serious crimes from happening. A primary concept of *Broken Windows* is that in any neighborhood, if a building is left with a broken window or graffiti long enough, disorder and decline of the building and surrounding area will escalate and spread.

In 1991, Timothy D. Crowe, the former Director of the National Crime Prevention Institute (NCPI), authored *Crime Prevention Through Environmental Design – Applications of Architectural Design and Space Management Concepts*, which broadens the field concepts into school and campus environments, convenience store design, residential development, parking lots and garages, office development, and malls and shopping centers. CPTED applications are now a federally supported program.

D.2 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 esthetically pleasing built environment. The goal is to create a climate of safety by designing environments that positively influence behavior, encourage desired activities, and discourage undesired ones. Additional objectives focus on crime prevention 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 providing adequate parking lot lighting. Shrubs should be kept trimmed to a maximum of 0.9 m. (3 ft) or at least below windowsills, and tree canopies should be trimmed up to 2.1 m (7 ft) *when security is an issue* (commonly known as the *7-3 Rule*).

CPTED principles applied to lighting design in a public access area include the use of luminaires that are tamper-proof, durable and, where practical, 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 stakeholders. They fall into three primary categories: normal users, abnormal users, and observers. The environment should 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?
- Does the facility or space correlate with the surrounding environment adequately?

Designation:

- What is the designed purpose of the space?
- Will the new facility or space fulfill the original intention?
- How well does the facility or space support its current use or its intended use?
- What, if any, conflicts exist with the proposed use of the facility or area?

Definition:

- How is the facility or space defined?
- Is it clear to the normal user or observer who owns the space?
- Are the borders of the facility or space clearly defined?
- Do any social or cultural definitions of the facility or space affect how the area will be utilized?

Design:

- Does the physical design support the intended function of the facility or space?
- Does the physical design of the facility or space support the definition with respect to desired behaviors?
- 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:

- Lighting should provide clear border definition of controlled spaces.

- Strategic lighting should clearly mark any transitional zones, i.e., areas where there is movement from public to semipublic to private spaces.

- 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.

- Distant or isolated areas should be evaluated for improvement using CPTED principles for lighting design.

- Lighting of formal gathering areas should be adequate for normal users, thus creating the perception that all other areas are *off limits*.

- 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).

D.3 CPTED Principles

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 identifiable 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. The presence of access control and surveillance contribute 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.

ATMs are a particular example of *image and maintenance* principles. Patrons will be obtaining cash. Among other recommendations, emphasis should be on open sight lines and visibility, especially at night. Customers should be advised to look out for loiterers and to take their receipt to avoid identity theft. How could CPTED concepts be better applied here?

There are 25 opportunity-reducing techniques of situational crime prevention and crime prevention through environmental design (see **Table D1**).

Some of the problem solving techniques suggested range from traditional target hardening strategies to more sophisticated technologies such as crime mapping and electronic camera surveillance systems.

The authors of this Guide trust that this brief overview of CPTED and its applications has provided the reader with a basic understanding of how these techniques can be applied to a given project where security is especially a concern. This Guide may conflict with local, state, or provincial ordinance, or with the US *Uniform Statewide Building Code* (USBC) in some occupancy types. Of course, when making recommendations or considering a course of action, it is important to recognize that these *do not guarantee a crime-free environment.* Experience demonstrates, however, that the application of CPTED principles does reduce the opportunity for crime, and can enhance quality of life.

Table D1. Techniques for Reducing the Opportunity for Crime.

Increase the Effort	Increase the Risks	Reduce the Rewards	Reduce Provocations	Remove Excuses
1. Harden targets • Steering column locks and immobilizers • Anti-robbery screens • Tamper-proof packaging	6. Extend guardianship • Take routine precautions: go out in group at night, leave signs of occupancy, carry phone • "Cocoon" neighborhood watch	11. Conceal targets • Off-street parking • Gender-neutral phone directories • Unmarked bullion trucks	16. Reduce frustrations and stress • Efficient queues and polite service • Expanded seating • Soothing music/muted lights	21. Set rules • Rental agreements • Harassment codes • Hotel registration
2. Control access to facilities • Entry phones • Electronic card access • Baggage screening	7. Assist natural surveillance • Improved street lighting • Defensible space design • Support whistleblowers	12. Remove targets • Removable car radio • Women's refuges • Pre-paid cards for pay phones	17. Avoid disputes • Separate enclosures for rival soccer fans • Reduce crowding in pubs • Fixed cab fares	22. Post instructions • "No Parking" • "Private Property" • "Extinguish camp fires"
3. Screen exits • Ticket needed for exit • Export documents • Electronic merchandise • tags	8. Reduce anonymity • Taxi driver IDs • "How's my driving?" decals • School uniforms	13. Identify property • Property marking • Vehicle licensing and parts marking • Cattle branding	18. Reduce emotional arousal • Controls on violent pornography • Enforce good behavior on soccer field • Prohibit racial slurs	23. Alert conscience • Roadside speed display boards • Signatures for customs declarations • "Shoplifting is stealing"
4. Deflect offenders • Street closures • Separate bathrooms for women • Disperse pubs	9. Utilize place managers • CCTV for double-deck buses • Two clerks for convenience stores • Reward vigilance	14. Disrupt markets • Monitor pawn shops • Controls on classified ads. • License street vendors	19. Neutralize peer pressure • "Idiots drink and drive" • "It's OK to say No" • Disperse troublemakers at school	24. Assist compliance • Easy library checkout • Public lavatories • Litter bins
5. Control tools and weapons • "Smart" guns • Disabling stolen cell phones • Restrict spray paint sales • to juveniles	10. Strengthen formal surveillance • Red light cameras • Burglar alarms • Security guards	15. Deny benefits • Ink merchandise tags • Graffiti cleaning • Speed humps	20. Discourage imitation • Rapid repair of vandalism • V-chips in TVs • Censor details of modus operandi	25. Control drugs and alcohol • Breathalyzers in pubs • Server intervention • Alcohol-free events

ANNEX E – GOVERNMENT APPROVALS

Government regulations, codes, or local ordinances that regulate lighting may dictate 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 or standards concerning light trespass, glare, and light pollution. Some governmental entities have a project approval process that requires formal application and review. This is particularly applicable to larger municipalities. In some instances, these regulations encompass new construction standards or changes to existing layouts, resulting in increased illuminance or different types of light sources. Regulatory boards may require a formal presentation of the proposed design before the board.

When a formal presentation is required, it is important to provide detailed information regarding the scope of the project and the justification for the lighting layout. Experience shows that some existing standards and codes are outdated, do not make allowances for technological developments, and were written to address some past political expedience. *When security is an issue*, it may be necessary to ask for a variance,[53] or deviation, from the established standard. The following should be considered for inclusion in a presentation:

- Description of the property or facility and how it is to be used
- Drawings showing pole placement and spacing, pole heights, and types of luminaires to be installed
- Special security needs at the site
- Explanation as to why *security is an issue* at this location

When documenting why *security is an issue*, it will often be helpful to complete a statistical analysis of the site under consideration and the surrounding area. In addition, a tour surrounding properties and the neighborhood should be part of the preparation, including measurement and documentation of what is observed. Photometric measurements and photographs of neighboring sites with poor or excessive lighting schemes are very helpful, especially when offering an improved systems approach.

It is not reasonable to go into such a governmental hearing assuming acceptance of the presentation. Public entities, and especially regulatory boards, often see themselves as defenders of the existing regulation, no matter how outmoded or impractical it may be. The presenter should be prepared to argue that the *protection of persons should trump vague or arbitrary regulations*.

It is very important from the risk management perspective to document a variance request and the final decisions of the board. If the request for an adequate security lighting system is rejected, the designer should consider respectfully placing the board on notice that the operator of the facility may not be able to provide reasonable security and safety to users of the property, and that the board's rejection of the proposed lighting design may bear some liability for the board. Should the rejection stand, the designer may want to consider further discussions on this issue with legal counsel and the insurance underwriter's risk management team before proceeding.

ANNEX F – ADDITIONAL RESOURCES ON LIGHTING AND CRIME

Arnheim R. *Art and Visual Perception: A psychology of the Creative Eye*. Berkley and Los Angeles: University of California Press; 1967.

ATM Security: Banker's Resource Kit. American Bankers Association. 1994.

Barr R. Lawes H. *Towards* a *Brighter Monsall: Street Lighting* as *a Factor* in *Community Safety - the Manchester Experience*. Manchester, UK: Manchester University; 1991.

Boyce PR, Rea MS. *Human Factors in Lighting*. London: Taylor and Francis; 2003.

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Online Resources:

http://www.popcenter.org/library/reading/PDFs/60steps.pdf

http://www.popcenter.org/library/reading/pdfs/crimeanalysis25steps.pdf

American Institute of Architects [AIA] – www.aia.org

American National Standards Institute [ANSI] – www.ansi.org

American Society of Industrial Security [ASIS] – www.asis.org

Canadian HR Reporter – Journal of Human Resources Management – www.hrreporter.com

Factory Mutual Research Corp. [FM] – www.fmglobal.com

International Code Council [ICC] – www.iccsafe.org

International CPTED Association [ICPTEDA] – www.cpted.net

International Facilities Management Association [IFMA] – www.ifma.org

International Organization for Standardization [ISO] – www.iso.org

National Association of Industrial & Office Properties [NAIOP] – www.naiop.org

National Crime Prevention Council [NCPC] – www.ncpc.org

National Institute of Justice, U. S. Department of Justice, Office of Justice Programs – www.ojp.usdoj.gov/nij/

National Institute of Standards & Technology [NIST] – www.mist.gov

Security Industry Association [SIA] – www.siaonline.org

Security Management – www.securitymanagement.com

Underwriters Laboratories [UL] – www.ul.com

U. S. Department of Homeland Security [USDHS] – www.dhs.gov

U. S. Department of Justice [USDOJ] – www.doj.gov

END NOTES

1. *RP-10 American National Standard Practice for Protective Lighting.* Protective Lighting Committee, Illuminating Engineering Society. 1977.

2. Illuminating Engineering Society of North America (IESNA), in 2010 changed its name to Illuminating Engineering Society (IES).

3. ANSI/IES RP-28-16, *Lighting and the Visual Environment for Seniors and the Low Vision*

Population. Lighting for the Aged and Partially Sighted Committee, Illuminating Engineering Society. 2016.

4. Security Lighting Presentation, February 2010.

5. Security Lighting Presentation, January 2011.

6. University of Mississippi, January 2011.

7. Security Lighting Presentation, February 2011, and May 2011.

8. Published at www.ossrisk.com, February 2011.

9. Incandescence is exploited in incandescent lamps ("light bulbs"), in which a filament is heated to a temperature at which a fraction of the radiation falls in the visible portion of the electromagnetic spectrum. The majority of the radiation, however, is emitted in the invisible, infrared portion of the spectrum, rendering incandescent lights relatively inefficient as a light source.

10. *Crime*. A wrongdoing classified by a state or national government, usually classified as either a felony or misdemeanor. A crime is an *offense* against a public criminal law.

11. *Due diligence*. The care that a reasonable person exercises to avoid harm to other persons or their property. Also, research and analysis done in preparation for a recommendation or transaction.

12. *Crime Prevention Through Environment Design (CPTED)*. (For more information of this program, see **Annex D**.)

13. The Jeanne Clery Disclosure of Campus Security Policy and Campus Crime Statistics Act, or Clery Act, is a federal statute codified at 20 U.S.C. § 1092(f), with implementing regulations in the US Code of Federal Regulations at 34 C.F.R. 668.46.

14. *Nadir*. The direction pointing directly below a particular location; the opposite of *zenith*.

15. Crime in the United States, 2009 Federal Bureau of Investigations.

16. See ANSI NEMA ANSLG C78.377: www.nema.org/stds/ANSI-ANSLG-C78-377.cfm This document is now used for indoor and roadway lighting: http://www.nema.org/stds/C136-37.cfm

17. For more detailed information on LED development applications, see a listing of available data at http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_standards.pdf

18. *Economy of force*. The principle of employing available security resources in the most effective and efficient manner practical, in an attempt to allocate a minimum of resources necessary to accomplish established goals.

19. *Critical infrastructure*. Assets, systems, and networks, whether physical or virtual, so vital to the United States that the incapacity or destruction of such assets, systems, or networks would have a debilitating impact on security, national economic security, public health or safety, or any combinations of those matters.

20. *Homeland security*. A concerted national effort to prevent terrorist attacks within the United States, reduce America's vulnerability to terrorism, and minimize the damage and recover from attacks that do occur. The term denotes both the government and civilian component of the effort. Because the US Department of Homeland Security includes the Federal Emergency Management Agency, the term also has implications for preparedness, response, and recovery to natural disasters.

21. *Bridge Lighting & Other Signals*.

22. Military Handbook. *Design Guidelines for Security Fencing, Gates, Barriers, & Guard Facilities*. Department of Defense; 1993.

23. *Sensored fence*. A perimeter fence provided with full-time monitoring and with sensors placed on the fence to allow for detection and an active response. Sensors may be motion, temperature, CCTV or a combination thereof.

24. *Active monitoring*. Trained personnel continuously observe in live-time CCTV monitors and have capability of dispatching responses to observed behavior or events. A *passive* monitoring system is one that does not have an individual monitoring the system in live time, and no intervening response is practical.

25. NFPA 70. *National Electric Code*.

26. IEEE C2-2012 - 2012 *National Electrical Safety Code* (NESC).

27. United States Army Corps of Engineers. TI 811-16, *Manual, Lighting Fixtures Standard Drawing,*

Series 40-06-04 Technical Instruction, Lighting Design.

28. *Jail Design Guide*, 3rd ed. National Institute of Corrections, US Department of Justice; 2011.

29. *Model Law Enforcement & Jail Policies & Procedures*. OSS Law Enforcement Advisors; 2016.

30. *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.

31. United States Air Force. *Electronic Security System*, Section 28; 2011.

32. *IDS*. An intrusion detection system (IDS) is a device or software application that monitors security system activities and reports to a monitoring station. Some IDS systems can take positive action by activating light and alarms, locking doors, and performing other countermeasures.

33. *Sally port*. An area enclosed by walls or fence where law enforcement vehicles may enter and exit through secured gates, safely remove detainees or prisoners, and conduct other investigative procedures.

34. FAA Visual Flight Rules.

35. FAA Instrument Flight Rules.

36. For detailed information on collection and analysis of crime statistics, see **Annex C**.

37. *A Bankers Resource Kit: ATM Security*. American Bankers Association. 1994.

38. *Exterior ATM vestibule*. An outdoor structure enclosed on at least three sides and that may be roofed, protecting ATM or AHD customers from the weather while providing some degree of privacy for the transactions.

39. A five-foot arc usually measured from wall face to wall face; may exceed 180° if, for example, the device is located near a corner of a building.

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

41. It is noteworthy that *Terrorism* or *Terroristic Threats* have not been added to this listing, and are only viewed from the perspective of the resulting injury or damage.

42. Defined as forced sexual assault or penetration of a female by a male, and ignores assaults on males. Efforts to update this definition have been unsuccessful at the federal level; however, most states carry the offense of Sexual Assault as a more encompassing term.

43. *Instant-start lighting*. A luminaire equipped with a sensor that detects movement below or approaching it, and quickly activates it. The luminaire goes to a stand-by condition after a preset time expires.

44. *Aggravated robbery*. The taking of money or goods in the possession of another, from his or her person or immediate presence, by force, with a weapon, or intimidation. Aggravated robbery is a serious crime, a Part I Crime as defined by the US Justice Department. (For more information on various crimes, and crime categories, see **Annex C – Crime Analysis and Foreseeability of Crime**.)

45. *The Lighting Handbook*, 10th ed. New York: Illuminating Engineering Society of North America. 2011.

46. http://www.opid.org/

47. *Crimewatch*. A community-police-government project in many communities in the US, Canada, and the United Kingdom. For an example, see: http://www.dallascrimewatch.org/cities/dallas/local-crime-reports.asp

48. *Peace bond*. A bond required as part of a court order to guarantee that a person will stay away from another person he/she has threatened or bothered. The bond will be forfeit (given up) if the order is violated, but that is no consolation to a person injured, molested or murdered by the violator.

49. *Restraining order*. A command of the court issued upon the filing of an application for an injunction, prohibiting the defendant from performing a threatened act until a hearing on the application can be held.

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

51. Professional mental health and religious counselors are exempt from report obligations.

52. Criminal victimization in the United States, 2014. Bureau of Justice Statistics, US Justice Department.

53. A code variance is an exception to a standard in the code, which if granted allows an applicant to build or develop a project that could not otherwise be legally built.

54. Criminal victimization in the United States, 2008. Bureau of Justice Statistics, US Justice Department.

55. Mayhew P, van Dijk, JJM. International Crime Surveys. Leiden University; 1957.

56. *Dram shop*. A legal term referring to a bar, tavern or the like where alcoholic beverages are sold. *Dram shop liability* refers to the body of law governing the liability of taverns and other commercial establishments that serve alcoholic beverages. Generally, dram shop laws establish the liability of establishments arising out of the sale of alcohol to minors or visibly intoxicated persons who subsequently cause death or injury to themselves or others.

57. *Post-event analysis*. A post-event analysis often includes a Visual Perception Analysis conducted by police, crime prevention professional, accident reconstructionist, or security professionals after a critical event such as a murder, sexual assault, or kidnapping, and usually occurs in a civil tort or criminal case wherein the courts are considering whether the claims manager or property owner was civilly or criminally negligent in the provision of a *reasonably safe property*.

60. UFC 3-530-01, *Unified Facilities Criteria* (UFC, US Department of Defense; 2015.

61. *Street Lighting and Crime: Diffusion of benefits in the Stoke-on-Trent Project*. Kate Painter and David P. Farrington. Institute of Criminology, University of Cambridge.

62. *Street Lighting in Dudley* [England]. Kate Painter. Institute of Criminology, University of Cambridge, Cambridge, England.

63. Real-World Risk Management. White Paper. Project Management Institute; 2015.

64. http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22727.pdf

65. *Guide to the Preparation of Physical Security Briefs: Physical Security Guide*. Lead Agency Publication G1-005; January 2000.

66. *Ingress Protection (IP)*. A voluntary testing process to evaluate the degree of protection provided by a product's enclosure. The first digit specifies the degree of dust protection, and the second digit specifies the degree of moisture protection. For example, *IP65* indicates dust tight (6) and protected against low-pressure jets of water; limited ingress permitted (5). For additional information, refer to ANSI/IEC 60529-2004.

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