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Security Lighting Planning Document for Nuclear Fixed Site Facilities

Prepared by H. J. Wait, M. W. Manning, D. R. Page

Mason & Hanger-Silas Mason Co., Inc.

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ABSTRACT

This document has been prepared as an aid in planning security lighting at nuclear fixed site facilities. While the recommendations enclosed cover the minimum requirements established in Title 10, Code of Federal Regulations (CFR), Part 73, additional suggestions are made for further enhancing a facility's security lighting and related security capabilities. Planning considerations and information are provided for lighting of the isolation zones, protected areas, portals, vital areas and material access areas. Recommendations are made relative to indoor, outdoor, fixed, portable and other unique applications of security lighting.

TABLE OF CONTENTS

LIST OF FIGURES

Figure		Page

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I. INTRODUCTION

This planning document is a reference guide of security lighting considerations. The minimum requirements of 10 CFR Part 73 are covered with examples of lighting equipment and configurations to meet them. Additionally, recommendations are made to improve the security lighting at nuclear fixed sites. The basic philosophy, concepts and goals of security lighting are covered as well as light sources, equipment and configurations. Auxiliary equipment, portable systems and backup equipment are included. Operation, maintenance and testing recommendations are provided.

It is important to recognize that this document is intended as a planning guide to illustrate basic security lighting considerations and requirements. It is recommended that any actual site lighting design be accomplished by a qualified engineering organization or company.

This document is organized to first discuss security lighting philosophies in Section (2) and is followed with information in Sections (3) and (4) on the characteristics of light and vision which contribute to the visibility of objects or persons in security lighting situations. Section (4) is concluded with a brief summary of recommended lighting levels at various areas within a protected site. Section (5) provides information on the use of lighting to the disadvantage of an intruder. Section (6) covers other general equipment for security lighting purposes. Installed or fixed lighting application configurations are provided in Section (7) which cover a range of lighting levels for perimeters, protected areas and portals. Lighting for CCTV systems is also discussed in this section. Sections (8) and (9) address the use, operation, maintenance, and testing of lighting systems. Summary recommendations are listed in Section (10).

2. SECURITY LIGHTING PHILOSOPHY

2.1 General

Security lighting is accepted as an integral part of a security system. Many references can be cited that explain the benefits and cost effectiveness of security lighting. Unfortunately, most lighting requirements are based solely upon illumination level. The design of a security lighting system generally gives little consideration to the impact of various lighting techniques upon intruder and response force behavior. Three distinct psychological/behavioral processes have been found to be relevant to security lighting system design: (1) psychological deterrence, (2) visual detection and identification, and (3) visual incapacitation. These established processes should be applied in the design of an optimum security lighting system. (Reference No. 1.)

2.2 NRC Requirements

Present NRC security lighting guidelines require that isolation zones and all exterior areas within the protected area be provided with illumination sufficient to detect the presence of unauthorized persons, vehicles, materials, or unauthorized activities, determine whether or not a threat exists and assess the threat, if any. The guidelines require a capability of observing the isolation zones and the physical barrier at the perimeter of the protected area, preferably by means of closed circuit television or by other suitable means which limit exposure of responding personnel to possible attack. Isolation zones and all exterior areas within the protected area shall be provided with illumination not less than 0.2 footcandles measured at ground level. (Reference No. 2.) Additionally, NRC general guidance for lamp restrike time (time to restart lamps after a power interruption) is 60 seconds maximum for these areas.

2.3 Goals

Security lighting is necessary for night time surveillance of indoor and outdoor areas. Proper illumination levels are expected to discourage would-be intruders and render them visible to guards during general surveillance or alarm assessment should they attempt entry. Security lighting requires adequate light, glaring light in the eyes of the intruder, and minimum light on the patrolling or observing guard.

Two basic methods or a combination of both may be used to provide practical and effective security lighting. The first method is to light the boundaries and approaches; the second, to light the area and structures within the general boundaries of the property. The Nuclear Regulatory Commission requires both.

The goals of an effective security lighting system are:

1. Discourage or deter entry attempts by intruders.

2. Maximize the probability of intruder detection should entry be attempted.

3. Provide glare effective in handicapping the intruder and avoid glare which handicaps guards or other personnel authorized to be in the immediate area of the security lighting system.

4. Provide additional illumination for areas most susceptible to intrusion.

5. Provide adequate illumination levels for intruder detection.

6. Provide adequate illumination levels and suitable light to dark ratios for the determination of false alarm causes on existing or planned perimeter intrusion detection systems.

7. Provide convenient switch and control access.

8. Provide supplementary portable lighting or searchlights to permit exploration inside and outside the protected area, and to backup fixed lighting systems during emergencies.

9. Provide protection for luminaires, supports, distribution systems and auxiliary equipment by locating them within the protected area where they are not readily accessible.

10. Provide an adequate maintenance program to assure lighting reliability.

11. Provide an adequate testing program to assure lighting capability and performance to specification.

12. Provide for operating procedures for use during normal and emergency situations.

The guidelines presented should be incorporated in the security lighting system design or upgrading to achieve optimum conditions for intruder: (1) psychological deterrence, (2) visual detection and identification, and (3) visual incapacitation. (Reference Nos. 1 and 3.)

3. DETERRENCE CHARACTERISTICS

3.1 General

An important objective of security lighting is the deterrence of potential intruders from initiating an intrusion attempt. A major deterrent for intruders is a high probability of their being detected and apprehended. Security lighting systems should be designed to increase this probability. As a result, the intruder has a greater estimate of his apprehension probability and is more likely to be deterred from initiating an intrusion attempt.

The security lighting system can be considered the first line of defense due to its serving as a deterrent to both the amateur and experienced intruder. (Reference No. 4.) This is not to imply that the deterrent effect of security lighting alone will suffice to provide protection.

3.2 Physiological/Psychological Effects

A significant physiological effect in security lighting is adaptation. Adaptation level is the average luminance of objects and surfaces in the immediate vicinity of an observer and is important when considering deterrence. As a fully dark-adapted person approaches security lighting perimeters, the brighter lights enter into the visual field and the person's adaptation level begins to change. The change in adaptation level reduces the ability to see low-iuminance low-contrast objects such as observers within the perimeter. The potential intruder now has a difficult task of studying the terrain immediately ahead and watching for more distant patrolling security guards. This undesirable situation places the potential intruder in a physiological disadvantage and possibly a psychological disadvantage. As the potential intruder advances closer to the lights, the adaptation level may be high enough that the person is virtually blind to dark objects behind the lights. The psychological disadvantage of not knowing whether or not observation is taking place causes tension or fear which could increase the adrenalin flow which causes pupil dilation and an increase in the effect of glare. This, of course, will heighten the deterrence value of the security lighting. (Reference No.5.)

3.3 Effectiveness

The reduction of crime in urban, industrial and residential areas as a result of security lighting has been studied and documented on numerous occasions. Approximately 75 percent of all urban burglaries against commercial establishments occur during the hours of darkness against facilities having either little or no lighting (Reference No. 1). The incidence of crime has a direct relationship with the number of hours of darkness in a given 24-hour period. (Reference No. 1.) Comparisons of urban crime patterns before and after new street lighting was installed show that increased illumination levels result in a reduction of crime in the lighted area. The above mentioned trends are not to imply that urban crime and the threat to a nuclear facility are exactly the same. It is apparent that when properly motivated individuals plan a criminal act they are not deterred by security lighting or even security forces in many cases. In these situations, a well-planned security lighting system can aid in detection and apprehension of intruders. It can however, be concluded that security lighting is an effective deterrent to many potential intruders.

4. VISUAL DETECTION CHARACTERISTICS

4.1 General

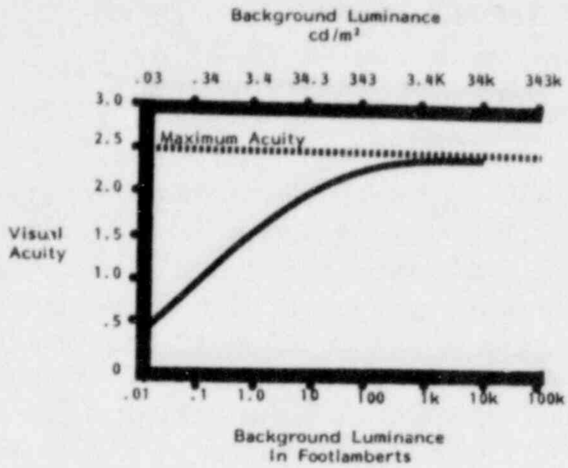
There are several significant factors relative to the effectiveness of security lighting not the least of which is how the human eye responds to various light sources and stimulus. Some of the most important considerations include the lighting intensity and area contrast, the frequency of the light or color, lighting uniformity, exposure time of the intruder and the size of the image of the intruder or target. These factors are very important in planning a lighting system. It is also difficult to integrate these factors into a definitive specification. Therefore, it is necessary to attempt to optimize as many of the conditions as possible.

4.2 Lighting Intensity and Contrast

As noted in the Illuminating Engineering Society Lighting Handbook (Reference No. 6), visual acuity is the ability to distinguish details. Visual acuity is a function of the brightness of the background. As the illumination decreases, the visual acuity diminishes. For dark objects on light backgrounds with a luminance of approximately .34 cd/m^2 (.1 footlamberts), the acuity is 50 percent of maximum. At 6.9 cd/m^2 (2 footlamberts), visual acuity is approximately 90 percent of maximum. Figure 1 describes the basic relationship (Reference No. 1). The units of measure used to describe illumination and luminance are:

	English	SI
Illumination	Footcandle	Lux
Luminance	Footlambert	Candela/Meter^2 (cd/m^2)

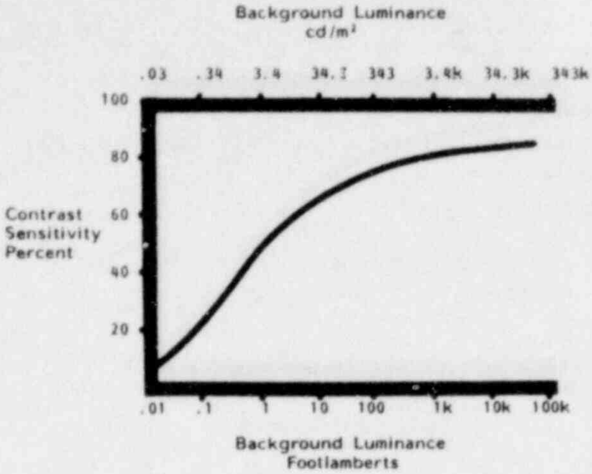
Illumination is essentially the amount of light available at any point or flux and luminance is the amount of light reflected from or emitted from an object at its surface. Note that a footlambert is a measure of luminance equal to $1/\pi$ candle per square foot. A one foot square emitting or reflecting light at one lumen per square foot would be one footlambert. The SI equivalent is cd/m^2.



VISUAL ACUITY RELATED TO BACKGROUND LUMINANCE

Figure 1

Contrast sensitivity is the ability to detect contrast area borders. The probability of intruder detection is greatly increased as the contrast between the intruder and background increases. At low light levels where the contrast is relatively low, dark on light targets seem to have the advantage over light on dark for detection. (Reference No. 7.) Also at very low luminance levels, color will always enhance visibility of the intruder. These observations and observations by others would tend to indicate that for detection or assessment purposes as much of the background as possible should be white or of a light color or illuminated to as high a level as practicable. This would include isolation zones, building faces, etc. Figure 2 (Reference No. 6) illustrates this concept. Figure 3 illustrates the fact that for areas of higher luminance, less task/target/intruder to background contrast is required for detection of a specific sized target. (Reference No. 8.)



CONTRAST SENSITIVITY RELATIVE TO BACKGROUND LUMINANCE

Figure 2

Contrast, as used in Figure 3, is an absolute value of target luminance less background luminance divided by the larger of the two numbers. Background luminance is measured as horizontal for these purposes and will provide a conservative estimate. Target luminance, on the other hand, is measured vertically and can be approximated by multiplying the horizontal illumination by the distance from the light source and dividing by the source mounting height.

$$\text{Illumination Vertical} = \frac{(\text{Illumination Horizontal})(\text{Distance})}{(\text{Mounting Height})}$$

As an example, if a 9m (30 ft.) pole is set back 6m (20 ft.) from an 18m (60 ft.) isolation zone, the intruder is at the outer edge of the isolation zone and the illumination is 2 lux (.2FC) horizontal then:

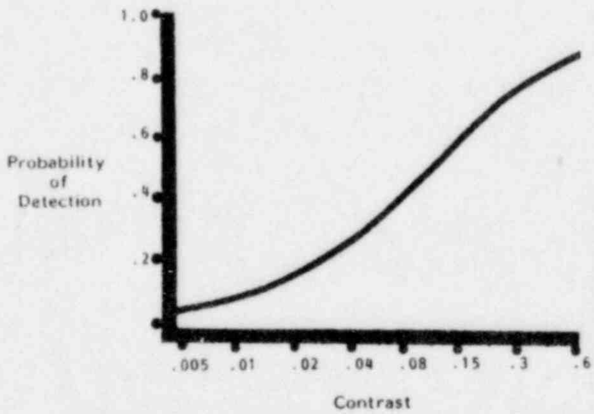
$$Iv = \frac{(.2FC)(80 \text{ ft.})}{(30 \text{ ft})} = .5FC$$

If the intruder is wearing olive drab clothing and the isolation zone is grass then:

L_t = Luminance of the Target = (.5FC) (.11 reflectivity) = .055 foot-lamberts

L_b = Luminance of the Background = (.2FC) (.17 reflectivity) = .03 footlamberts

$$C = \text{Absolute Contrast} = \frac{L_t - L_b}{\text{(Larger of two)}} = \frac{.055 - .03}{.055} = .45$$



PROBABILITY OF DETECTING TARGETS AS A FUNCTION OF CONTRAST

Figure 3

Utilizing this type of information and the reflectance factors in Figure 4, it is possible to determine relative effective illumination levels. This was accomplished in Reference No. 9 where it was concluded that:

1. "The prone target represents the most difficult visual target. This is true at all levels of illumination but particularly so at the currently recommended level of 2.1 lux (.2 footcandles)."

2. "Although vertical illumination determines target luminance, variations in vertical illumination have only a minimal effect on target detectability."

3. "The currently specified 2.1 lux (.2 footcandles) illumination will not assure detectability of all potential targets."

4. "A background luminance of no less than .24 cd/m^2 (.07 footlamberts) is required to provide an acceptable environment for detection of a variety of targets."

REFLECTIVITY OF VARIOUS GROUND COVERINGS

Material	Reflectivity
Light Sand	.15
Sandy Soil	.11
Asphalt	.04
Concrete	.36
Crushed Stone	3-.65
Grass/Vegetation	.17

REFLECTIVITY OF VARIOUS COLOR CLOTHES

Material	Reflectivity
Black	.03
Gray	.52
Dark Green	.10
Sand/Beige	.40
Olive Drab	.11

REFLECTIVITY OF VARIOUS WALL MATERIALS

Material	Reflectivity
Aluminum	.6 - .7
Aluminum Paint	.6 - .7
White Plaster	.9 - .92
White Paint (Mat)	.75- .9
Limestone	.35- .65
Mirrored Glass	.8 - .9
Stainless Steel	.55- .65
Red Brick	.30- .40

REFLECTIVITY OF VARIOUS MATERIALS

Figure 4

The .24 cd/m^2 (.07 footlamberts) luminance is a function not only of the light source and level but also of the reflectance of the background. As an example of determining a rough approximation of the lux (footcandles) required to yield .24 cd/m^2 (.07 footlamberts), the following equation can be used.

$$\text{Illumination (footcandles horizontal)} = \frac{\text{Luminance (footlambert)}}{\text{Reflectance}}$$

$$\text{e.g., Footcandles} = \frac{.07 \text{ Footlamberts}}{.04 \text{ Reflectance (Asphalt)}} = 18.8 \text{ lux } (1.75 \text{ footcandles})$$

Therefore approximately 20 lux (2 footcandles) is required on an asphalt isolation zone or protected area to yield .24 cd/m^2 (.07 footlamberts). This is consistent with recommendations for major expressways, bikeways and pedestrian ways. (Reference No. 10.)

Reviewing the other potentially utilized protected area and isolation zone material reflectance factors, the level of recommended illumination can be approximated. For horizontal surfaces, these are shown in Figure 5. It is necessary to recognize that these are only estimates and there are many variables such as differences in materials, vegetation changes between seasons, the color of light used, the texture/roughness of the materials, position and proximity to the luminaire and observer.

Material	Reflectivity	Horizontal** Illumination		Background* Luminance at 2.2 lux (.2 FC)	
		Lux	FC	cd/m^2	FL
Light Sand	.15	5.0	.5	.1	(.03)
Sandy Soil	.11	6.8	.6	.07	(.02)
Asphalt	.04	18.8	1.8	.03	(.008)
Concrete	.36	2.0	.2	.24	(.07)
Crushed Stone	.3-.65	1.2-2.5	.1-.2	.2	(.06)
Grass Vegetation	.17	4.4	4	.1	(.03)
Red Brick	.35	2.2	.2	.24	(.07)

*These numbers are the expected background luminance obtained if the present lighting guidelines of .2 footcandles are used for illumination.

**These numbers are the illumination levels required to yield .24 cd/m2 (.07 footlamberts).

APPROXIMATE LIGHTING REQUIREMENTS FOR VARIOUS MATERIALS TO YIELD .24 cd/m^2 (.07 Footlamberts) BACKGROUND LUMINANCE

Figure 5

Even at these levels of illumination certain combinations of backgrounds and intruder clothing will not provide either adequate illumination or contrast levels to meet the minimum threshold in some cases.

As an example and somewhat of a saving factor, if a minimum of 21.5 lux (2 footcandles) is utilized, certain areas within the illuminated area will have a higher degree of illumination since the minimum specified illumination is normally on the edge of the zone. Illumination closer to the luminaire can normally exceed this by a factor of 3:1 (average to minimum) or 6:1 (as a maximum to minimum ratio). Therefore, for certain limited segments of the zone the illumination may be as much as 108-130 lux (10-12 footcandles) or given a variety of background surfaces, 1.4-27 cd/m^2 (.4-7.8 footlamberts).

For vertical surfaces which can be painted white, the quantity of illumination required is significantly reduced. If a horizontal illumination of 2 lux (.2 footcandles) is provided at a minimum the luminance of the wall should readily exceed .26 cd/m^2 (.075 footlamberts).

4.3 Color of Light

Another significant characteristic which is notable is the color availability. A highly monochromatic light such as that from low pressure sodium lamps which consist of light almost entirely at 589 and 589.6 nanometers wavelength, does not permit discrimination of colors. Therefore, where color discrimination is required such as at access portals, for emergency equipment or emergency egress points, another source of light should be used or mixed. Heterochromatic light (such as most light sources other than low pressure sodium) provide a greater depth of focus, but monochromatic light (such as low pressure sodium) provides a sharper image. (Reference No. 11.)

Research by the Illuminating Engineering Society (Reference No. 6) has shown that on the whole the visibility of objects in roadways or in the proximity of roadways is generally the same regardless of the color of light when the distribution and intensity are similar. Therefore, there seems to be no strong color preference for intruder detectability.

4.4 Lighting Uniformity

Since the observer's head and eyes are constantly changing fixation points, the retinas are subjected to light/dark adaptation. For this reason and to reduce any discomfort, strain or excessive adaptation time, it is important to provide lighting which is uniform with a minimum of potential glare sources in the eyes of security personnel.

Uniformity of illumination (uniformity ratio) is the ratio of the average lux (footcandles) of illumination to the point of minimum illumination. A maximum to minimum ratio is often specified. General recommendations for highway use are for an average to minimum ratio of 3:1 to 4:1 (Reference No. 10). The U. S. Air Force is specifying a 3:1 ratio in the clear/isolation zone for single fence configurations as noted in Reference No. 9. The U. S. Navy has specified an 8:1 light to dark maximum to minimum ratio. "The American Standards Practice for Protective Lighting" (Reference No. 3) recommends a maximum to minimum ratio in critical areas of 6:1.

It is anticipated that an average to minimum ratio of 3-4:1 or maximum to minimum of 6-8:1 of illumination measured horizontal would be appropriate for planning purposes at nuclear fixed site facilities.

It is obvious that at points where illumination levels differ in requirements such as at portal or interfaces with areas within the protected area that are illuminated to high levels for operational or maintenance purposes, that these ratios will be difficult to maintain. However, they should be utilized in areas not subject to illumination pollution from other sources.

For planning purposes, guard patrol routes and post locations should be such that they are exposed as little as possible to areas creating glare or causing constant light to dark observation adaptation.

4.5 Intruder Speed

Although the site's security system or personnel have no way to influence the speed of which an intruder might move in most areas, target speed significantly influences detectability (Reference No. 12). The faster a target is moving, the more probable will be its detection up to a limit well above the speed with which a human can run. If there are areas where long shadows of an intruder can be created such as up against a building, both the size and speed of the shadow may be a greatly amplified image of the intruder, therefore making the intruder more detectable.

4.6 Intruder or Target Size

Target size or intruder profile influences detectability (Reference No. 8). Smaller or more distant targets require either higher levels of illumination, higher contrast levels, closer observation points or seeing aids to increase visible detectability. Figure 6 (Reference No. 8) illustrates these relationships for various visual angles (size of targets), contrast and illumination levels. The visual angle of 2.67 degrees is equivalent to a person standing at a distance of 39m (138 ft.) or crawling at 6.4m (21 ft.). The angle of 1.33 degrees represents a person at 79m (260 ft.) standing or 13m (43 ft.) crawling. The angle of .67 degrees represents a person at 156m (513 ft.) standing or 26m (85 ft.) crawling. The angle of .33 degrees represents a person standing at 317m (1040 ft.) or crawling at 53m (173 ft.). It can be seen that both higher contrast levels and illumination enhance the probability of detection of still targets. These factors should be considered when planning lighting, patrols and alarm assessment strategies.

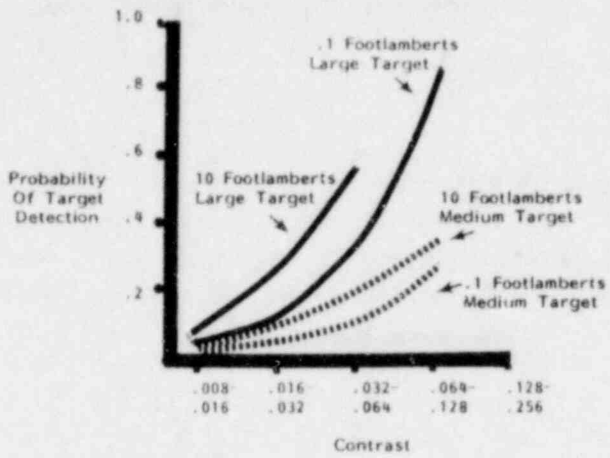
4.7 Target Search Time

Figure 7 derived from Reference No. 8 provides an indication of the time to search and find a still target. Notice that in areas of high target to background contrast, a search time of 20 or more seconds is required to achieve a reasonable probability of target detection. At lower contrast levels, the probability of detection is inadequate. This emphasizes the consideration for lighting strategies which provide either greater contrast levels, illumination levels or both.

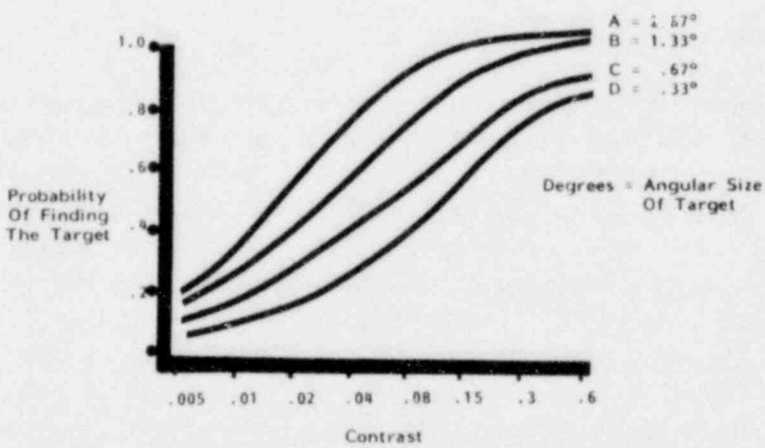
4.8 General Lighting Recommendations

As a result of the previous discussion, it is noted that while a minimum of 2.15 lux (.2 footcandles) is required by NRC, there are situations which would be significantly improved with an increased lighting level. It is recommended that the increased levels be considered when designing or updating the security lighting system for direct visual surveillance and assessments. Additionally, higher levels should be considered if CCTV systems are planned. Due to the number of variables it is difficult

Contrast, Size and Luminance

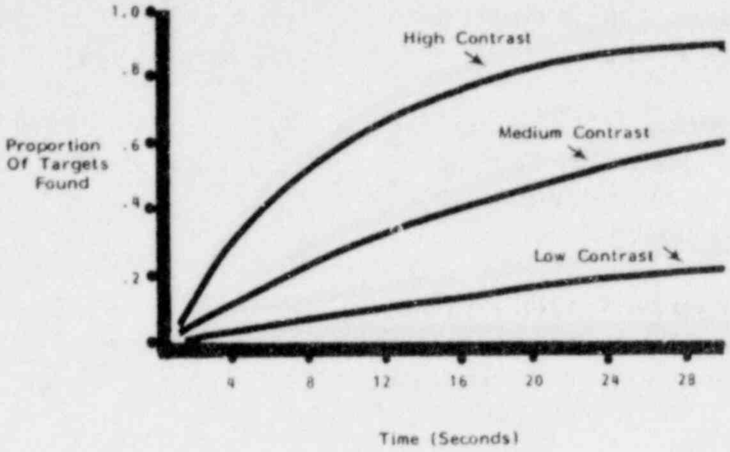


Contrast and Size



PROBABILITY OF FINDING TARGETS AS A FUNCTION
OF CONTRAST, SIZE AND LUMINANCE

Figure 6



SEARCH TIME FOR TARGET DETECTION FOR THREE CONTRAST LEVELS

Figure 7

to specify an exact level of illumination. However, the following minimum ranges of security lighting are recommended with the higher levels being preferred.

- Exterior Protected Area Isolation Zone — (2.15 to 21.5 lux) (.2 to 2 footcandles)
- Exterior Protected Area in the Area of Vital and Material Access Areas — (2.15 to 21.5 lux) (.2 to 2 footcandles)
- Exterior Protected Area Between Isolation Zones and Vital and Material Access Areas — (2.15 lux) (.2 footcandles)
- Exterior Vehicle and Pedestrian Access Areas — (21.5 lux) (2 footcandles)

- Interior and Exterior Badge and Credentials Check Areas (323 lux) (30 footcandles)

- Interior Area Lighting (May be Existing Lighting System) Used Only During Assessment Except Areas Requiring Continuous Surveillance (21.5 lux) (2 footcandles)

The above are measured horizontal and may be increased for CCTV or other operational purposes. A maximum to minimum ratio of 8:1 with 6:1 preferred and an average to minimum light to dark ratio of 4:1 with 3:1 preferred should be uitlized.

Note that the recommendation for the general protected area is for 2.15 lux (.2 footcandles) which is the minimum required by NRC. However, the planner should keep in mind that this provides a very minimum of detection capability and puts the burden of detection and assessment on areas with higher illumination levels. For example, if intrusion detection in the isolation zone is assessed either with instant direct visual or CCTV capability it is less important for the general protected area to have higher levels of illumination. On the other hand, if the isolation zone cannot be assessed within 2-3 seconds (depending on the location of the intrusion detection device), it is quite possible that the intruder has progressed into the general protected area and a higher level of illumination, say 21.5 lux (2 footcandles), would be more appropriate.

5. INCAPACITATING CHARACTERISTICS

5.1 General

Lighting can cause seeing disabilities. If the lighting system is not properly designed, this can cause problems for security personnel on patrols or assessments. While this section is discussed in the context of visual incapacitation of intruders, the planner should recognize problems which might be created for security personnel.

The use of illumination as an intruder incapacitation device has some applicable potential. Certain lighting techniques are inherently incapacitating or are capable of degrading human performance. Four major effects of lighting technique which may alter human response are (1) glare, (2) flash blindness, (3) stroboscopic, and (4) phototropism. Other effects also warrant consideration.

5.2 Glare

Glare is the technique of directing high intensity light into the eyes of an intruder. Its effect is to (1) obscure the intruder's visual target (disability glare), or (2) produce discomfort on the part of the intruder (discomfort glare). The source of disability or discomfort glare may be directly from illumination sources or indirectly from highly reflective objects. (Reference No. 1.)

Disability glare is a result of the retina being peripherally exposed to illumination sources considerably brighter than the luminance level to which the eye is foveally centered. The exposure to a brighter luminance level reduces foveal visual performance capability and therefore obscures the visual target. The magnitude of the effect depends upon the intensity of the glare source and the location (angular distance from the line-of-sight) of the glare source. The effects of two or more glare sources are completely additive. (Reference No. 1.)

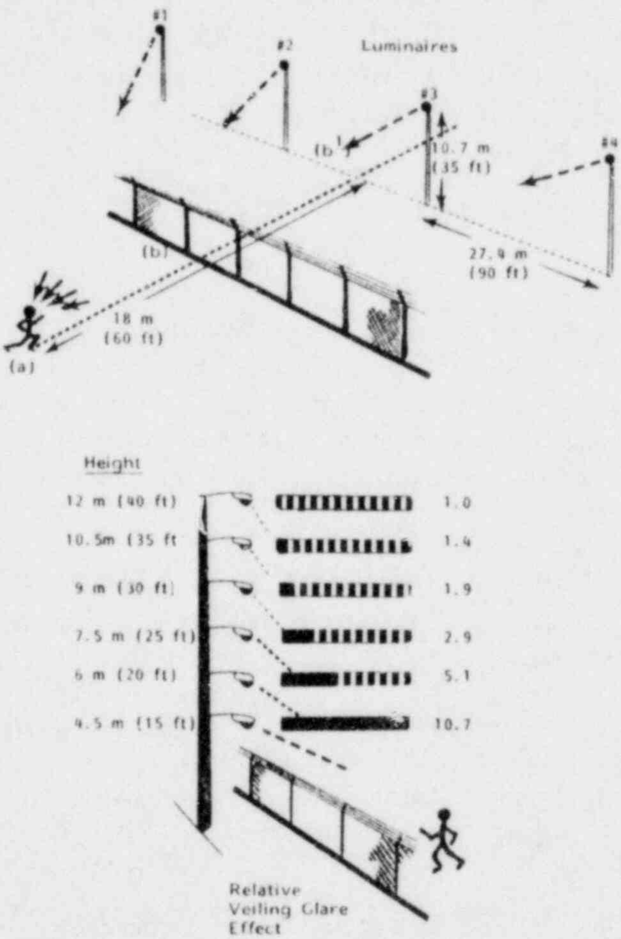
Disability Veiling Brightness (DVB) is a method utilized to determine the veiling glare effect of lighting systems (Reference No. 13). The formula for computing DVB is:

$$DVB = \frac{30\ EV}{\theta(1.5 + \theta)}$$

Ev = Vertical Footcandles at the Eye

θ = Angle in degrees between the "normal" line of sight and the glare source. The angle must consider not only the height of the luminaires but also the angle to the left or right of the line of sight.

DVB will be the sum of these effects from all sources of light in the view of an intruder. Figure 8 illustrates this type of situation. An intruder at point (a) will be visually disabled by the veiling brightness of all four luminaires. If the intruder is at the edge of the isolation zone, attempting intrusion at point (b) to (b^1), the primary DVB sources will be luminaires 2 and 3.



DISABILITY VEILING BRIGHTNESS (DVB)

Figure 8

Assuming, for example, that the intruder is at a distance of 18 m (60 feet) from the luminaire pole, the angle from the intruder's eye level to the luminaire is approximately 42°. If the vertical illumination at that point is 4.3 lux (.4 fc) then:

$$DVB = DVB_2 + DVB_3$$

$$DVB = \frac{30\ (.4)}{42\ (1.5 + 42)} + \frac{30\ (.4)}{42\ (1.5 + 42)}$$

$$= .0066 + .0066 = .0132$$

The configuration of luminaires 1 and 4 are very small contributors in this particular case because their distance significantly reduced their brightness and the angle to the line of sight is quite large.

If the height of the luminaires is lowered to 4.6m (15 feet) and the same illumination level is maintained then:

$$DVB = \frac{30\ (.4)}{38\ (1.5 + 38)} + \frac{30\ (.4)}{38\ (1.5 + 38)}$$

$$= .008 + .008 = .016$$

If the luminaires are spaced at 13.7m (45 feet) then:

$$DVB = \frac{30\ (.4)}{32\ (1.5 + 32)} + \frac{30\ (.4)}{32\ (1.5 + 32)}$$

$$= .011 + .011 = .022$$

If both the height and spacing reduction is accomplished then:

$$DVB = \frac{30\ (.4)}{22\ (1.5 + 22)} + \frac{30\ (.4)}{22\ (1.5 + 22)}$$

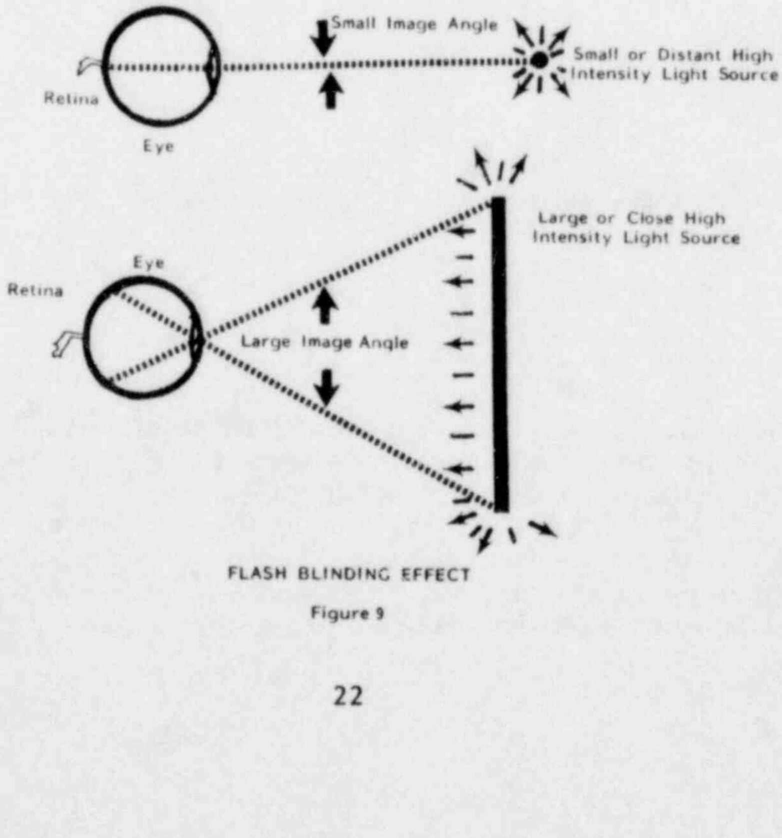
$$= .023 + .023 = .046$$

As a result of the above, it can be seen that the closer the luminaires are to the line of sight of an intruder the greater the glare deterrent and disability veiling brightness will be.

The above can be utilized to estimate the glare effectiveness of various lighting configurations. This can be used in evaluating glare as an intruder incapacitation device or to evaluate glare as a potential hazard to site security and other personnel. Figure 8 provides the relative veiling glare effect for a head-on approach to luminaires at various heights.

5.3 Flash Blindness

Flash blindness is the effect of high intensity flashes of light which cause substantial visual after images (Reference No. 9). After a "brief" super-adaptational-intensity burst of illumination to the eyes, there exists a period of visual insensitivity. The effect of the insensitivity is defined in terms of the time required for complete recovery to normal visual sensitivity levels. The magnitude of the effects of flash blindness depends primarily upon (1) flash duration, (2) intensity, (3) wave length composition, and (4) the visual angle of the flash relative to the line-of-sight. Severe effects can last up to several minutes for a single flash and may be repeated with additional flashes. Reference No. 14 provides a summary of various tests conducted to determine the variables relative to flash blindness. From this information, it is indicated that high intensity light sources can cause a period of flash blindness up to 210 seconds.

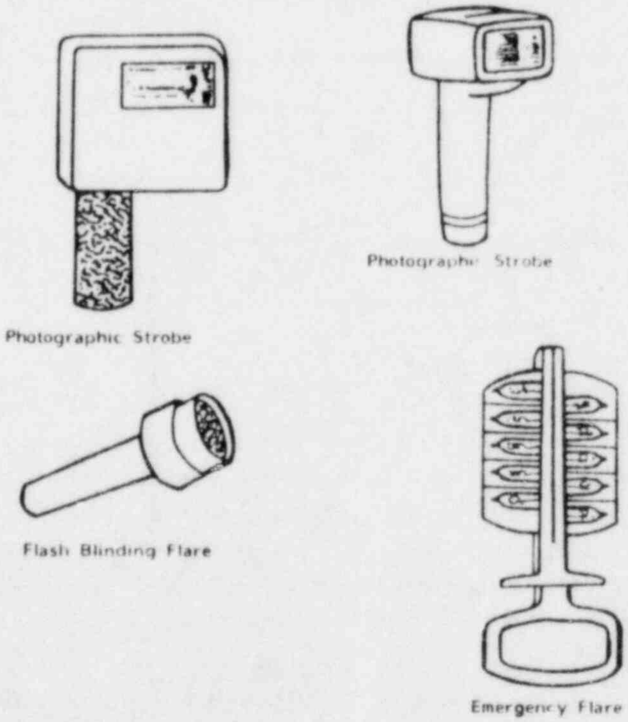


FLASH BLINDING EFFECT

Figure 9

As illustrated in Figure 9, high-intensity light flashes imaged on the retina produce residual images with the same shape as the light sources. A large close-up flash will create a very large residual image which will be difficult to see through until or unless the image or images provide a highly detectable contrast. A small flash or high intensity flash at a significant distance will create only small residual images therefore having very little residual effect since a large portion of the retina is not directly exposed. For example, a high intensity spotlight at a distance may provide a flash blinding source of only 20 minutes of arc. Therefore, while it will provide significant glare, flash blindness will be minimized. A strobe at a distance of 10 feet will provide approximately 2 degrees of arc and at 4 feet approximately 5 degrees which becomes more significant and potentially useful at closer range.

Flash blindness can be created to some extent with off-the-shelf, available devices. Some of these include photographic flash devices, photographic flash bulbs and emergency flares, special intruder flares or sweeping of high intensity flashlights or searchlights. Figure 10 illustrates some of these items. Note that the use of these items may also hinder the vision capability of the guard using them. The items listed in Figure 11 provide light of various intensities and durations. A 15,000 candlepower flashlight might be expected to cause 10 seconds of flash blindness if gazed at for a



FLASH BLINDNESS DEVICES

Figure 10

fifth of a second at very close range. A high intensity spotlight of 200,000 candlepower might cause 40-50 seconds of flash blindness if gazed at for one-fifth of a second at very close range. A searchlight of 3,000,000 candlepower might be expected to create flash blindness for 100-120 seconds if gazed at for one-fifth a second at close range. Flashlights, searchlights and spotlights normally have a highly concentrated beam. However, the further away the intruder is from the source of the light the less light available, therefore reducing the effectiveness of flash blindness.

	Portable	Duration	Intensity Candle Power	Cycle Time	Cost
Intruder Flare	Yes	Less Than 1 Second	6,000,000	Not Available*	$100
Flashlights	Yes	Continuous	2,000-15,000	None	$5-20
Spot/Searchlights Vehicle	Vehicle Only	Continuous	30,000-200,000	None	$15-60
Searchlights	No	Continuous	3,000,000	None	
Photographic Strobe	Yes	1/1,000 Second	1,000,000-6,000,000	.2-.10 Second	$20-400
Hand Flare**	Yes	Less Than 1 Second	Not Available	Fraction of Second	$5-10

*Requires Bulb Replacement

**Similar to Small Flashbulb

FLASH BLINDING DEVICE INFORMATION

Figure 11

Strobe/photographic equipment provides a very short duration flash (on the order of 1/1,000 second or less). Particularly in this case as well as in the case of continuous light, a slight deviation of gaze, turning away or blinking by the intruder during the flash or sweep of light will appreciably reduce the flash blindness effect.

Strobe lights are not only of very short duration but also they are not normally focused into a concentrated beam. Their range without a modification of beam covergence is limited by the fact that the light will diminish very quickly after 2-4m (10-13 feet). At close range or with a highly concentrated beam at a short distance, a small strobe or flashbulb device could create seconds of flash blindness. A larger strobe range could cause 10-30 seconds of flash blindness.

The advantages of using flash blinding devices are:

- Reasonably low cost
- Will work if used carefully at very close range
- No long term damaging effects to the eye of the intruder

The disadvantages of using flash blinding devices are:

- They must be used at very close range
- They will not in themselves immobilize an intruder
- The person utilizing the device can suffer some temporary vision degradation
- The intruder can avoid exposure by blinking or looking away

5.4 Stroboscopic

Stroboscopic effect is the use of periodic pulsating light to cause disorientation, confusion, or anxiety. (Reference No. 9.) The continuous flickering of lights is known to have physiological or psychological effects on certain individuals such as the onset of seizures. The effects of stroboscopic illumination are illusory motions, colors, or patterns which normally lead to distressful feelings of confusion or anxiety. (Reference No. 1.)

Research for this planning document has not revealed any practical applications of this effect for security lighting purposes. Since it is known that strobosopic lighting affects different people in different ways, there is no consistency noted for an application basis. Some people are known to work under stroboscopic lighting effects and have adapted readily.

A stroboscopic effect created by a relatively slow light pulsation could cause difficulties in the manner of light to dark adaptation. However, if the intruder has a flashlight available, the effect would be limited.

Stroboscopic lighting could also degrade the security guard's performance as well as the intruders.

Fluorescent and most high intensity discharge lamps have an inherent stroboscopic effect. This is not usually an obvious effect except around some rotating equipment, for example. This is discussed in subsequent sections.

For the above reasons additional consideration is not given to stroboscopic lighting effects for security lighting purposes.

5.5 Phototropic

Phototropic effect is the technique of using light to direct movement. A natural tendency of the human eye to orient toward light may result in a subsequent movement of the individual toward the source of light (Reference No. 9). This natural tendency is only slightly evident in humans and may be consciously avoided. It is thought that the proper placement of light within the facility perimeter may guide an intruder to a particular area which could be designed for higher apprehension probability. (Reference No. 1.) The absence of light in certain areas might also attract the intruder to utilize trapped (intrusion detection) routes or dead-end routes. Areas of low visibility or obscured vision should be reviewed for this reason.

5.6 Permanent Eye Damage From High Intensity Light

From an incapacitation standpoint, it is possible not only to utilize light sources to create effects of flash blindness and light/dark adaptation problems but also permanent effects such as chorioretinal burns. The extent and duration of these effects depends on exposure conditions and because the eye may focus on the radiant energy source, the hazard can be extreme even at long range (Reference No. 15). Both the irradiance (energy per unit of area per unit of time) incidence on the eye and the area of the irradiance source on the retina are inversely proportional to the square of the distance from the source. This is valid for open lamps or sources without concentrating reflectors or lenses or other mechanisms of concentration. A nuclear blast fire ball, for example, follows this rule. Devices such as searchlights or lights with reflectors or lenses or lasers however are primarily attenuated by scatter and reflection caused by atmospheric conditions and do not necessarily follow the same criteria, but are more dependent on focus patterns.

Permanent damage is caused by heat generated in the retina and adjacent structures by the radiant energy. If the rate at which the heat is generated is greater in an area than that which can be dissipated, the temperature will build up (Reference No. 15). The temperature above a certain threshold can cause injury to the rods and cones, optical nerve tissue, and other structures in the retina and choroid. Currently there is little reliable quantitative information on this threshold. Vision loss from such burns, although permanent and uncorrectable does not normally take the form of total blindness but rather creates blind spots. The extent of the impairment depends upon the size, severity and location of the burn. To cause extensive blindness would require either a small severe burn of the nerve fiber area (disc) which is not in the fovea and therefore would be exposed more by remote chance or by a very large/close high intensity source which would expose a very large portion of the retina. Neither of the above would seem to have practical application.

For many reasons, including marginal effectiveness, public acceptance and inherent hazards, permanent incapacitation via permanent blindness is not considered to be a recommended practice. Normal lighting equipment used for security purposes should not create any hazards.

5.7 Intense Light Source Incapacitation

Laser systems are capable of being utilized as antipersonnel and material devices. None, as such, are known to be used for protective or security purposes other than for military development, communication or intrusion detection. These are, therefore, not further considered in this planning document.

6. SECURITY LIGHTING EQUIPMENT

6.1 General

This section provides information on a variety of lamps, luminaires, supports, ballasts, distribution systems and related backup power systems. Combinations of these equipment items can be selected to provide the most cost effective security lighting which will meet the requirements at individual nuclear facilities.

6.2 Lamps

Many light sources and fixtures can supply the proper illumination for security lighting. Figure 12 shows representative lamp efficiencies and other information for light sources considered for security lighting. The light sources chosen will, of course, be those which fulfill the necessary requirements of illumination, and those which are cost effective. The characteristics for each lamp depends not only on the type lamp but also its size (rating), ballast type (if any), luminaire used and other considerations.

CHARACTERISTICS						
Lamp Type	Mean Lumens Per Watt	Start	Restrike	Nominal Life Of Lamp Hrs	% Lumen Maintenance At Rated Life	Color Discrimination
Incandescent	4(21)22*	Instant	Instant	750-1,000	85-90	Excellent
Fluorescent	35(62)100	Rapid	Rapid/Instant****	7,500-10,000	70-90	Excellent
Metal Halide	68(80)100	3-5 min.	10-20 min.	10,000-15,000	65-75	Excellent
Mercury Vapor	20(48)63	3-7 min.	3-6 min.	16,000-24,000	50-75	Good
High Pressure Sodium	95(127)140	4-7 min.	Instant**	16,000-24,000	75-85	Fair
Low Pressure Sodium	131(183)183	8-10 min.	Instant**	16,000-24,000	Basically Constant*****	Poor
Xenon Arc	***	Rapid/Instant	Instant	1,500		Excellent

*4(21)22 (4)--Minimum Mean (21)-Nominal Rating For Most Protective Lighting Applications 22 Maximum Mean

**Instant for most lamps if less than one minute of power interruption but at a reduced lumen output

***Use for searchlights only

****Low temperature ballast must be considered

*****Current increases until end of lamp life to keep lumen output consistant.

LAMP SELECTION INFORMATION

Figure 12

6.2.1 Incandescent

The incandescent lamp or "light bulb" produces a clean, color-true light. The lamp is a very reliable starter. It starts instantly and will restrike instantly. The incandescent lamp produces 21 lumens/watt which is very low when considering a cost effective method for illuminating a large area. The life expectancy of incandescent lamps is quite variable depending on the type and size of lamp, fill gas used, and operating voltage. Nominally 750-1000 hours is an accepted standard service life but some lamps such as projector lamps or searchlight lamps may last only 10-25 hours and other special long-life lamps may last several thousand hours. Voltage deviations from the rated voltage will cause diminished lumen output if the voltage decreases and increases output if it increases. Lumen maintenance at rated life is approximately 85 percent. Incandescent lamps do not require a ballast, do not normally cause stroboscopic effects, do not create radio interference and do not make audible noise.

"Halogen Lamps," "Iodine-Quartz," "Tungsten-Halogen" and "Krypton" lamps are all variations of incandescent lamps. Some of these may have a rated life of up to 12,000 hours with very high lumen maintenance factors.

The primary disadvantage of incandescent lamps is their relative inefficiency.

6.2.2 Fluorescent

Fluorescent lamps are cylindrical and long in shape. There is an electrode at each end with a "pool" of metallic mercury on the inside of the tube. A current flow between the electrodes vaporizes the metal and causes a gas arc. There is a thin coating of phosphor on the inside of the tube which fluoresces and gives off visible light due to the large quantities of ultraviolet radiation from the gas arc. The efficacy of fluorescent lamps is approximately 62 lumens/watt. The temperature sensitivity makes these lamps most useful as an indoor lighting source. Fluorescent lamps are rated at approximately 10,000 hours for outdoor lamps and 7500 hours for indoor lamps. Some lamps are rated as low as 6000 hours and as high as 24,000 hours. Voltage deviations reduce the lamp efficiency and shortens the life of the lamp. Low voltage can cause starting and restrike difficulties as well. Typically a 10 percent decrease or increase in voltage will cause 5 percent decrease or increase respectively in lumen output. Depending on the ballast used, the lamp will tolerate a dip in voltage from 50 to 80 percent. Ballasts are required for fluorescent lamps. A variety of lamp color outputs are available and all will provide good color discrimination. Lumen maintenance (lumen output) at rated life may vary from 70 to 90 percent. Ballasts, even though functional, can make audible noise if defective. Under certain conditions fluorescent lamp systems can also cause electromagnetic radiation or interference. Fluorescent lamps are also subject to flicker and stroboscopic effects. As a result, rapidly moving objects may give a blurred image and rotating equipment may appear to be moving in a direction opposite to or slower or faster than it actually is rotating. The stroboscopic effect can be minimized by using lead-lag type ballasts or by using 3-phase operation of 3 adjacent lamps or pairs of lamps or by operating at a higher frequency (400 Hz or higher). Normally, rapid start lamps will start or restrike within 1 second.

6.2.3 Mercury Vapor

Mercury vapor lamps produce light by passing current through a vapor or gas rather than through a tungsten wire. The lamp consists of an inner arc tube and an outer glass envelope. The outer envelope filters ultraviolet radiation which would otherwise be harmful. If the outer envelope breaks, some lamps will automatically extinguish to prevent this hazard. These types are recommended for open luminaires which are not enclosed with glass or plastic lenses. The efficacy of mercury lamps is 48 lumens per watt depending on the lamp size and ballast selection. The life expectancy rating varies from 16,000 to 24,000 hours. The response of mercury vapor lamps to voltage changes is dependent on the type of ballast used. A 10 percent change in voltage using a typical high reactance ballast will cause a 30 percent change in lumen output. If a constant wattage ballast is used, lumen output will remain relatively stable. With an auto-regulator type ballast, power dips of 40-50 percent can be tolerated without creating drop-out and restart requirements. Typically a mercury vapor lamp will reach near maximum lumen output in 3-7 minutes. Restrike time is from 3-6 minutes after a power interruption as short as 1/120 second. An interruption in the power supply or a sudden voltage drop may extinguish the arc. Most ballasts are designed to permit a voltage drop which varies with the type of ballast used. Before the lamp will restrike it must cool sufficiently to reduce the vapor pressure to a point where the arc will restrike at the voltage available. Restrike will not be at full rated output until the warm-up cycle is completed. When the lamp is an enclosed fixture, the restrike time may be slightly longer. Lumen maintenance at rated life varies widely from 50 to 75 percent. Mercury vapor lamps can create stroboscopic effects. In locations where this is a problem, pairs of lamps can be operated on lead-lag ballast or 3 lamps can be operated on 3-phase power supply systems. Lamps are also available as self ballasted or can have remote ballast. The ballasts are prone to create an audible hum. Where this is a problem they can be set up remotely. Electromagnetic radiations causing interference with certain instrumentation should also be considered. Power loss to the ballast may vary from 4-25 percent with the greatest loss attributed to the smaller lamps.

6.2.4 Metal Halide

Metal halide lamps are similar in construction and concept to the mercury vapor lamp. The lamp contains a solid inside the tube which vaporizes when current flows between the electrodes. The lamp has high intensity and very clean light with respect to color. The efficacy of a metal halide lamp is approximately 80 lumens/watt. The life expectancy rating for metal halide lamps is from 10,000 to 15,000 hours. The metal halide lamp is similar to mercury vapor lamps except that additional metal compounds including metals such as thallium, indium, and dysprosium are a part of the system. These additives help produce more white light. The response of metal halide lamps to voltage changes is dependent on the type of ballast used. A typical high reactance ballast with a 10 percent line voltage charge will cause a 30 percent plus or minus change in lumen output. With a constant wattage ballast the lumen output change will be insignificant. With an auto-regulator ballast power dips of 40-50 percent can be tolerated without drop-out and restriking required. The time required to start metal halide lamps depends on the ballast used but normally requires 3-5 minutes. Restrike time is very poor and 10-20 minutes may be required. Lamps will not restrike at full rated output and will require cool down as well as warm up time. Drop-out with restrike required will occur if the power source is interrupted for as little as 1/120 second. Lumen maintenance at rated life is from 65-75 percent. Metal halide lamps provide only minor stroboscopic effects. Power loss to the ballast depends on the type of ballast and lamp size. It varies from 5-17 percent with the greater loss on the smaller lamps. This is because the ballast requ res a certain amount of power regardless of lamp size. For larger lamps the ballast consumes a smaller percentage of power. Electromagnetic radiation from the metal halide lighting systems can cause interference in certain instrumentation and sould be considered.

6.2.5 High Pressure Sodium

High pressure sodium lamps use xenon gas as the inert gas which starts the lighting arc for the lamp. An amalgam of mercury and sodium vaporizes as a result of the starting xenon gas and gives off light. The light produced is amber in color. The high pressure sodium lamp has a tube that encloses the gases and then a tube which encloses the device. During operation the inside tube containing the gases reaches a temperature of approximately 1100°C The high temperature produces a higher pressure inside the tube. Due to the high pressure, the high pressure sodium tube is made of sintered aluminum oxide. The lamp will start in 3-7 minutes. The lamp has an efficacy of approximately 127 lumens/watt. The life expectancy rating of the lamp is from 16,000 to 24,000 hours. High pressure sodium lamp lumen output only varies slightly with line voltage changes. For example, a 10 percent decrease in line voltage will cause only a 1 percent decrease in lumen output depending on the ballast used. Voltage dips which require restriking vary from 15 to 50 percent. With reactor type ballast, 12-20 percent dips can be tolerated. With auto-regulator type ballast, 40-50 percent dips can be tolerated. Most high pressure sodium lamps will restart within one minute after a power interruption. A power interruption of only 1/120 second will cause restrike. When lamps do restrike they will not be at full rated output until the warm-up cycle is completed. Lumen maintenance at rated life is 75-85 percent. Power loss to the ballast varies from 16-21 percent. High pressure sodium lamps will cause stroboscopic effects. These can be minimized by operating pairs of lamps on lead-lag ballast or by arranging 3 lamps on separate phases of 3-phase power distribution systems. High pressure sodium lamps are available in self-ballasting configurations. High pressure sodium lamps provide adequate color discrimination but produce an amber/yellow color light. Electromagnetic radiation from high pressure sodium systems may cause interference with certain instrumentation or alarm systems and should be considered. The slight audible hum of ballast should also be considered.

6.2.6 Low Pressure Sodium

Low pressure sodium lighting utilizes pure metal sodium in an inert gas combination of neon-argon. The ignition of the lamp is by means of a gas discharge through a neon-argon gas mixture. Because the lamp need not vaporize a substance to initiate the arc, they are considered very reliable starters. The efficacy of the lamp is approximately 183 lumens per watt. Low pressure sodium lamps require approximately 8-10 minutes to reach full lumen output. Manufacturers indicate that 90 percent of low pressure sodium lamps will reliably restrike after power interruptions of up to 5 minutes. The remaining 10 percent of the lamps will restrike in less than 1 minute. The life expectancy rating is from 16,000 to 24,000 hours. Low pressure sodium lamp output varies only slightly with line voltage changes. A 10 percent decrease in line voltage will cause only a 2 percent decrease in lumen output. The low pressure sodium lamp provides a highly monochromatic yellow light. Color discrimination is poor. There is no appreciable lumen depreciation during the lamp's expected life which minimizes over-specification requirements. Since the lamps are highly efficient, significantly smaller cables and lower power requirement distribution systems can be used, however, consideration must be given to sizing the system for the end of life cycles since the lamps have a higher operating current at the end of their life.

6.2.7 Xenon Lamps

High pressure short-arc xenon lamps are used where high lumen output is required from a small source. It is very appropriate for searchlight applications. Xenon lamps will reach full rated lumen output in a few seconds. Other short-arc lamps such as mercury or mercury-xenon require several minutes to reach rated output. Xenon lamps require ballasts/ power supplies to provide the high voltage starting pulse. Xenon lamps would normally be used for searchlights but not for other applications relative to security lighting. They are available in the range from 100 watts to 2500 watts. Typical searchlight applications include 1000 and 2500 watts. These would be specified where very high lumen ratings are required (35,000,000 - 90,000,000 candlepower).

6.2.8 Carbon Arc Lamps

A carbon arc lamp is an electric discharge lamp in which light is produced by an arc discharge between carbon electrodes. A carbon arc source radiates because (1) incandescence of the electrodes, and (2) the luminescence of vaporized electrode material and the surrounding gaseous atmosphere. The choice of different electrode materials results in changes in brightness, total radiation, and spectral energy distribution. The most practical application of carbon arc lamps for security lighting purposes is in searchlights. Although carbon arc lamps do not require ballast, they do require power supplies. It is likely that for searchlight applications, an incandescent lamp would be more appropriate and lower in initial and continuing cost.

6.2.9 Infrared Lamps

Infrared lamps are typically variations of the incandescent lamp. They are designed to operate at a very low filament temperature to minimize visible light and maximize the infrared. These lamps would require additional light filtration for security lighting applications. They are available in a range from 125-2500 watts. Reference Section 6.6.7.

6.2.10 Ultraviolet Lamps

Ultraviolet lamps producing "blacklight" have applications in security lighting. The blacklight can be produced by both incandescent and fluorescent lamps which are appropriately filtered. Their use is most appropriate for close range inspection and a variety of lamp types, sizes and fixtures are available. Reference Section 6.6.9.

6.2.11 Other Lamps

There are a variety of other types of lamps available for highly specialized applications. None of these however seem to have application to security lighting.

6.3 Luminaires and Supports

6.3.1 General

Lighting systems require luminaires and support for the luminaires. The luminaire is generally considered to be the lamp and fixture for the lamp.

Supports for the luminaires include poles, wall brackets, ceiling brackets or ground mounting fixtures.

Factors to be considered in selecting luminaires include lamps, beam spreads, luminaire efficiency, type of fixture, designs for dirt depreciation control, designs for hazardous locations, indoor vs. outdoor applications and environmental exposure.

Supporting structures must be selected for each application. Typically pole, wall, or ground mounting of the luminaire will be specified. Material types for poles as well as height and number of luminaires per pole must be selected.

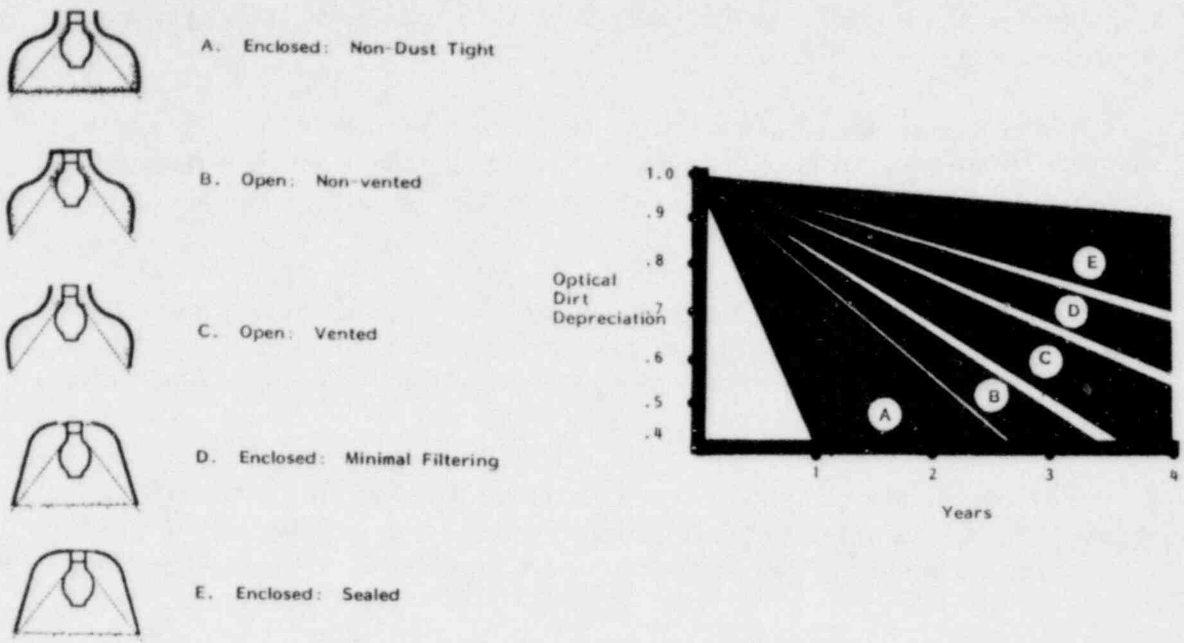
A very wide variety of systems are commercially available. Manufacturer's information is available on specific items and systems selection. Planning and design by an experienced illumination engineer is recommended.

6.3.2 Luminaires

Luminaires are designed for indoor or outdoor applications. Luminaires combine various lamps with fixtures which are either open with or without ventilation or enclosed.

The selection of luminaires relative to whether they are open or enclosed depends largely on the exposure of the luminaire to dirt and dust. For indoor lighting, open ventilated luminaires are utilized more than open non-vented luminaires because the dirt and dust will not accumulate as rapidly. Where there is a high dirt content in the air or fumes, etc., enclosed sealed luminaires can be utilized. Outdoor luminaires are normally of an enclosed type for weather protection and to minimize cleaning and maintenance but also may be open and ventilated. Figure 11 illustrates the fixture types relative to open, enclosed and ventilation configurations. Although dirt depreciation varies widely because of exposure and luminaire design, Figure 13 provides an indication of the relative dirt depreciation from dirt and dust. Notice how the accumulation of dirt and dust on the lamps, reflectors and lenses significantly reduces the lumen output of the luminaire.

Luminaires for wet locations, underwater and hazardous gas or dust locations may also be considered. Sealed luminaires are readily available for this purpose. Performance specifications are included in Underwriters Laboratories Standards Numbers 781, 676, 595, 844 and 57



RELATIVE LUMEN DEPRECIATION FROM DIRT AND DUST

Figure 13

In selecting luminaires, consideration should be given to ease of maintenance. Access to the luminaire, ease of lens removal, lamp removal, ballast access and cleaning ease should be reviewed.

Underwriters Laboratories Standards covering luminaires, lamps and ballasts are listed below:

- Ballasts, Fluorescent Lamps #935-1978
- Ballasts, High Intensity Discharge Lamps #1029-1976
- Emergency Lighting and Power Equipment #924-1977
- Fixtures, Electric Lighting #57-1972
- Fixtures, Electric Lighting for Use in Hazardous Locations #844-1972
- Fixtures, Electric Lighting, Marine Type #595-1974
- Fixtures, Electric Lighting, Underwater, for Swimming Pools #676-1977
- Lampholders, Edison Base #496-1975

- Lampholders, Starters, and Starter Holders for Fluorescent Lamps #542-1974
- Lamps, Portable Electric #153-1976
- Lighting and Power Equipment, Emergency #924-1977
- Lighting Units, Portable Electric, for Use in Hazardous Locations, Class I, Groups C and D, and Class II, Group G, #781-1978

6.3.2.1 Outdoor Luminaires

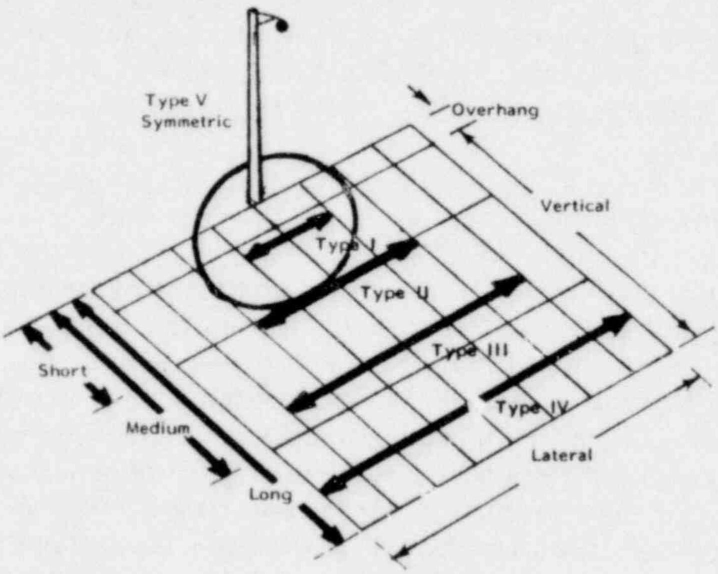
Outdoor luminaires are generally of two types, a roadway luminaire or floodlight luminaire. Either of these types can be used for both isolation zone illumination or other protected areas by utilizing various configurations of supports and luminaires. Outdoor luminaires are normally weatherproof by enclosure or open ventilated. Outdoor luminaires should be manufactured from aluminum, galvanized metal, plastics, other alloys or be appropriately coated with a protective finish to assure minimal maintenance and maximum service life.

6.3.2.1.1 Roadway Luminaires

The Illuminating Engineering Society has established luminaire classifications for roadway types by vertical light distribution, lateral light distribution and control of light distribution above maximum candle power (Reference No. 16). Figure 14 illustrates these criteria. Vertical light distributions are divided into short, medium and long. These refer to the relative reach of illumination from the luminaire (for example, in the direction of across the road). The lateral illumination refers to the distribution parallel to the roadway. The control of light describes the amount of illumination falling outside of the specified design area. "Controlled" is less than or equal to 10 percent, "semi-controlled" or "semi-cutoff" is not more than 30 percent and "non-cutoff" provides no limitation. As shown in Figure 14, the roadway luminaire is normally designed to hang over the illuminated area. Applications for this type luminaire are covered in Section 7. As an illustration, a typical specification or desicription for a 7.3 m (24 foot) wide roadway would be as follows (Reference No. 16):

Light Distribution -	Type	III
	Vertical	L (Long)
	Control	Semi-Cutoff

Lamp Data	Designation	Mercury 700w Clear
	Output (Lumens)	39,000
Pole Data	Height	10.7m (35 ft.)
	Overhang	1.2m (4 ft.)
Arrangements	-	One Side
Spacing	-	61m (200 ft.)
Illumination	Average	1.49 Horizontal
	Minimum	.51 Horizontal
	Uniformity	2.9:1 Avg. to Minimum



ROADWAY LUMINAIRE LIGHTING DISTRIBUTION

Figure 14

An additional consideration for roadway luminaires is the luminaires' coefficient of beam utilization. This is the fraction of lumens from the lamp which reach the illuminated area. It is a function of the luminaire design including configuration, reflectivity of materials used, lens material, and lamp utilized.

To complete the information required to determine the luminaire configuration design, the luminaire dirt depreciation (LDD) factor and lamp lumen depreciation (LLD) factor and other factors such as equipment factors or external factors must be considered.

Normally, manufacturers provide complete photometric data on their luminaires for planning and design purposes. Most manufacturers and distributors will provide a complete computer analysis of configurations and cost for a client's application as a customer service.

6.3.2.1.2 Floodlight Luminaires

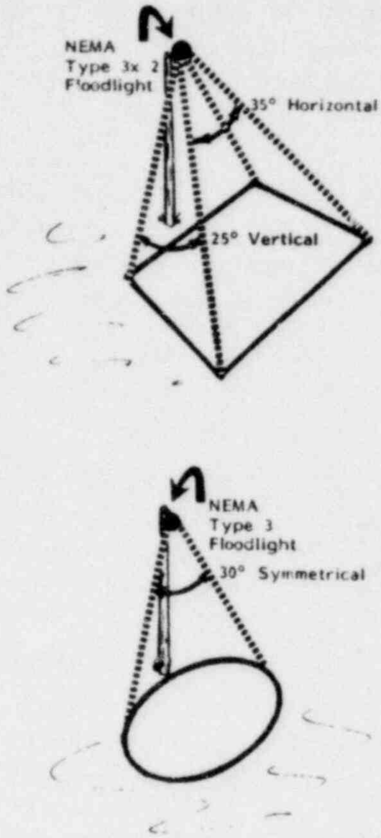
The National Electrical Manufacturer's Association and the Illuminating Engineering Society have designated criteria for floodlight luminaires. These are described by NEMA types which define 7 beam spread degrees (Reference No. 6) as shown below.

NEMA Type 1	10-18 Degrees Spread
NEMA Type 2	18-29 Degrees Spread
NEMA Type 3	29-46 Degrees Spread
NEMA Type 4	46-70 Degrees Spread
NEMA Type 5	70-100 Degrees Spread
NEMA Type 6	100-130 Degrees Spread
NEMA Type 7	130-Up Degrees Spread

These designations refer to a symmetrical (circular) beam. However, the designations can be utilized to define "rectangular beams." This would be designated, for example, by Type 6x4 Floodlight. The 6x4 designates the type of horizontal spread and vertical spread respectively. A $110^o \times 50^o$ floodlight would be a Type 6x4. Obviously, a wide variety of flood configurations can be defined and are available commercially. Figure 15 illustrates several configurations which describe the NEMA type designations.

Floodlight luminaires can be utilized for both "roadway type" of isolation zone illumination or protected area illumination.

As in the case of roadway luminaires, several factors must be considered in planning or designing. Such factors include the luminaire utilization factor, luminaire dirt depreciation factor (LDD), the lamp lumen depreciation factor (LLD), other equipment or exterior factors, luminaire height and luminaire aiming point.



NEMA TYPE FLOODLIGHT DESCRIPTIONS

Figure 15

Manufacturers provide complete photometric information on their luminaires and will normally assist in the planning and design as a customer service. It is recommended that the design of illumination systems be accomplished by an experienced illumination engineer.

6.3.2.2 Indoor Luminaires

A wide variety of indoor luminaires are commercially available. In high bay areas, high intensity discharge luminaires, or high wattage incandescent or fluorescent luminaires are normally utilized. Although enclosed luminaires can be utilized and are appropriate in hazardous or wet areas, ventilated open luminaires are becoming more common. In high bays, glare is not usually a problem since the luminaires can be mounted high in the ceiling. In low bay areas and offices, lamps used in luminaires are usually shielded by louvers, baffles or diffusers to minimize glare problems. Primarily, fluorescent and incandescent and low wattage high pressure sodium luminaires are utilized in low bay or office areas.

As in the case of outdoor illumination, many factors must be considered in planning or designing indoor luminaire configuration. General indoor illumination considerations and criteria for nuclear power plant lighting are provided in Reference No. 17, "Nuclear Power Plant Lighting." Indoor illumination for nuclear power plants is predominantly continuous and an integral part of operational requirements. However, several recommendations are made which relate to luminaire selection and in some cases apply to other nuclear fixed sites. These include:

- Refueling Floor - Enclosed and gasketed luminaires, wall mounted.
- Crane Illumination - Enclosed and gasketed high bay luminaires.
- Pools - Underwater luminaires in pools, mounted around pools on wall.
- Bridge Crane - Enclosed and gasketed luminaires mounted on crane as required.
- Decontamination and Waste Areas - Enclosed and gasketed luminaires.

The luminaires for the above should be of a heavy duty industrial type with high impact globes or covers and vibration proof. Luminaires used in the pool areas should be of stainless steel or low zinc bronze alloys. The use of zinc galvanized and aluminum luminaires and related fixtures should be avoided in the PWR reactor containment areas. Luminaires and related fixtures should be located and designed to minimize the potential of items falling into pools.

Design and planning for general indoor illumination is beyond the scope of this document due to the wide variety of luminaires and operational illumination requirements within nuclear fixed sites. Section 7 does address several applications where security/safety illumination may be required as a minimum if operational illumination levels are not otherwise available.

6.3.2.3 Special Luminaires

"Pit Lights" are protected luminaires which can be installed in the ground or in wells of wet and harsh environmental areas. These luminaires are ideal for installation in roadways at vehicle portals and inspection stations. They are weather protected and have a durable protective lens.

Underwater luminaires for use in reactor pools are commercially available. For security lighting purposes these would normally already be installed for operational lighting purposes.

6.3.3 Luminaire Structural Supports

6.3.3.1 General

Indoor and outdoor luminaires are supported by wall mountings, ceiling mountings, light standards, poles, high mast structures and a variety of other methods. This section reviews some of the basic considerations for planning and design.

6.3.3.2 Outdoor Luminaire Structural Supports

6.3.3.2.1 General

Luminaire support structures include wall mounting, common light standards, pole top standards and high mast/tower systems. Design standards which will aid in preparing specifications on designs are noted in Reference No. 10 and "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" by the American Association of State Highway and Transportation Officials (Reference No. 18).

Primary design and selection considerations include the local environment, selected luminaire system, structural support loads, materials selection, soil conditions, cost, space available, maintenance and other unique site requirements.

6.3.3.2.2 Poles and Masts

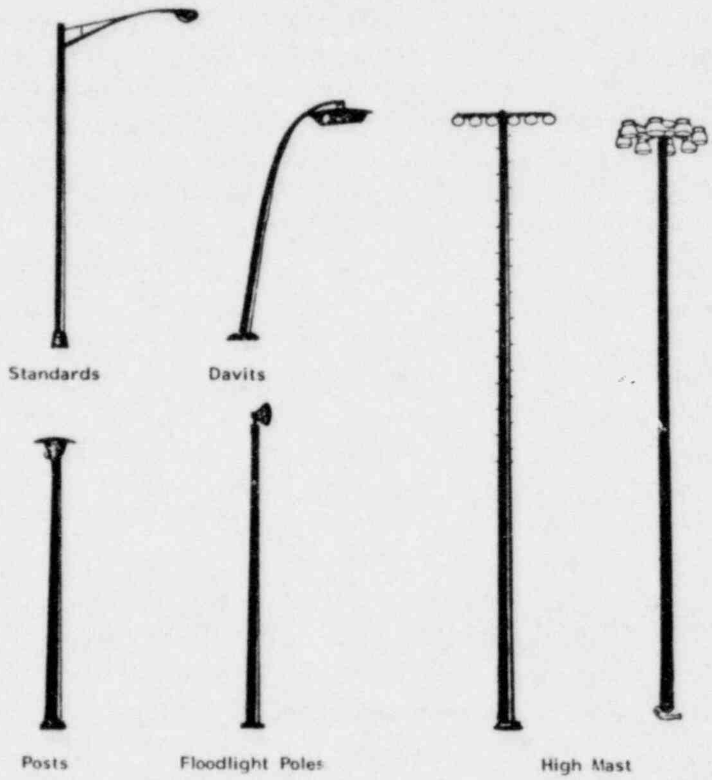
6.3.3.2.2.1 General

Poles and masts for luminaire support are commonly made from treated wood, steel, aluminum or reinforced concrete. Pole and mast heights of up to 46 meters (150 feet) are available. Poles and common light standards are used for perimeter illumination. For this purpose, the luminaire height is usually 12 meters (40 feet) or less. Generally each pole will have 1 to 4 luminaires depending on design requirements. High masts or towers are used to illuminate large areas and may utilize up to 12 or more luminaires. While shorter poles can usually be serviced from a "bucket truck" which is currently available with working heights up to approximately 18 meters (60 feet), taller masts will require either climbing aids (cables or pegs, for example) or luminaire lowering devices. A variety of pole and mast configurations are shown in Figure 16.

Pole and mast loads must be considered for planning and design purposes. These loads consist of dead loads (the weight of the luminaires, supports, lowering devices, and other fixtures including CCTV devices, if appropriate), ice loads (as determined for the installation area) and wind loads (based on regional maximum wind speeds on a 50-year mean recurrence with special consideration given to exposure to gusts; high winds or turbulence). Reference No. 19 provides computational details and regional information.

If luminaire support structures are to be utilized for CCTV cameras as well as luminaires, particular attention should be given to structure flexure resulting from wind loads and its effect on image quality. The slightest camera movement may cause a very distracting video image movement. At sites where this is likely to be a consideration, an analysis of the anticipated windloads, camera movement and impact on the video image should be completed.

High mast systems are more economical when large areas require illumination. High mast systems reduce glare at ground level which is desirable within the security area. Poles at a relatively low level along the isolation zone create glare for the intruder, selective higher intensity illumination in key areas and can be aimed away from the protected area thereby eliminating glare in the eyes of the security force.



TYPICAL OUTDOOR LUMINAIRE SUPPORTING STRUCTURES

Figure 16

6.3.3.2.2.2 Steel Poles and Masts

Steel poles and masts are one of the most expensive options from the standpoint of initial cost as indicated in Figure 17. However, they are durable if properly protected against corrosion. This can be accomplished by specifying galvanized steel, stainless steel, painting or other pretreatment. Stainless steel is very expensive but requires a minimum of maintenance. Aluminized steels will also require a minimum of maintenance.

Steel masts are available in heights up to 46 meters (150 feet) or more if required.

6.3.3.2.2.3 Aluminum Poles and Masts

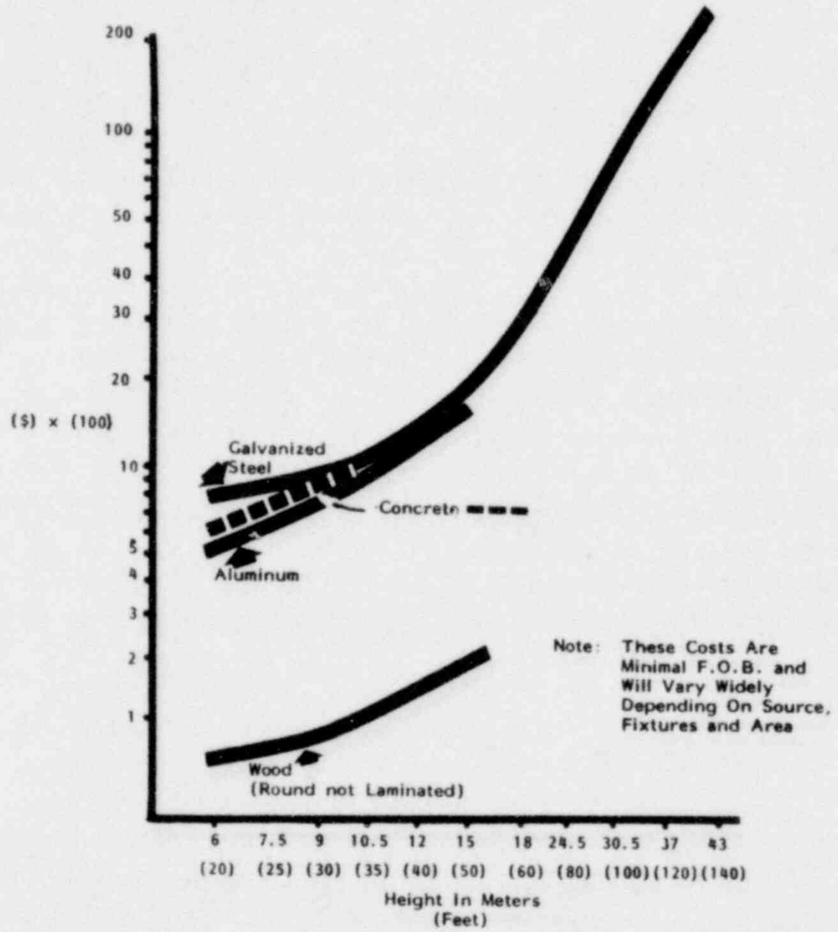
Aluminum poles and masts are very close in cost to steel poles of equal height. They have very long service lives and require a minimum of maintenance.

If aluminum poles or other fixtures are utilized, precautionary measures should be taken where they come in contact with wood or dissimilar metals. The purpose of this is to minimize the effects of corrosion and electrolysis (Reference No. 18). Surfaces which come in contact with wood, masonry or concrete can be protected by application of a coating of alkali-resistant bituminous paint.

Additional information on aluminum structures is available in "Specifications for Aluminum Bridge and Other Highway Structures," The Aluminum Association, New York, April, 1969.

6.3.3.2.2.4 Wood Poles

Treated wood can be utilized for luminaire supports with heights of up to 15-18 meters (50-60 feet). Wood poles should be pressure treated with either creosote or pentachlorophenol type preservatives. Depending upon environmental exposure at the installation, a service life of 20-30 years can be anticipated. As shown in Figure 17, wood poles have a relatively low initial cost. Wood poles require a minimum of maintenance and foundation expense. The aesthetics of wood poles is limited due to the requirement of external conduit and fixtures and non-existent architectural



COMPARATIVE POLE AND MAST COST

Figure 17

stylization. Wood poles are more subject to fire damage. They are appropriate for use where aesthetics are not significant and high masts are not required. They should provide excellent service as isolation zone and perimeter luminaire supports. Wood laminated poles which may be somewhat more aesthetically designed as well as round poles are available. The laminated poles may have internal raceways and therefore not require external conduit and fittings. Laminated poles are available in heights of up to 9 meters (30 feet). The cost of laminated wood poles ranges from approximately $650 for 6 meters (20 ft.) to $1400 for 9 meters (30 ft.) poles.

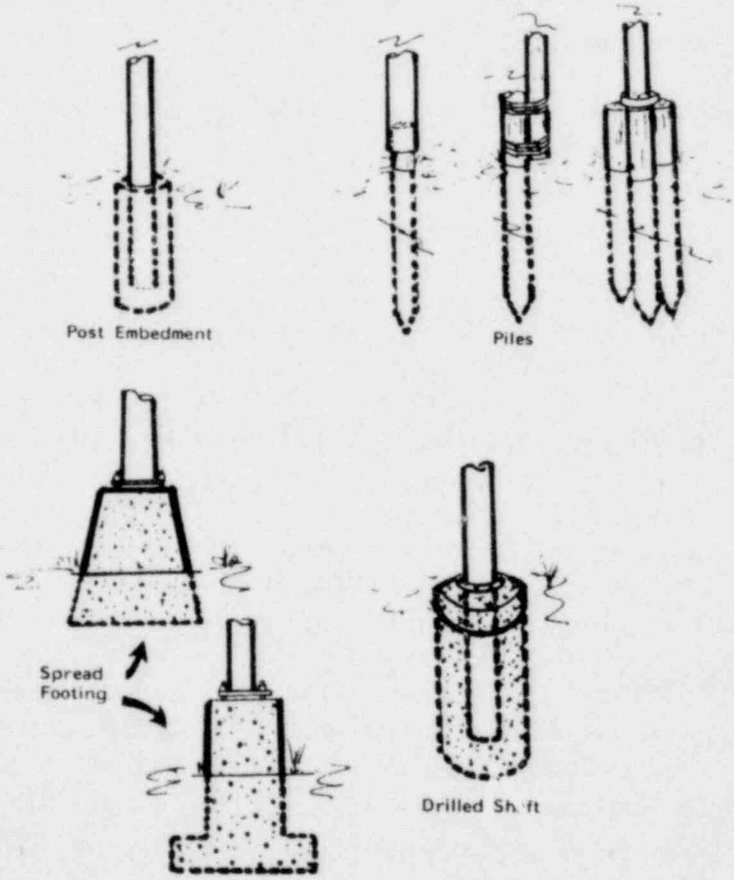
6.3.3.2.2.5 Concrete Poles

Concrete poles are available in a range of fron. meters (10 feet) to 12 meters (40 feet). The poles are prestressed and manufactured usually by centrifugal casting processes or non-centrifugal processes. Aggregate surface options with a polished Terrazzo finish make the poles aesthetically attractive. Maintenance should be minimal since the poles, with the exception of miscellaneous fixtures, are basically inert. Extensive exposure to salt spray or splash should be avoided.

6.3.3.2.2.6 Foundations

Foundation requirements for luminaire supporting structures depend upon the type of pole utilized, height and weight of the pole and luminaires, pole wind and ice loads, and soil conditions. Soil information including type, density and ground water conditions should be investigated by the foundation designer.

Generally foundations will be either of a post embedment, piles, drilled shaft or spread footings type. These are illustrated in Figure 18. Post embedment can be utilized for relatively short poles in relatively dry and stable soil conditions. This is a common foundation for wood poles (telephone poles, etc.). Piles may be used when soils are constantly wet at shallow depths or caving of sides precludes use of drilled shafts or spread footings. Drilled shafts can be utilized for "deep" foundations which are desirable where horizontal loads or cantilevered loads are prevalent. Spread footings provide a larger vertical bearing surface for heavy loads or unstable soil conditions.



TYPICAL LUMINAIRE SUPPORT STRUCTURE FOUNDATIONS

Figure 18

Soils such as loose sand and soft clay will require foundations which are larger or deeper or both. Soils such as hard clay may permit smaller foundations. Foundations should be deep enough to be well below the frost line to prevent frost heaving.

Foundations should be designed by an experienced engineer to assure that all appropriate design requirements are considered.

6.3.3.2.3 Wall Mounts

Fixtures and luminaires designed for wall mounting are readily available. They normally add little if any cost to the luminaire and avoid the cost of poles or masts. Floodlight luminaires are available with brackets which require attachment using several bolts.

6.3.3.2.4 Ground Mounts

In some instances it may be desirable to mount luminaires at ground level to floodlight a building or sign. This can be accomplished by utilizing an appropriate embeded spike or post or a small spread footing. Luminaires with mounting brackets can be bolted directly to the support.

6.3.3.3 Indoor Luminaire Structural Supports

Indoor luminaires are normally suspended from the ceiling area or wall mounted. Standard hardware is available for this purpose or mounting features are offered as an integral part of the luminaire. Brackets usually require attachment with several bolts. Ceiling suspended units may either be clamped or bolted on to roof support structures.

6.4 Ballast Systems

6.4.1 General

Ballast systems are required for high intensity discharge (HID) lamps and fluorescent lamps to provide power to the lamp at the proper voltage and current levels. Generally the ballast is an integral part of the luminaire but in some cases can be separated from the lamp by as much as 1-46 meters

(3-150 feet). High pressure sodium and mercury vapor lamps are also available as self-ballasted (with the ballast built into the lamp). Self-ballasted lamps are not as efficient as those with regular ballasts. Generally the efficiency of a ballast increases with the output rating of the lamp used. Since the ballast consumes power as well as the lamp, they must be added together including power factor to determine total power requirements.

6.4.2 High Intensity Discharge (HID) Lamp Ballasts

6.4.2.1 General

There are several important factors to be considered when selecting ballasts for security lighting systems. These include efficiency, crest factor, range of temperature exposure, fusing, grounding, voltage regulation, extinction voltage (drop-out or dip-voltage) and power factor.

The efficiency of a lighting system or luminaire is based not only on the power consumed by the lamp but also the ballast. In computing the net lumens per watt the number of watts should include both the lamp and ballast. Generally the higher powered lamps and ballast are more efficient.

The crest factor is the ratio of maximum lamp current to R.M.S. (root-mean-square) current. A maximum crest factor (approximately 2.0 for mercury vapor and 1.8 for metal halide and high pressure sodium lamps) must be maintained by the ballast to assure maximum lamp life.

Mercury vapor and metal halide lamps have minimum specified starting temperatures for given starting voltages. Lower temperatures may require higher voltages. It is important to assure that the specified ballast will meet the minimum requirements.

Some manufacturers do not recommend fusing of high intensity discharge lamp ballasts and indicate that a reactor type ballast should never be fused. Since ballast normally fail in an open circuit condition, the value of fuses is diminished. If fused, interruptions will be minimized by using fuses or breakers with a rating of 3 times maximum current. Grounding of lamp sockets should be considered only if primary and secondary ballast transformers are isolated from each other.

Ballasts must assist in controlling lamp voltage over a range of line voltage deviations. Voltage dips causing extinction or drop-out should also be controlled. Most ballast will tolerate dips up to 15-20 percent with some tolerating dips of up to 50-60 percent.

Power factor ratings of ballasts are important from an economic standpoint. Ballasts with power factors of 50 percent use approximately twice as much power as a 90 percent power factor rating. Utility companies may charge a premium for power consumed at a low power factor. Figure 19 illustrates several common ballast types.

6.4.2.2 Reactor Ballast

The reactor ballast is small and low cost and applies to mercury vapor and sodium vapor lamps. A voltage of plus or minus 5 percent of ballast rated operating voltage is required for mercury vapor and plus or minus 10 percent for sodium vapor. The reactor ballast generally has a power factor of 50 percent, however, it can be corrected to 90 percent with the addition of an expensive capacitor across its lines. Starting current is higher than operating current. Use of a mercury reactor ballast for high pressure sodium lamps will cause a very short lamp life.

6.4.2.3 Lag Type Ballast

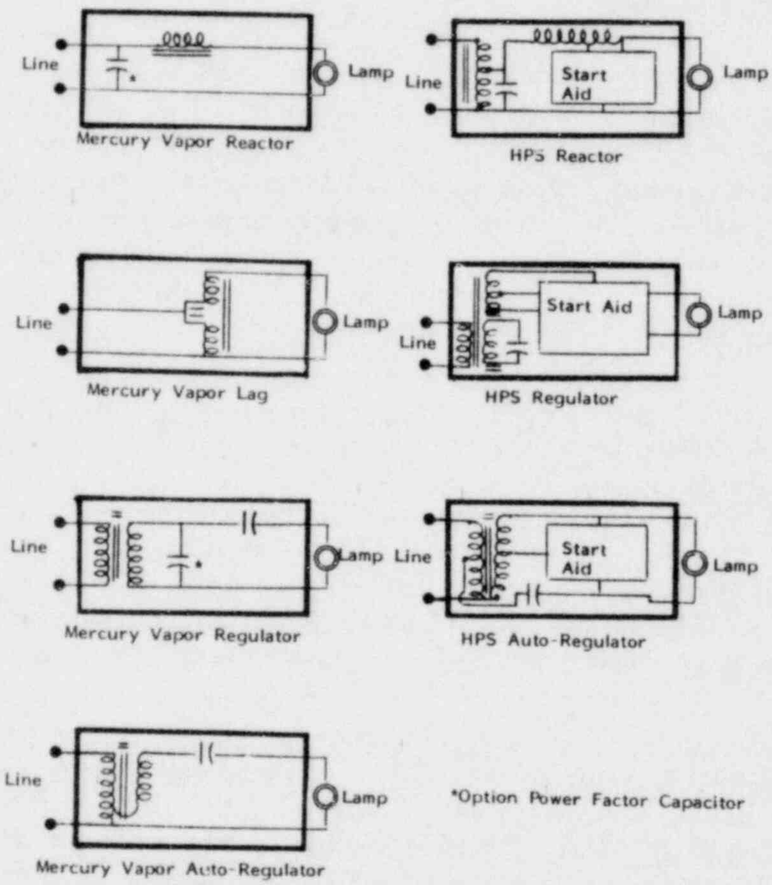
Lag type ballasts have low power factor ratings of 50 percent and can tolerate voltage dips of only 15-20 percent. They have a crest factor of 1.4 and require a closely regulated line voltage (plus or minus 5 percent). They are only used on mercury vapor lamps. The ballast losses are greater than the reactor ballast. Starting current is higher than operating currents.

6.4.2.4 Regulator Type Ballast

The regulator ballast has a crest factor of 1.8 and a power factor of 95 percent. It can tolerate large voltage dips of up to 50-60 percent and line voltage deviations of plus or minus 13 percent. It has among the highest ballast losses. It is only used for mercury vapor lamps.

6.4.2.5 Auto-Regulator Ballast

The auto-regulator ballast is low cost and relatively efficient. It has a crest factor of 1.6 and power factor of 90 percent for mercury vapor and metal halide and 95 percent for high pressure sodium. It can tolerate voltage dips



BASIC BALLAST TYPES FOR HID LAMPS

Figure 19

of 40-50 percent and line voltage deviations of plus or minus 10 percent. It is commonly used on mercury vapor, metal halide and high pressure sodium with the addition in manufacturing of a lamp voltage transformer and starting aid.

6.4.2.6 Auto Transformer Ballast

This ballast is used for low pressure sodium lamps. It will start lamps in temperatures as low as -34°C (-30°F). It has a power factor rating of 95 percent and requires that line voltage be controlled to plus or minus 10 percent.

6.4.3 Fluorescent Lamp Ballast

Ballast for fluorescent lamps should be an instant starting type with a high power factor rating. Both of these features are common.

6.4.4 Xenon Arc Lamp Ballast

Xenon arc lamps require power supplies designed specifically for the type and rating of the lamp used. These are normally provided by the manufacturer of the searchlight or luminaire.

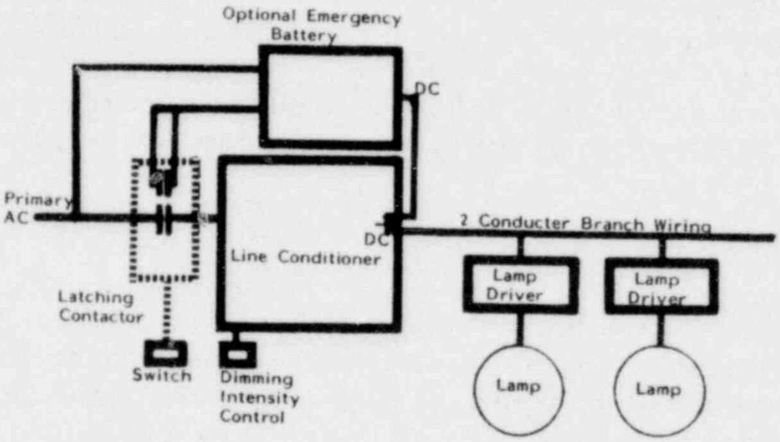
6.4.5 Other Ballast Systems

6.4.5.1 General

Several newer types of ballast and ballast features have been recently developed. These systems are discussed in the following paragraphs.

6.4.5.2 Transistorized Arc Control

The transistorized arc control system made by Wide-Lite utilizes solid state components and provides features such as built-in dimming, potential to be tied directly in with a D.C. battery bank for use as an emergency power supply, silent operation, stroboscopic effect free and it can provide power for several power cycles which may prevent drop-out and restrike after very brief power interruptions. (Reference Figure 20.) This system is available for 175 watt and 400 watt metal halide and mercury vapor lamps and 150 watt and 360 watt high pressure sodium self-starting lamps. An energy savings of 7-10 percent is claimed when used with metal halide lamps. Line voltage variations of plus or minus 10 percent will not cause lamp power to vary more than plus or minus 1 percent. The dimming feature permits adjusting the lumen output to the minimum required. Dimming from 100 to 60 percent of rating is claimed. Additional savings can be realized by allowing lamps to operate at partial output until higher levels of lighting are desired for increased visual or CCTV assessment (savings of approximately 40 percent).



TRANSISTORIZED ARC CONTROL

Figure 20

6.4.5.3 GE Steadilux (Trademark)

The GE Steadilux is a hybrid design which combines a conventional core and coil and capacitor with an electronic control. It achieves a plus or minus 1 percent regulation of lamp watts for plus or minus 10 percent line voltage variation. The power control features keep the lamp output almost constant over the life of the lamp. This minimizes the need to overspecify or plan for excessive lamp lumen depreciation. Improved energy efficiency of at least 10 percent is claimed. This ballast is available for 150, 250 and 400 watt high pressure sodium lamps. This feature adds approximately 68 dollars to the cost of the luminaire.

6.4.5.4 "Hot Lamp Restart"

General Electric manufactures a "Hot Lamp Restart" feature. Although most high pressure sodium lamps will restrike within one minute, two to three minutes may be required to achieve full lumen output. The "Hot Lamp Restart" will restart the GE Lucalox (Trademark) lamp instantly without significant lumen degradation after outages of up to 10 seconds. If the power outage is less than 30 seconds but more than 10 seconds it will restrike instantly but lumen output will be slightly diminshed. Presently, this is available as an option on reactor ballast for 50, 70, 100 and 150 watt lamps only. This feature adds approximately 65-76 dollars to the ballast cost. Although not stated by the manufacturer, this method of restart may decrease the life of the lamp.

6.4.5.5 Automatic Auxiliary Lamp Switching Ballast

High intensity discharge luminaires and ballast are available which during power interruption will automatically switch power to an auxiliary lamp (usually tungsten halogen) which will provide immediate light. When the main lamp restrikes and reaches output from 40 to 60 percent, the auxiliary lamp extinguishes. When this system is used in conjunction with an auxiliary power source, emergency lighting can be provided.

Manufacturers who provide these systems include Wide-Lite (LiteMatic - 250, 400, 1,000 watt HID plus 150 watt tungsten halogen auxiliary) and GE (400, 1,000 watt HID plus 250 watt quartz auxiliary; 250 watt and smaller HIDs plus 150 watt quartz auxiliary). These systems add approximately 55-109 dollars to the cost of each luminaire not including the auxiliary lamp. Caution in designing systems such as these is necessary in determining the total circuit load for all the lamps simultaneously.

6.4.5.6 Dimmers

Dimmers are available for incandescent, fluorescent and high intensity discharge lamps. Dimmers may be manually controlled or automatically controlled. The purpose of dimmers is to allow adjustment of lumen output to specific levels. Their use is appropriate for taking advantage of ambient light (reducing the lumen output to provide minimum net levels) or for compensating for lamp and dirt depreciation (by automatically increasing lumen output only as required).

A wide variety of commercial and industrial dimmers are available for fluorescent and incandescent lamps. Since these are not used primarily for security lighting except in isolated areas, they are not covered in detail.

One system, the Automatic Energy Control (AEC) manufactured by Wide-Lite, provides an automatic dimming system which monitors the light available and adjusts the luminaire output to a specified level. This system is available for 400 and 1,000 watt high intensity discharge lamps. As an indoor system, it can compensate for lamp and dirt depreciation and ambient light. As an outdoor system, it can compensate for lamp and dirt depreciation, ambient light and ambient atmospheric conditions such as rain, fog, etc.

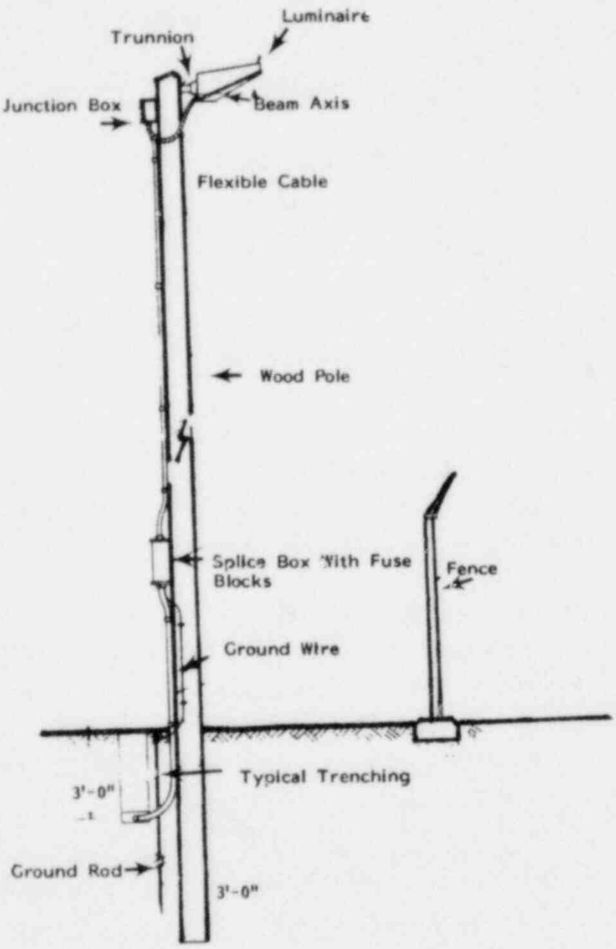
6.5. Power Systems and Distribution

6.5.1 General

The purpose of this section is to highlight unique factors relative to security lighting system power systems and distribution.

6.5.2 Primary Distribution

There are a variety of circuits suitable for various kinds of security lighting systems. There is also a choice to be made between overhead and underground distribution systems. While overhead systems are generally more accessible for maintenance, they are more susceptible to damage by ice, storms and adversaries. When choices are available, it is recommended that an underground system be utilized. A typical installation is illustrated in Figure 21. Note in the figure that the electrical conduit is located on the backside or secured side of the pole (wooden in this case) and that each luminaire is fused. The fuse box should be kept as close to the ground as possible to minimize the quantity of exposed non-fused circuit. It is recommended that the security lighting distribution system and related substation systems be located within the protected area and out of the line-of-sight from off-site as much as possible.



TYPICAL SECURITY LIGHTING POLE CIRCUIT

Figure 21

There are many circuit options for security lighting systems. Caution should be utilized to assure that each luminaire is independent from others. Damage to one pole should not affect other poles nor cause large segments of the security lighting system circuit to open. Separate pole fusing will prevent this in case of luminaire malfunction or pole/luminaire damage.

Lighting circuits should be planned to avoid overloading or blowing fuses or breakers which will affect total lighting reliability. Separate conduits and feed circuits are desirable whenever possible. Having all or large segments of luminaires on one circuit significantly reduces the overall security lighting reliability and alternatives should be considered. Separate lighting systems for portals (vehicle and personnel), protected area outdoor lighting, material access areas, vital areas and security alarm stations are recommended. Refer to Figure 22 as a partial typical example.

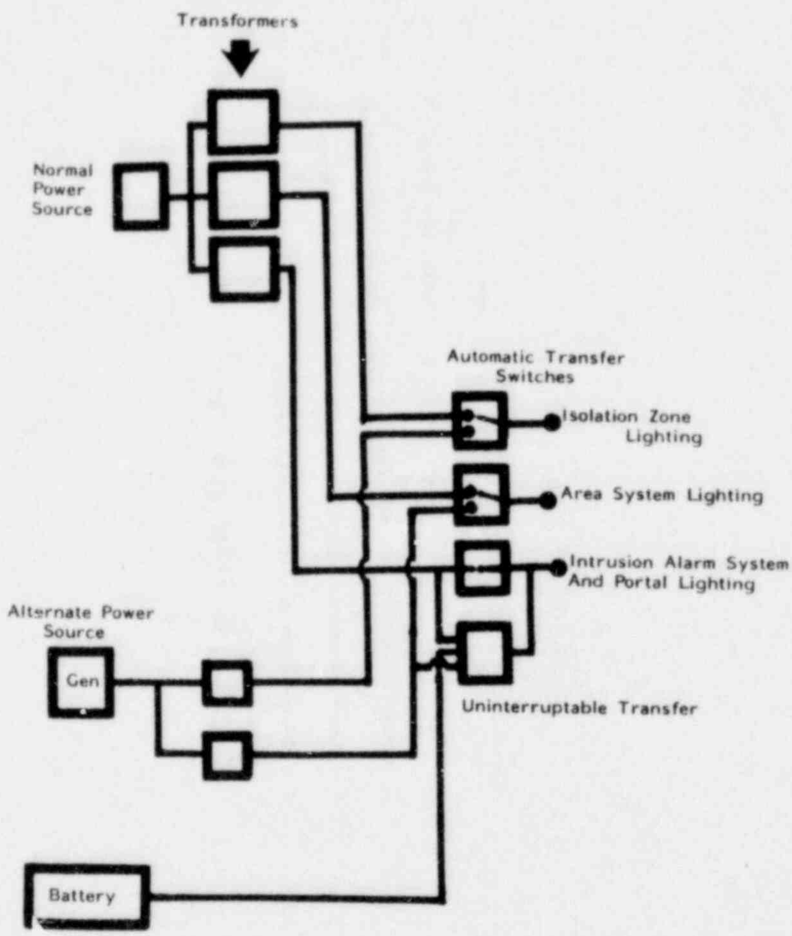
Where 3-phase power distribution systems are planned, it is possible for alternate luminaires to utilize separate phases of the 3-phase system. This method will provide some continuous illumination in case of a failure of a single phase. This approach also minimizes stroboscopic effects which are common to most high intensity discharge lamps and fluorescent lamps.

As shown in Figure 23, poles with 3 luminaires may use 2 phases alternating on each pole. Poles with one luminaire may alternate phases on each pole. If poles have more than 3 luminaires, other combinations can be worked out to assure load distribution and best assurance of continuous illumination.

Similar systems can be worked out utilizing single-phase by alternating off neutral if the luminaires are selected for 1/2 of the single phase voltage. However, it may not be advisable to either mix or lower the voltage for maintenance and economy reasons. (Reference Figure 24.) Isolation switches should be provided at each pole to manually transfer a damaged circuit to an alternate feed. This can be accomplished by feeding a row of fixtures from both ends and sizing either circuit to carry the full load at an increased acceptable voltage drop.

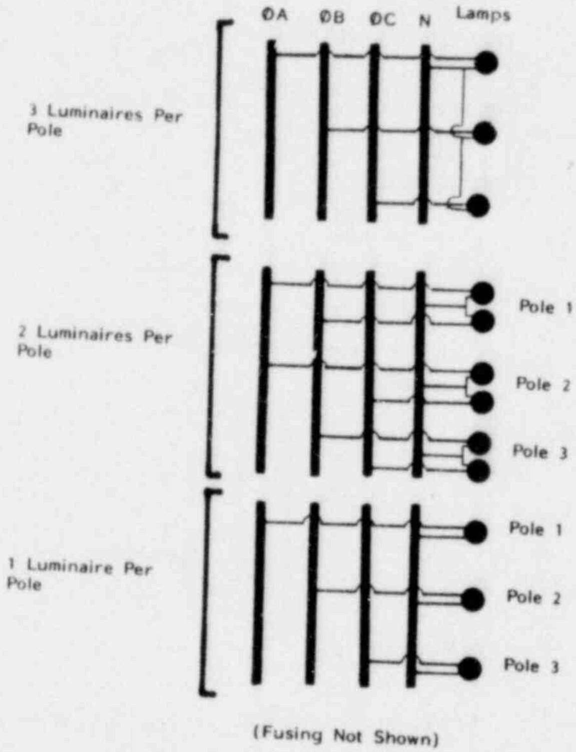
6.5.3 Power Surges and Losses

As noted in the sections on lamps and ballasts, luminaires are sensitive to power surges and losses. Voltage drops due to "brown outs" or other causes can result in diminished illumination in some cases or cause certain



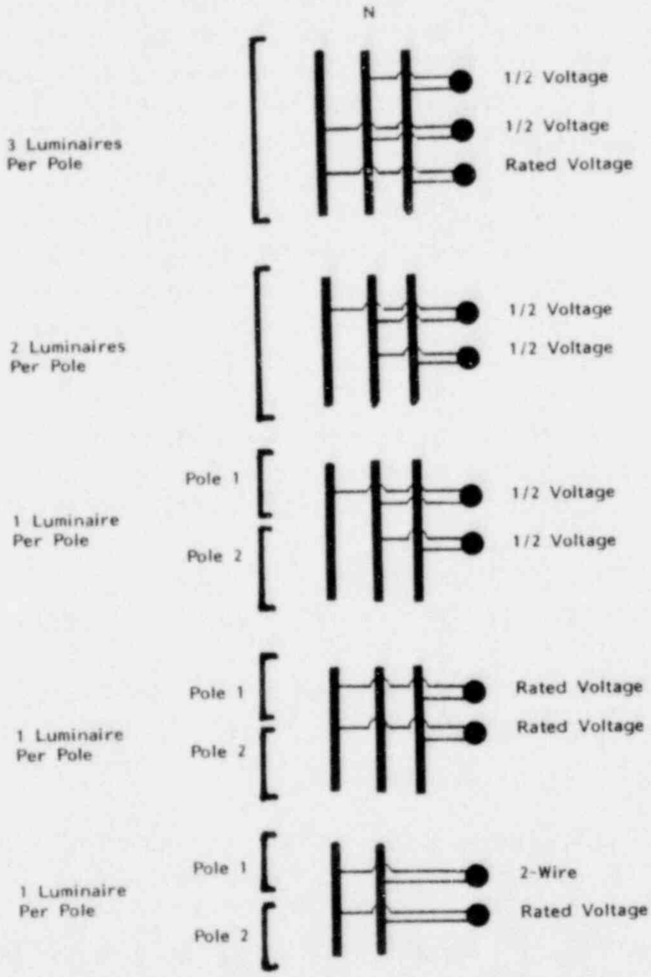
PARTIAL TYPICAL LIGHTING SYSTEM POWER DISTRIBUTION

Figure 22



3-PHASE LUMINAIRE WIRING DIAGRAMS

Figure 23



SINGLE PHASE LUMINAIRE WIRING DIAGRAMS

Figure 24

types of luminaires to drop-out or reduce output. Complete failure of a momentary or long-term type can be caused by adversaries, equipment failure, accidents, lightning strikes or other storm damage.

Tests run by the National Bureau of Standards (Reference No. 19) indicate that a person can penetrate a perimeter chain-link fence in 6 to 47 seconds. Intruders in a running mode can cover from 15-25 feet per second. This would indicate that a 60 foot isolation and fence zone at a protected area perimeter could be penetrated and cleared in from 8.4 to 51 seconds. If the intruder continues to run into the protected area, penetration of up to 135 to 1,290 feet could be accomplished within one minute. If the intruder initiated the power outage, access to the proximity of vital or material access areas could readily be accomplished for the purpose of sabotage or threatened sabotage. Using this rationale, it is recommended that lighting systems for the isolation zone provide for a maximum of 10 seconds outage. The backup power supply should be of an uninterruptable type or a generator type with luminaires which will reliably restrike within 10 seconds. To accomplish this would mean that an independent power source would have to come on within 10 seconds and instantly restrike the lamps or that an uninterruptable power supply will be required to sustain the lighting system until power is either returned or the backup system is activated.

Power changes beyond the tolerance limits of various luminaires can have several detrimental effects. If the voltage drops marginally, lamps may not operate at rated output or cease to operate until restarted with the proper power level.

Typical effects of power changes are summarized by type of lamp below:

- Incandescent lamp output varies with voltage applied to the lamp. Start and restart time to full output is almost instantaneous. Power dips do not cause restart delays.

- Fluorescent luminaires are usually of an instant or rapid start design. They will restrike almost as quickly as incandescent lamps.

- Metal halide lamps require a 3-5 minute startup cycle to reach 80 percent of rated light output. If the power is interrupted for more than 1/2 cycle or 1/120 second, restart will be required. Restart for metal halide requires 10-20 minutes. If an auto-regulator type ballast is uitlized, power dips of 40-50 percent can be tolerated without drop-out. To avoid the restrike time requires use of an uninterruptable power supply. Reference No. 9.)

- Mercury vapor luminaires typically start in 3 - 7 minutes. Restarting is required if the lamp's power is interrupted for more than .008 seconds. It must cool down before restarting. Cool down and restart can take from 3 to 6 minutes. (Reference No. 9.) To avoid 3 to 6 minutes outages would require an uninterrupted power system. Significant power dips can be tolerated to the extent of 60 percent depending upon the type of ballast used. The dip-voltage which can be tolerated without causing drop-out or restrike are shown below:

Regulator Type	50-60% DIP
Lag Type	15-20% DIP
Auto-Regulator Type	40-50% DIP
Reactor Type	15-20% DIP

- High pressure sodium (HPS) lamp restart capabilities are similar to mercury lamps in that if the power source is interrupted for more than 1/120 second reignition is required. (Reference No. 9.) However, since they do not have to cool down as much, the restrike time is from 1/2 to 1 1/2 minutes with a nominal time of 1 minute claimed by most manufacturers. Initial start requires 3 to 4 minutes for 80 percent output. Voitage dips can be tolerated without drop-out or requiring restrike to the extent of 15-50 percent depending on the type of ballast used as shown below:

Reactor Type	15-20% DIP
Regulatory Type	40-50% DIP
Auto-Regulator Type	40-50% DIP

- HPS lamps in a luminaire of German design (Reference No. 9) used by the U.S. Air Force in Europe provide a ballasting system which will allow instant restart with outages of up to 60 seconds and requires a 30 second restart time if the outage is for no more than 120 seconds. Otherwise, it is necessary to accept a minute outage or provide an uninterruptable power supply.

- General Electric manufactures a "Hot Lamp Restart" feature as an option on ballasts for 50, 70, 100 and 150 watt high pressure sodium lamps which will provide instant restart with outages of up to 10 seconds and instant restart with outages of up to 30 seconds at slightly reduced lumen output. In this case, an interruptable power source could provide rapid restrike illumination (such as a generator with a 10 second power up time).

- Low Pressure Sodium (LPS) lamp output varies slightly with line voltage changes. Start time for low pressure sodium lamps requires about 10 minutes. If power is interrupted, the lamp stays hot enough to restart instantly within the normal time frame necessary to start a generator. Therefore, service could be expected to be restored within 10 seconds with a generator or continuous service can be provided with an uninterruptable power source. Since the LPS lamps will instantly restart with only momentary power interruptions, momentary power dips in line voltage do not cause drop-out or restrike. Manufacturer's claims for restrike time for low pressure sodium lamps as noted in Reference No. 9 are as follows:

  "35 and 55 watt lamps will re-ignite immediately following a power drop out with a reliability factor of plus 95%."

  "90, 135, and 180 watt lamps will re-ignite immediately following a power drop out with a reliability factor of plus 75%."

  "Lamps that do not restrike immediately will strike within a maximum of 2 minutes."

  "The amount of light provided when lamps re-ignite will be dependent upon the duration of the outage. In general, if power is restored within 30 seconds those lamps which re-ignite immediately will provide 90% plus of their maximum light output." Note that lamps which have been extinguished in excess of the 30 seconds will require additional time to reach rated output.

  "The latest information from the lamp manufacturer is that 90% of the lamps will restrike immediately with interruptions up to 5 minutes. The other 10% will take 58 seconds to restrike."

In summary:

An uninterruptable power supply will provide continuous power to all luminaires.

An interruptable power supply will provide power to restrike incandescent and fluorescent luminaires instantly, metal halide luminaires in 10-20 minutes, mercury vapor luminaires in 3-6 minutes, high pressure sodium luminaires in 1 minute (instantly with optional ballast features) and low pressure sodium lamps 90 percent instantly if within 58 seconds.

It is recommended that luminaires and backup power supplies be combined such that isolation zone illumination will restrike within 10 seconds, that protected area illumination will restrike within 60 seconds, that portal area illumination is continuous and that vital and material access area illumination is continuous. Note that the general requirement recognized by NRC is for a 60 second restrike maximum time in the protected area.

6.5.4 Backup Power System

6.5.4 1 General

The backup power supply for the security lighting systems should be on site within the protected area, considered a vital area and additional to the primary or preferred power system. It does not have to be exclusively for the purpose of lighting. The security lighting backup power can be derived from systems designed to provide backup power for purposes other than security if the system is on site within the protected area and has adequate capacity and appropriate activation criteria.

Typical systems and combinations of systems to be selected from include:

- Uninterruptable Power Supplies
- Interruptable Power Supplies
- Generator Sets
- Special Ballast Systems

U. S. Nuclear Regulatory Guides provide a significant amount of information on backup and emergency power systems. Several of these guides are listed below:

Regulatory Guide 1.108; August 1976 (For Comment); Periodic Testing of Diesel Generators Used as On-Site Electric Power Systems at Nuclear Power Plants.

Regulatory Guide 1.118; June 1978; Periodic Testing of Electric Power and Protection Systems.

Regulatory Guide 1.128; October 1978; Installation Design and Installation of Large Lead Batteries for Nuclear Power Plants.

Regulatory Guide 1.129; April 1977 (For Comment); Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants.

Regulatory Guide 1.137; Fuel-Oil Systems for Standby Diesel Generators.

Regulatory Guide 1.30; Quality Assurance Requirements for the Installation, Inspection and Testing of Instrumentation and Electrical Equipment.

Regulatory Guide 1.32; Use of IEEE Std 308; Criteria for Class IE Power Systems for Nuclear Power Generating Stations.

Regulatory Guide 1.41; Pre-Operational Testing for Redundant On-Site Electric Power Systems to Verify Proper Load Group Assignments.

Regulatory Guide 1.47; Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems.

Safety Guide 1.6; Independence Between Redundant Standby (On-Site) Power Sources and Between Their Distribution Systems.

Regulatory Guide 1.75; September 1978; Physical Independence of Electrical Systems.

Regulatory Guide 1.81; Shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants.

Regulatory Guide 1.9; November 1978 (For Comment); Selection, Design, and Qualification of Diesel-Generator Units Used as On-Site Electric Power Systems at Nuclear Power Plants.

Regulatory Guide 1.93; December 1974; Availability of Electric Power Sources.

Regulatory Guide 5.3; June 1974; Materials Protection Contingency Measures for Uranium and Plutonium Fuel Manufacturing Plants.

Branch Technical Positions, BTP ICSB6; Capacity Test Requirements of Station Batteries Technical Specifications.

Branch Technical Position, BTP ICSB-11, Stability of Off-Site Power Systems.

Safety Guide 9; March 1971; Selection of Diesel Generator Set Capacity for Standby Power Supplies.

NUREG Report, CR-0509; Emergency Power Supplies for Physical Security Systems (details planning information for backup power systems).

Minimum requirements for emergency or standby systems which are vital to protection of human life or safety in public facilities are covered in the National Electrical Code, NFPA (National Fire Protection Association) 101-Life Safety Code, and in the National Uniform Building Code.

Another excellent source is the IEEE's Recommended Practice for Emergency and Standby Power Systems. Std 446-1974.

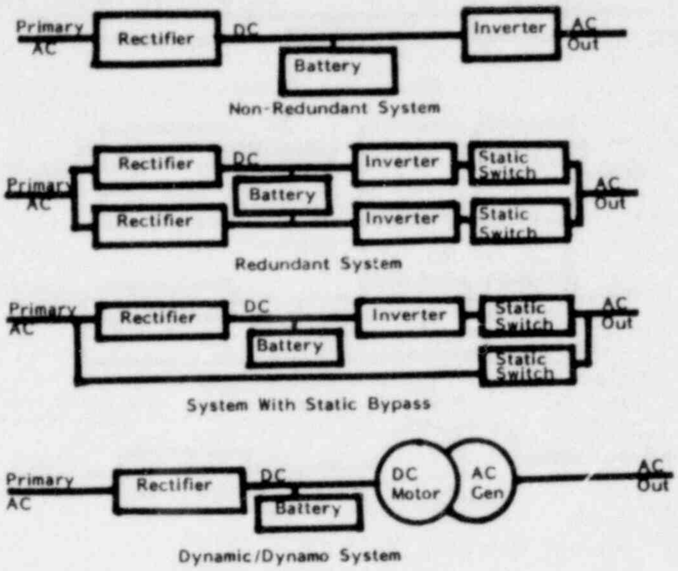
6.3.4.2 Uninterruptable Power Supplies

For the purposes of security lighting backup power systems, uninterruptable power systems (UPS) are systems which provide constant power to protect equipment against power outages or voltage variations and assure continuity of operation. A system typically consists of storage batteries, power inverters and related controls. Several typical systems are shown in Figure 25. Redundancy built into the uninterruptable power systems provide much greater reliability. However, since the uninterruptable system itself is a redundant system, it is not necessary to provide extra assurances for security lighting.

The cost of various sizes of uninterruptable power systems are shown in Figure 26. These costs vary depending on type of system, shipping and installation requirements. The costs shown include only the equipment cost and not the cost of a facility for the equipment.

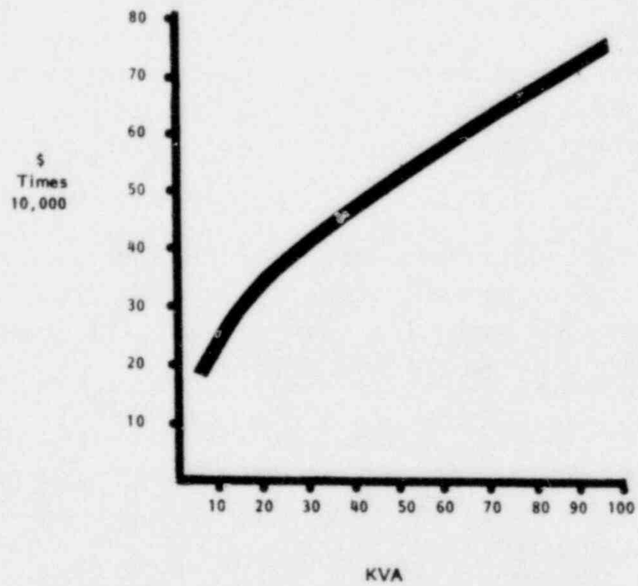
Typically UPS's will be designed to provide about 15 minutes of power for security lighting systems. Therefore, generator sets are required or other power sources for continuous operation when the failure of the primary power source exceeds 15 minutes.

In specifying a long life UPS/Battery System, the user should consider use of the lead-calcium/lead-acid batteries instead of lead-antimony/lead-acid to provide an approximate service life of 20 years in float use, up to 30 percent reduction in water servicing and no equalize requirements with proper float (Reference No. 20). With these battery systems, the user should also



TYPICAL UNINTERRUPTABLE POWER SYSTEMS

Figure 25



RELATIVE COST OF UPS SYSTEMS
(With 15 Minute Backup)

Figure 26

be aware that some capacity is lost after 15-18 years. IEEE Standard 450-1975 recommends that batteries be replaced when they reach 80 percent capacity. This early replacement can be avoided if a 125 percent capacity rating is specified at installation. Typically, a monthly test for 30 seconds of discharge and an annual full discharge test would be appropriate. Reference Numbers 21 and 22 provide systems planning details.

6.5.4.3 Interruptable Power Systems

For the purpose of security lighting backup power systems, interruptable power systems are those which do not provide continuous power during an interruption of the primary power source. This results from either time required to start a generator set or mechanically switch to a backup source such as a battery inverter system or other sources. Figure 27 illustrates several typical systems.

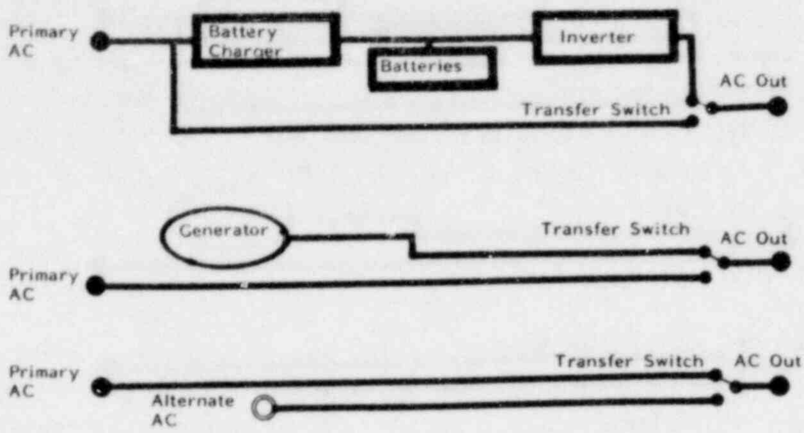
Generators for backup power supplies are available in a wide range of outputs. They can be powered by steam, gas, propane/butane, gasoline or diesel fuel. Figure 28 shows the relative approximate cost of several types and various sizes of systems. This cost includes equipment only and not a facility for the equipment.

Generators cannot start fast enough and switch into the power grid to avoid a momentary void in current flow. Depending on the size, condition, and ease of starting, the interruption may be from a nominal time of 10 seconds to several minutes. Diesel powered sets may require a longer period to start if additional time is necessary for "glow plugs" to heat up (in the order of 1 minute extra).

If a generator set is installed along with a UPS system, it may not be necessary to have a 15 minute battery system for the UPS. If the generator set is highly reliable, the battery capacity of the UPS system can be reduced.

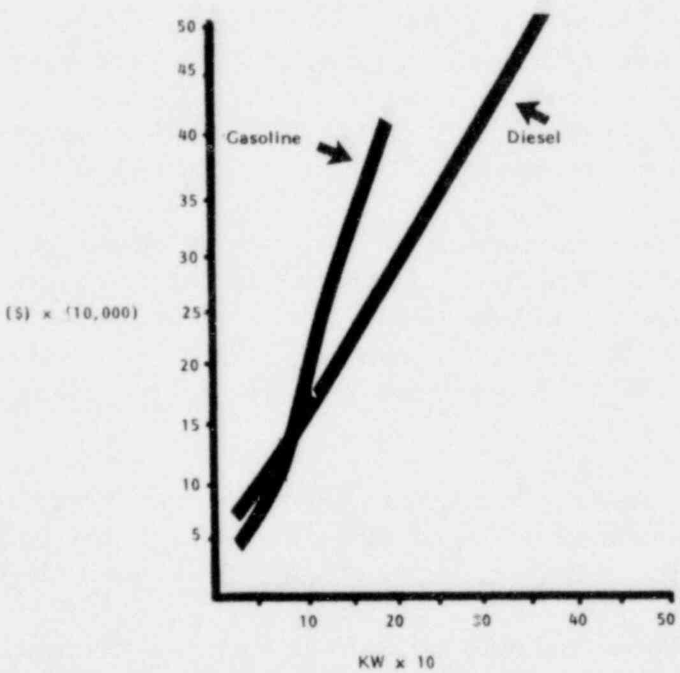
Generator set installations should be planned with the following considerations in mind:

- radio interference shielding
- exhaust muffling
- vibration controls
- engine or fuel heating



TYPICAL INTERRUPTABLE POWER SYSTEMS

Figure 27



RELATIVE COST OF GENERATOR SETS

Figure 28

- multiple fuels and fuel storage quantities
- unit location and space available
- careful load analysis
- security protection of the unit and switchgear
- environmental protection of the unit (weather, rodents, etc.)

Gasoline engine generators are normally lower in initial cost for smaller units, start more rapidly, require more maintenance and are available in sizes up to 150-200 KW.

Diesel engine generators are generally more expensive initially for smaller units, more economical to operate, have less maintenance and are good for continuous operation.

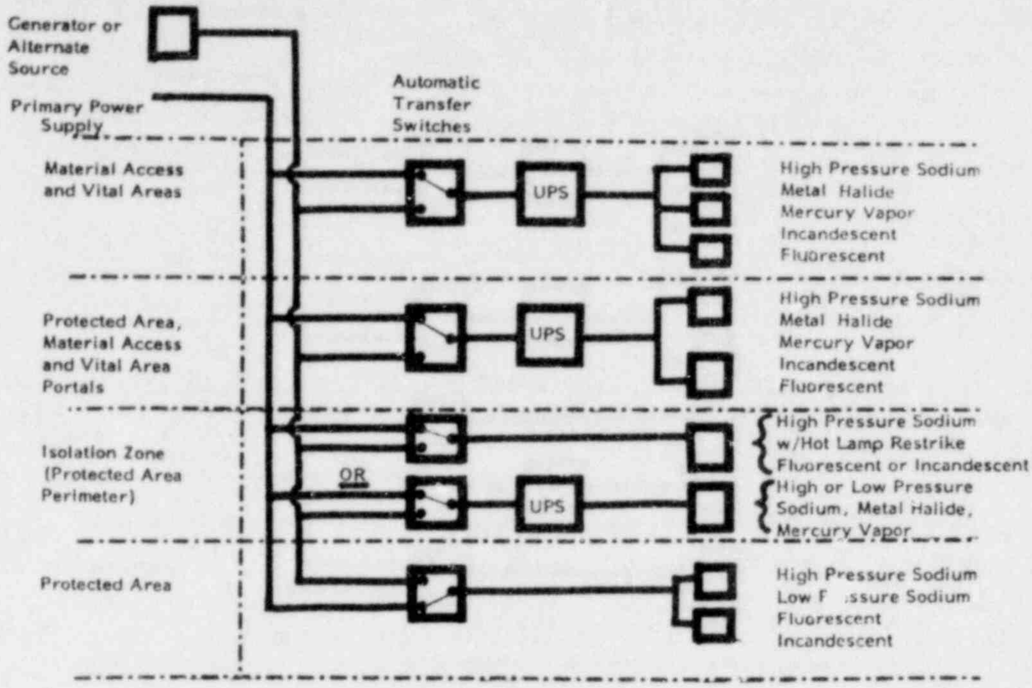
Gas powered engine generators start quickly and have relatively low maintenance cost due to clean running of gas or propane.

Gas turbine driven generators are available but less common in use. They operate on gas or oil fuel and are relatively compact but require noise control and do not start as quickly as gasoline engine powered generators.

Reference Numbers 21 and 22 provide systems planning details.

6.5.4.4 Typical Power Systems for Security Lighting

With all of the various kinds of luminaires and backup power systems, there are many combinations which will meet the recommended criteria. Figure 29 outlines several combinations utilizing uninterruptable power systems (UPS) and one or more backup generators. Note that the material access and vital areas are on an UPS to assure no lapse in illumination. Since the UPS is used, there is a variety of luminaire types which can be selected. The portals are provided with the same features as the material access and vital areas. The UPS need only provide power long enough to get the generator started and on line. The isolation zone can tolerate illumination lapses of up to 10 seconds. Therefore, either instant start luminaires with a 10 second start time for the generator or an UPS with any luminaire is appropriate. The general protected area can have illumination lapses of up to 60 seconds. Therefore, the generator with the noted luminaires should be adequate. In the case of area illumination, metal halide or mercury vapor will not restrike in time unless an UPS is provided.



TYPICAL SECURITY LIGHTING POWER SYSTEM

Figure 29

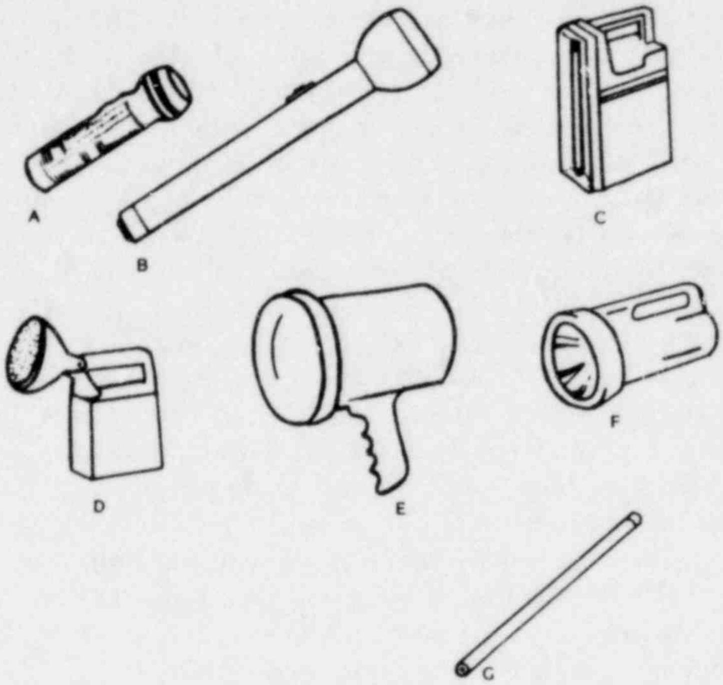
6.6 Portable Security Lighting Equipment

6.6.1 General

Portable security lighting primarily consists of hand-held, vehicle supported, self-sufficient or portable floodlights. Hand-held lights normally support foot patrols. Vehicle support lights enhance vehicle patrol and contingency support. Portable floodlights and self-sufficient units are used normally to support an unlighted or insufficiently lighted area in emergency or contingency situations.

6.6.2 Hand-Held Portable Lights

Hand-held portable lights of the flashlight or lantern type provide effective patrol support both indoors and outdoors. Typically these units are available with incandescent, fluorescent or quartz-halogen bulbs. They may also be either rechargeable or operate from one-time use disposable cells. Units should preferably be weatherproof. Figures 30 and 31 illustrate some of these types of units. Note that fluorescent units "C" do not provide an effective beam. A minimum of 4,000 CP rating is recommended. (Most 6 volt or 5 cell units meet this rating.)



HAND-HELD PORTABLE LIGHTS

Figure 30

	Hand-Held Unit	Output Candlepower	Cost Dollars
A.	2-Cell Flashlight	2,000 Beam	3 - 30
B.	5-Cell Flashlight	4,000-7,000 Beam	4 - 30
C.	Fluorescent	500, Diffuse	20 - 50
D.	Lanterns	15,000-95,000 Beam	20 - 450
E.	Lantern	22,000 Beam	12 - 35
F.	Lantern	15,000-40,000 Beam	10 - 35
G.	Chemical Flare	Not Available, Diffuse	2 3 each

HAND-HELD PORTABLE LIGHTS CHARACTERISTICS

Figure 31

Alkaline or rechargeable cells/batteries are recommended due to their extended service life. Alkaline cells will last several times longer than standard carbon cells. Rechargeable cells can be recharged several hundred times. "D" size cells of the nickel-cadmium type are available with several power ratings. Typical rechargeable cells available in hardware stores are rated at approximately 1.2 amp-hours. They are also available with 3.5-4.5 amp-hour ratings which extends the use period by a factor of three. The higher rated cells may have to be acquired through a battery shop or electronics store. In addition to nickel-cadmium "D" size cells, battery packs of various voltages, sizes and power ratings are available. Sealed lead-acid batteries are available in "D" size cells which have a rating of 2.5 amp-hours. It is notable that the voltage of different "D" size cells varies by type of battery. Carbon and alkaline "D" cells are nominally 1.5 volts per cell. Sealed lead-acid "D" cells are 1.8-2.0 volts per cell. Multi-cell flashlights normally have bulbs installed for 1.5 volt cells. Higher voltage cells will increase the light output but decrease the life of the bulb. Lower voltage cells will decrease the light output but increase the life of the bulb. When replacing or substituting cells and bulbs, care should be taken to match total cell voltage with the properly rated bulb. Note that NiCad cells require an exercising program to prevent the cells from establishing a "memory effect." That is, they should be intentionally discharged to varying levels of discharge and, at least on an annual basis, to a complete discharge.

Gel-type cells are available for various lantern configurations with 6 and 12 volt requirements. These are sealed, maintenance-free batteries which can be recharged several hundred times.

Chemical Lights or Chemiluminescent devices are a recent innovation. These are in the configuration of small plastic containers in the shape of a cigar. When activated they provide a yellow-green light for approximately three hours. During the first hour of use they provide a rather bright light which degenerates to a marker status. They are subsequently discarded. Typical uses would be for marker flares. The cost of each unit is from $2.00 to $3.00 each. Reference Figure 30 C. Different units provide varying amounts of light for varying durations of up to 12 hours. The level of illumination provided is low and they would provide light over only a few square meters.

6.6.3 Vehicle Mounted Lights

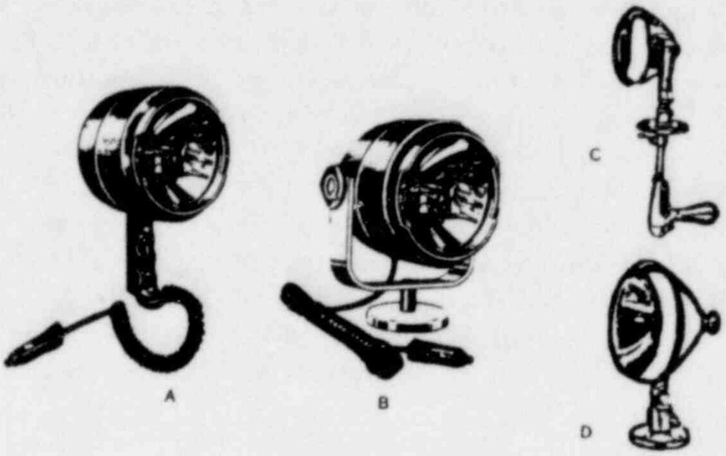
Vehicle mounted lights for security purposes are recommended for all security assigned and backup vehicles. The lights operate by plugging into the vehicle's cigarette lighter, special plugs or permanently fixed to the vehicle and wiring. Units with a minimum of 75,000 candlepower are recommended. Figures 32 and 33 provide information on several configurations of vehicle mounted fixtures. The advantage of "A" and "B" is that they can be moved by hand. In addition, "B" with a magnet or clip on base can be directed and left unattended. The fixture described by "D" can be directed but not readily moved. The fixture illustrated in "C" can be directed from within the vehicle and minimizes exposure of the security personnel to weather or adversaries.

6.6.4 Portable and Self-Sufficient Floodlights

Portable and self-sufficient floodlights are available in many configurations. They would be utilized to provide security lighting at locations where the permanent lighting has been temporarily incapacitated due to damage or failure, for area maintenance purposes or for coverage of gates and areas which are experiencing protest, picketing or other related activities. The type and size of the units depend on the application. Equipment illustrated in Figure 34 "A" and "B" would be used in locations where power was available within reach of extension cords. Units illustrated in Figure 34 "C", "D" and "E" are typical of those which can operate either on available power or motor generators integral to the lighting unit. The motor generators normally operate from either gasoline or diesel fuel. Typically, with previous notice, equipment such as this can be rented. However, for emergencies, available on-hand equipment is recommended. Figure 35 provides characteristics of several types of portable, self- sufficient floodlights.

6.6.5 Fixed Directable Lighting

Fixed, directable lighting for security purposes includes searchlights and beacons. Security lighting of this type can, in certain situations, significantly enhance the security force's capability of nighttime alarm assessment and intrusion deterrence. It is of particular value when a significant portion of the protected area, isolation zone and perimeter of the protected area is visible from the guard post. Figure 36 illustrates



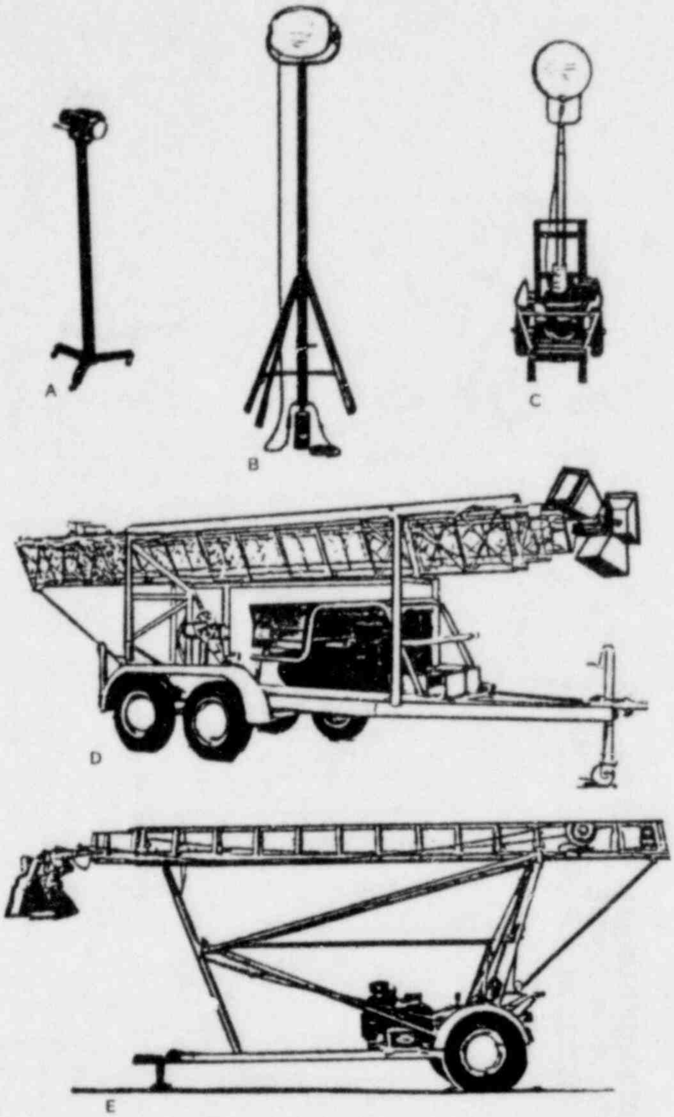
VEHICLE MOUNTED LIGHTS

Figure 32

Vehicle Mounted Unit	Output Candlepower	Cost Dollars
A	30,000-360,000	15-30
B	200,000	40-50
C	20,000-75,000	40-50
D	20,000-75,000	40-50

VEHICLE MOUNTED LIGHTS CHARACTERISTICS

Figure 33



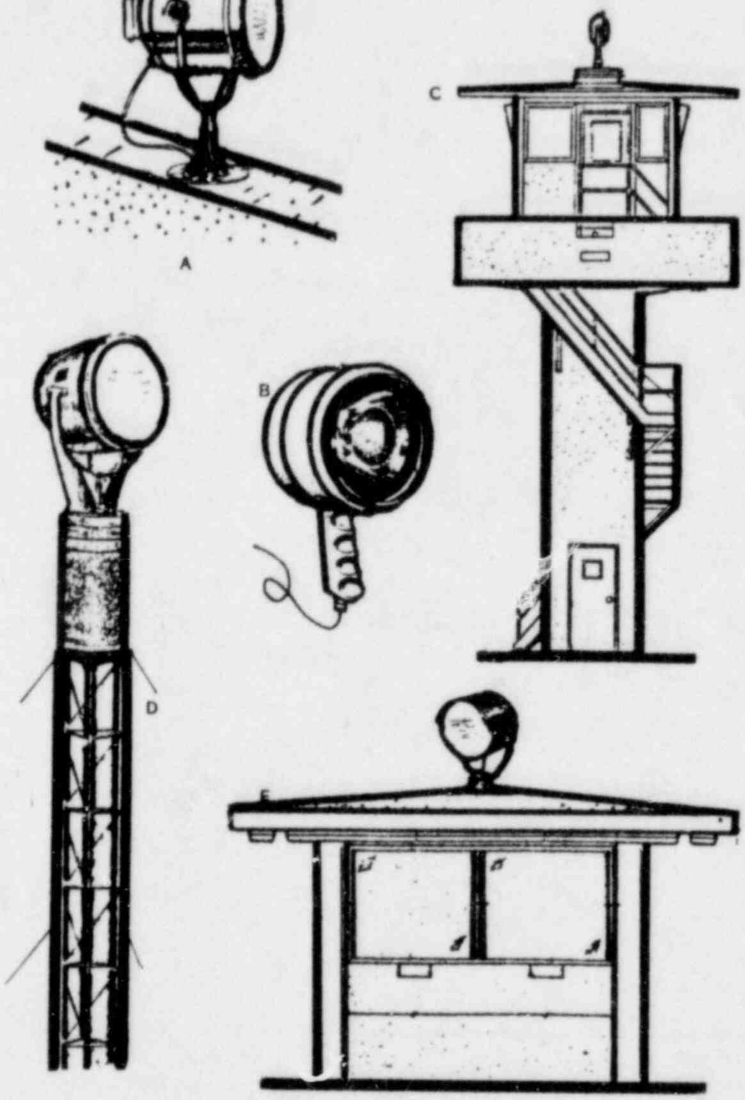
PORTABLE AND SELF SUFFICIENT FLOODLIGHTS

Figure 34

	Power	Cost
Type A or B	1,000 Watt Metal Halide, Quartz or Other Options	$1,000- 2,000
Type C	1.5 kw; 1,000 Watt Metal Halide	$2,000- 6,000
Type D	2.4 kw; Quartz or HID	$3,500- 7,000
Type E	2.4 kw; Quartz or HID	$7,500-13,000

PORTABLE AND SELF-SUFFICIENT FLOODLIGHT CHARACTERISTICS

Figure 35



FIXED DIRECTABLE LIGHTING

Figure 36

several possible installation concepts for searchlights. The illustration "A" is of a hand directable searchlight which could be mounted in many locations. Another hand-held light configuration for fixed locations shown in "B" is a spotlight with a connecting cord to the power source. Illustrations "C" and "E" are of the pilot house type with controls within the guardhouse or tower. Illustration "D" depicts a tower mounted searchlight which is remotely controlled by a distant electric control or "joy stick." The lights in "C", "D" and "E" can be controlled by a "joy stick." A single searchlight can also be controlled from more than one post if it has remote electric controls. Other remote controlled installations might include searchlights mounted high on existing towers, walls, buildings, antennas or CCTV towers. Special equipment for this purpose or adaptations of CCTV pan and tilt equipment can be used. The availability of lighting systems of this type permit the security personnel at a fixed post or a protected environment to explore within or without the protected area or to supplement existing lighting when and where required.

Light sources for these purposes include incandescent, xenon short arc, and carbon arc. Power ratings for searchlights of 20 cm (9 inches) in diameter to 90 cm (36 inches) vary from 200,000 candlepower to several hundred million candlepower. Figure 37 provides some of the various sizes, power and ratings of searchlights and approximate costs based on models manufactured by The Carlisle and Finch Company.

An additional consideration for fixed searchlights is the effective range of lights of different intensities during different atmospheric conditions. As derived from Reference No. 6, Figure 38 illustrates the effective range for relatively small targets such as a vehicle (4-wheel) or small group of men in a variety of weather conditions.

Figure 39 provides an approximation of the searchlight beam spot size considering different degrees of beam divergence. For example, if a spot is desired to have a minimum size of 6 m (20 feet) and a maximum size of 15 m (50 feet) a divergence of approximately 6 degrees would provide this at a distance between 58 m (190 feet) and 145 m (475 feet).

The light available which is perpendicular to the searchlight beam can be approximated by the following formula:

$$\text{Light Available} = \frac{\text{Beam Candlepower}}{(\text{Distance})^2}$$

For a 3 million beam candlepower rated searchlight, the illumination available at 610 m (2,000 feet) would be estimated by:

$$\text{Light Available} = \frac{(3{,}000{,}000)}{(2{,}000)^2} = \frac{3{,}000{,}000}{4{,}000{,}000} = .75 \text{ footcandles}$$

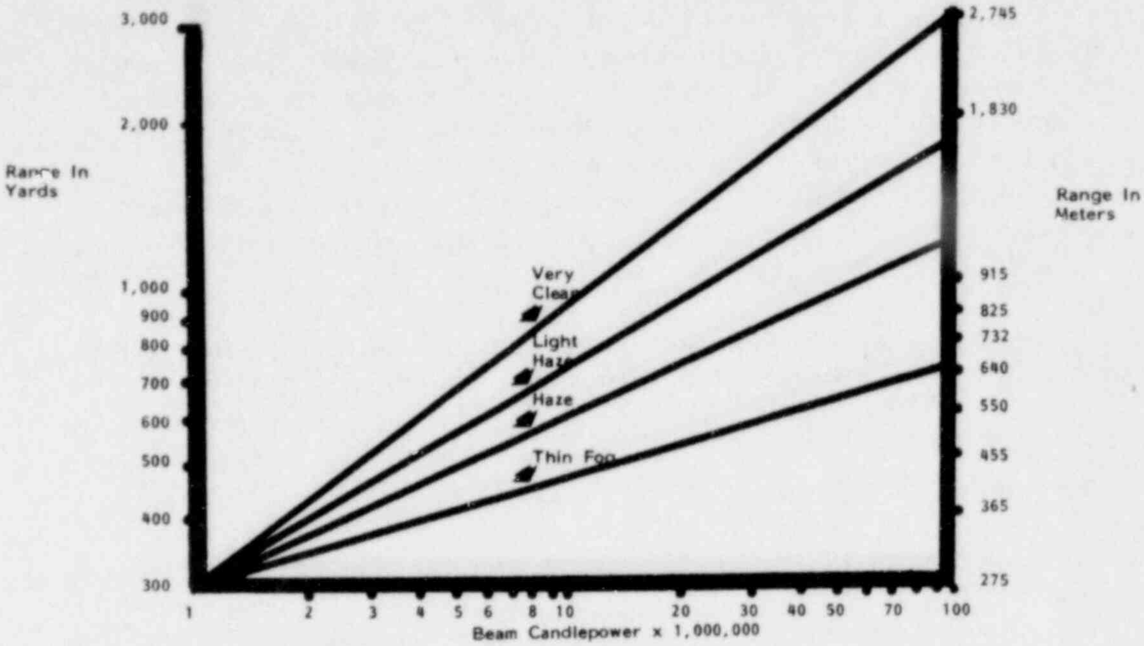
Note that this may vary depending on the rating method used by the manufacturer.

Searchlights are also available with focus and remote focus devices. With these accessories, it is possible for the beam to vary from a few degrees of divergence to 20 degrees.

			Cost (Dollars)		
Searchlight Size	Power Watts	Beam Candlepower	With Manual Controls	With Electric Controls	Power Supplies
10 in. Incandescent	100 — 600	350,000 — 780,000	400 — 1,100	1,000 — 1,000	—
12 in. Incandescent	100 — 1,000	560,000 — 1,650,000	400 — 1,200	1,050 — 1,200	—
15 in. Incandescent	100 — 1,000	940,000 — 3,280,000	500 — 1,300	1,200 — 1,400	—
19 in. Incandescent	500 — 1,500	1,540,000 — 4,750,000	800 — 1,400	1,700 — 2,300	—
19 in. Xenon	1,000 — 2,500	36,000,000 — 90,000,000	3,800	4,700	1,800
24 in. Incandescent	1,000 — 3,000	2,750,000 — 7,660,000	3,000	3,700	—
5-6 in. Hand-Held	—	—	15-50	—	25.75

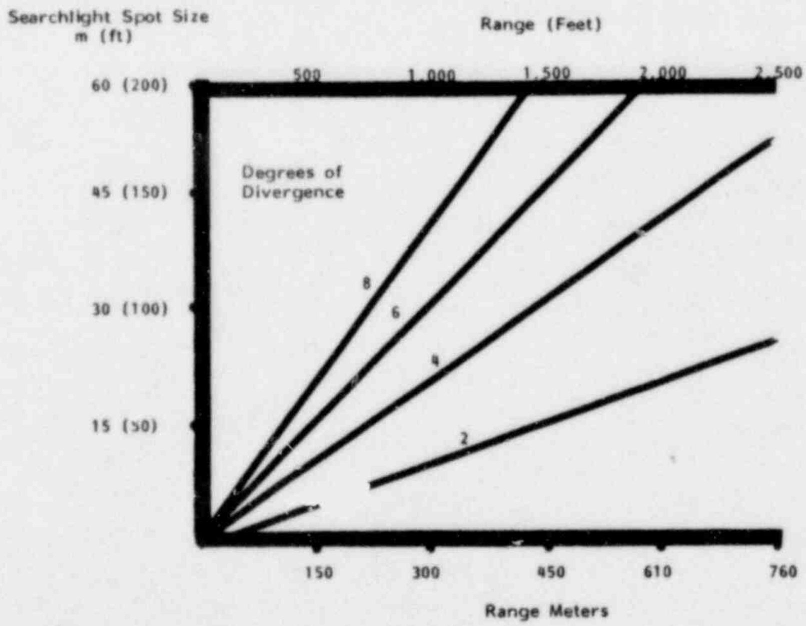
SEARCHLIGHT CHARACTERISTICS

Figure 37



SEARCHLIGHT RANGE

Figure 38



SEARCHLIGHT DIVERGENCE AND RANGE SELECTION

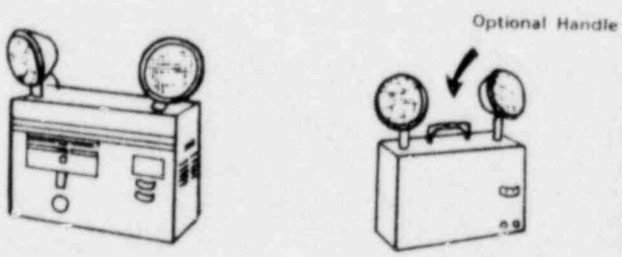
Figure 39

Lamps utilized in searchlights are either "projection type" or "tungsten-halogen type" for searchlights in the smaller size range. The life expectancy of the projection type lamp is from 25-50 hours in most cases with some lamps with life expectancies of up to 200 hours. The life expectancy of tungsten-halogen types is approximately 500 hours. In all cases, spare lamps should be in stock and the lights utilized only when necessary. Xenon lamps are available in 1,000 and 2,500 watt ratings and have an average life of 1,500 hours.

Since searchlights are normally utilized outdoors, it is important to assure that they are of weatherproof and corrosion resistant design.

6.6.6 Unitized Emergency Lighting Units

Unitized emergency lighting units can be effectively utilized to provide a backup lighting system for critical areas, as "portable" emergency lights or even as a third level of backup where deemed appropriate. Figure 40 illustrates several of the most commonly used types of units.



UNITIZED EMERGENCY LIGHTING UNITS

Figure 40

These units usually consist of a diffused lens or lamp, a storage battery or set, a battery charger, and a power failure sensor. The units in operation are on continuous charge. If the primary power source fails, the lights are automatically switched on.

Units are available which will provide continuous light from 1 to 12 hours. The cost of single units varies from approximately $150 to $400 each.

Since the units are rather heavy and have options which include acid electrolyte, they are normally permanently mounted on walls or on a shelf. With the installation of one or more handles however, they can be quite portable and, in an emergency, can be relocated to the emergency site or area of need.

Ceiling mounted units, flush units, explosion proof units and units which have central battery and charging systems are also available.

6.6.7 Infrared Seeing Aids

6.6.7.1 General

The primary application of infrared light for security lighting is for surveillance. Infrared light or the IR region of electromagnetic radiation is that portion of the spectrum located between the visible wavelengths and the microwave wavelengths. The IR band is divided into three regions:

- Near IR (between .72 - 1.2 microns)
- Intermediate IR (between 1.2 - 7.0 microns)
- Far IR (between 7.0 - 1,000 microns)

Sometimes the 8.0 - 30 micron region is also referred to as the long wavelength (LWL) region.

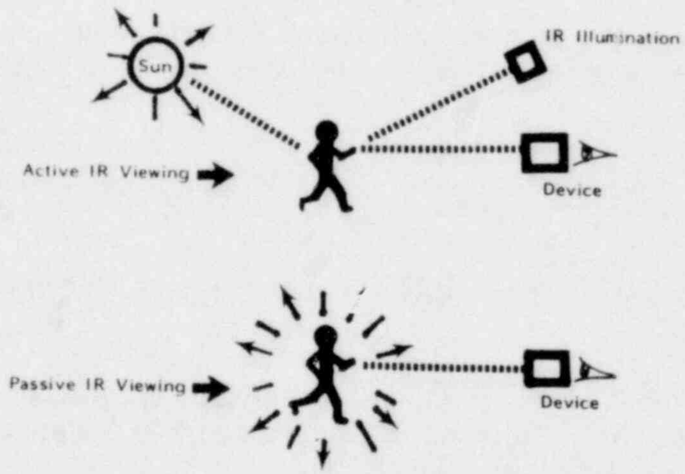
The first IR development for practical surveillance application was that of the IR imaging tube which converted IR radiation into visible light. During WW II these were called sniperscopes.

Although some IR seeing aids can be used with IR illuminators, their biggest advantage is that many can operate in the passive mode. Reference Figure 41. This results from the fact that most natural objects radiate in the IR region and therefore do not require illuminators or transmitters. The advantages of passive IR systems are:

- Relatively small and lightweight
- Relative low cost (as compared to active systems)
- Capable of passive or active operation
- Effective against camouflaged targets and the cover of darkness
- Day or night operation
- Greater angular accuracy than radar
- No minimum or maximum range limits
- Minimum auxiliary equipment

Disadvantages to IR systems are:

- Line of sight use only
- Atmospheric conditions such as fog, clouds, etc., can obscure target
- Can be decoyed
- Some systems require cryogenic cooling during operation



ACTIVE AND PASSIVE IR VIEWING

Figure 41

With the above in mind, it is obvious that an IR seeing aid device could be useful for periodic scanning during nighttime surveillance of dark areas beyond the lighted isolation zone, continued surveillance during power outages, or intrusion alarm assessment assistance (particularly in looking for camouflaged or low profile intruders). Infrared radiation from ground targets under surveillance with passive devices is due to thermal emissions or reflected solar or illuminating device energy. Most ground targets such as vehicles and personnel may be much warmer than their surroundings. Although special low-emissivity paints and insulations could be used it will usually be difficult to camouflage against visual and IR detection simultaneously (Reference No. 23).

6.6.7.2 IR Lamps

Most lamps produce IR radiation. Standard tungsten filament and quartz-iodine lamps are commonly utilized. Filters or dichroic mirrors are necessary to block visible radiation in applications where IR radiation only is required. (Reference No. 23.) Sources of this type range from hand-held units to truck-mounted night driving devices to tank mounted 1,800 watt searchlights. The systems are primarily utilized for military purposes. Smaller systems can be made utilizing a Kodak Cold Mirror Filter No. 310 or equivalent which will transmit light in the .9 to 1 micrometer range (Reference No. 24). Argon, krypton, xenon, cesium, mercury and rubidium gaseous arc lamps can also be utilized. At the present time, for larger systems, xenon arc lamps are predominantly used for near infrared night vision equipment (Reference No. 23). Input power for these lamps varies from 150 w to 30 kw. More than 10 percent of the light output of the xenon lamp is in the IR region.

Various flashlamps and flashtubes can also be utilized with filters and would be appropriate for surveillance photography where pictures are to be taken without the knowledge of persons at the scene.

The criteria for filtering visible light from the lamp's total spectrum of output would include:

- No transmission less than .8 micron with IR optimized
- No white light pinholes
- High temperature tolerance (as required)

6.6.7.3 IR Seeing Aid Devices

Presently, most of the military IR devices utilize thermal imaging with scanning systems in the 3-5 and 10 micron region (Reference No. 23). However, the systems used most frequently for sights and viewing devices utilize image tubes and screens.

From a current commercial standpoint, an infrared viewer manufactured by Hughes Aircraft Company is available. The cost of this hand-held portable unit is $8,000 - $10,000. It utilizes a rechargeable power supply and a small cylinder of argon gas provides the cryostat coolant which must be refilled after about four hours of operation. The registered trade name is Probeye. This device works on passive emissions of IR and does not require an IR illumination source. Therefore its range is unlimited. Reference Figure 42.

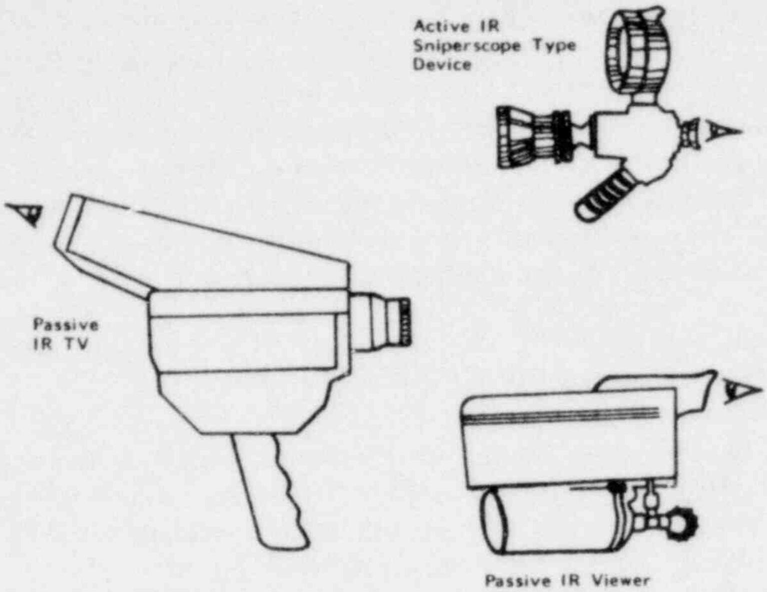
An infrared viewer is also available through Law Enforcement Associates. This device uses active IR provided by a beam from the unit. Its range is 50-150 meters. It costs approximately $1,450 and is called the Nite-Site Infrared Viewer. Reference Figure 42. Surplus Army M3 Sniperscopes which operate from 6 volt battery packs are available from Edmund Scientific at a cost of approximately $400 each. This system also utilizes an active IR source which is an integral part of the unit.

An infrared TV system is available from Xedar Corporation which operates in the 8-14 micron region. It weighs about 7 pounds and is utilized by direct viewing. The cost is approximately $9,000. Reference Figure 42. Units are available for fixed locations as well as portable units.

Considerable eye and search fatigue can develop if these devices are utilized for direct veiwing over an extended period of time.

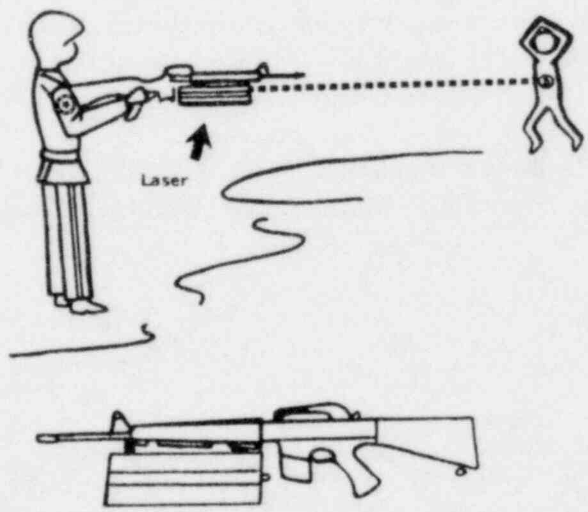
6.6.8 Laser Target Designators

Small light weight lasers are available as target designators for light weapons. These can be quite effective for nighttime use when standard gunsights are difficult to see. (Figure 43 illustrates this concept.) Equipment is available through York Arms (Laser Lok Sight), for example, at an approximate cost of $500 per unit.



IR SEEING DEVICES

Figure 42



LASER TARGET DESIGNATORS FOR SMALL ARMS

Figure 43

Other weapon sight systems have been developed for military purposes utilizing infrared and "starlight" seeing aids. These include "starlight" devices such as the AN/PVS-2, AN/PVS-4 and M9821. Infrared aiming devices similar to the laser target designator in function which are rifle mounted such as the AN/PVQ-4 Infrared Aiming Light project a spot which can be seen with special night vision sensors such as the AN/PVS-5 goggles. Although mentioned in this guide, the use and availability of systems such as these may be controlled by state and federal law.

6.6.9 Ultraviolet Light Equipment

Combinations of ultraviolet light and ultraviolet sensitive tracing materials can be utilized for protective purposes. The primary use of these materials would be to detect tampering or theft attempts, for example. This is accomplished by marking items which require special control with "invisible" (to visible light - but sensitive to ultraviolet light) powders, ink, crayons, pastes or paints. Ultraviolet lamps (black light) are then used at check points to detect any of the marked materials. The marked materials will appear in fluorescent colors when exposed to the ultraviolet light.

Fluorescent powders can be dusted on items or areas requiring no access or controlled access. Persons tampering with these items or areas are then detected at the check point when the fluorescent material appears on hands or clothing.

Small portable lamps cost $40 - $100. Bottles of powders, inks, etc., cost $5 - $15 each. They can be procured at a local police officer supply company.

7. SECURITY LIGHTING APPLICATIONS

7.1 General

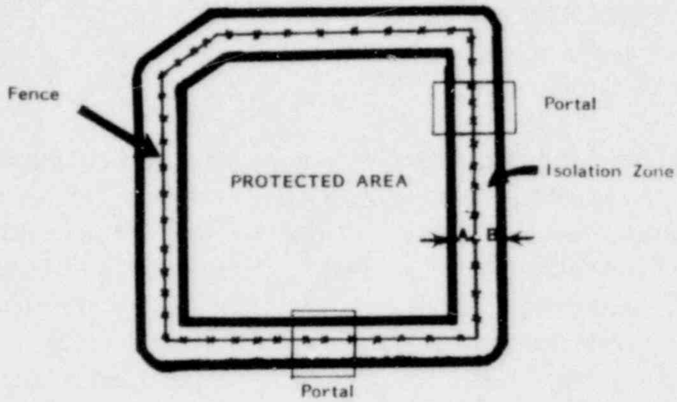
Based on the foregoing reviews of requirements, goals, lighting effects and equipment, this section provides information on specific applications, concepts and configurations. Outdoor lighting of isolation zones, protected areas and portals as well as indoor concepts are covered. The information provided is conceptual only and should not be construed as design information. It is recommended that any security lighting application be designed by a properly qualified and experienced engineering firm or organization. Some of the application information will reference specific manufacturer's products. It should be noted that this in no way is meant to exclude other manufacturers' equipment with equivalent features and quality. It is necessary to use specific manufacturer's information due to the unique photometric data on each specific luminaire.

Except where there are special requirements, luminaires reviewed in detail will include only high and low pressure sodium. This is because of their higher efficiency ratings and better restrike characteristics. Costs noted in this chapter are for comparative purposes only and do not include design, contractor markup, contingencies, or costs common to all systems unless otherwise noted. Isolation zone and portal lighting costs include wood poles. Area lighting costs include steel galvanized poles.

7.2 Security Lighting for the Protected Area Isolation Zone

7.2.1 General

The isolation zone is the area at the protected boundary on either side of the fence designated as a clear zone. Figure 44 illustrates this area. Specific NRC requirements are for a minimum illumination of 2.15 lux (.2 footcandles) for the entire protected area. Recommendations for the illumination of these areas are: for measurements to be made horizontally at .15 meters (6 inches) above the ground; levels increased to those noted in Section 4.6 as appropriate; lighting to be provided a minimum of 9.1 meters (30 feet) both inside and outside of the protected area fence or 18.2 meters (60 feet) from a protected area boundary building wall; and with an average to minimum illumination ratio not to exceed 4:1 with less than 3:1 recommended and maximum to minimum ratio of 8:1 with less than 6:1



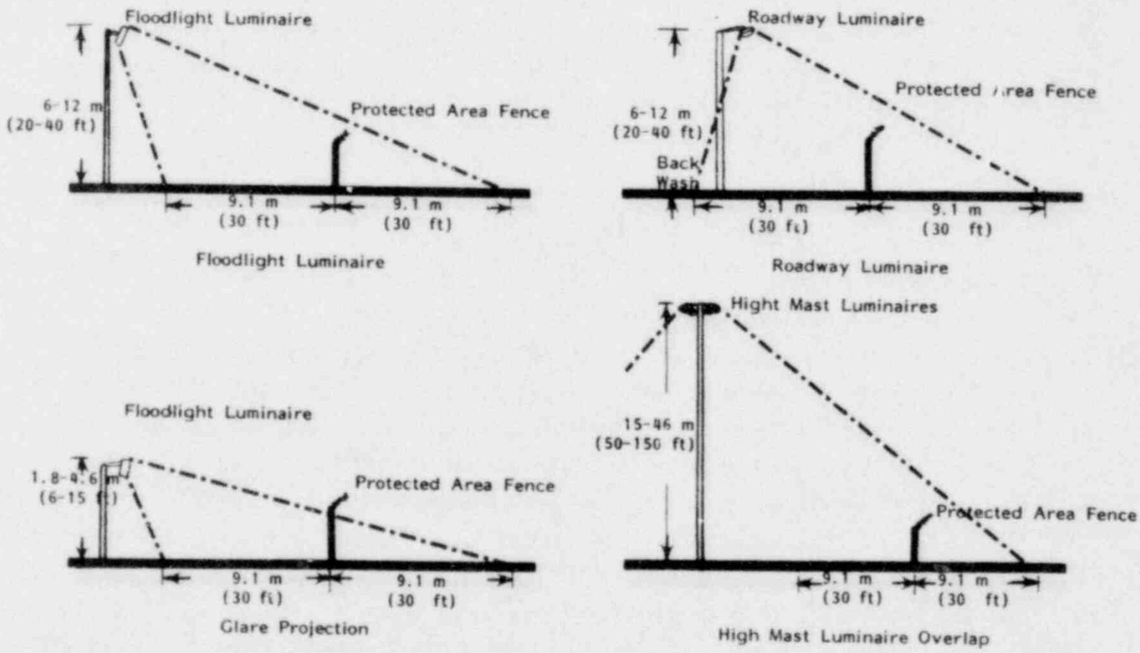
A = Minimum of 9.1 meters (30 feet)

B = Minimum of 9.1 meters (30 feet)

Minimum illumination of 2.15 lux (.2 footcandles) horizontal with average to minimum ratio not to exceed 4:1 with less than 3:1 recommended.

SECURITY LIGHTING OF THE ISOLATION ZONE

Figure 44

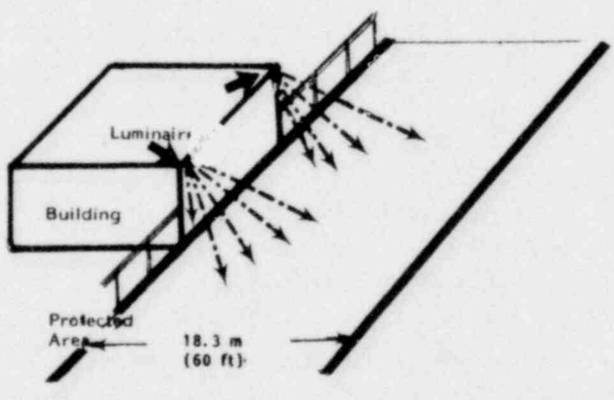


ISOLATION ZONE LIGHTING CONFIGURATIONS

Figure 45

recommended. If double fences are utilized, the isolation zone should include 9.1 meters (30 feet) minimum inside the inside fence and 9.1 meters (30 feet) minimum outside the inside fence.

Illumination of the isolation zone can be accomplished in four basic ways--these include floodlight luminaires, roadway luminaires, floodlights in specific glare configurations and with high mast or "parking lot" illumination. Figure 45 illustrates these concepts. Note that in all cases the poles or masts should be set back into the protected area at least 2.4 meters (8 feet) from the fence to preclude utilizing poles as an aid in climbing the fence. Figure 46 illustrates the isolation zone concept if a building wall is utilized as the protected area barrier. In this case, floodlights can be located on the building.



BUILDING USED AS A PROTECTED AREA BARRIER

Figure 46

Floodlights for glare projection have been utilized by the USAF (Reference No. 9). This consisted of 250w HPS lamps mounted in pairs approximately 4.6 meters (15 feet) high and 35 meters (115 feet) apart. However, due to poor uniformity of lighting which affects both direct visual and CCTV observation capability, the concept has been abandoned. Other tests (Reference No. 5) indicate that the glare in the eye of the intruders was optimized when 500 w tungsten-halogen lamps in symmetric floodlights were used at a height of 3 meters (9.8 feet) and spaced at 10 meters (32.8 feet). These were setback 10 meters (32.8 feet) from the fence. However, no measure of lighting uniformity was provided. Illumination uniformity is a problem when luminaires are mounted close to the ground and at the same time are required to provide uniform illumination as far as 18.2 meters (60 feet) away (isolation zone) plus any setback distance. Simulations run by Independent Testing Laboratories, Inc. (Reference No. 25) indicate that uniformity (maximum to minimum) gets worse as an inverse function of the pole height. That is, a 6 meter (20 foot) pole may have 4 times a maximum to minimum illumination ratio as a 12 meter (40 foot) pole with other factors held constant. As a result, no specific glare projection configurations are included in this planning guide although some systems shown have poles only 6.1 meters (20 feet) high. This is not meant to preclude a licensee from investigating such a configuration.

Figure 47 provides a summary of basic isolation zone lighting configuration characteristics which are detailed in subsequent figures.

7.2.2 Floodlight Lighting of the Isolation Zone

The advantage of utilizing floodlights is the ability to direct light away from the protected area without creating glare within the protected area. The disadvantage is that they do not provide as wide a spread of light as roadway luminaires. Figures 48 through 51 include several configurations of poles, heights, luminaires, lighting levels and spacing. Note that corners or other irregularities in the isolation zone require separate computations. Cost estimates are based on 1979 dollars and may vary considerably due to local conditions. The cost estimates do not include design cost, contractor markup, other contingencies or items common to all systems. They are provided for comparative purposes only. Many other lighting configurations reviewed did not meet the lighting uniformity criteria and are not included.

No	Lamp	Luminaire	Min FC	Avg-Min FC	Units/ Pole	Height (Ft)	Set Back (Ft)	Spacing (Ft)	Annual Cost ($/Ft)	Initial Cost ($/Ft)
1	400w HPS	Roadway	.19	2.8	1	40	40	350	.71	3.01
2	400w HPS	Roadway	.23	2.3	1	50	40	350	.75	3.23
3	400w HPS	Flood	.19	3.76	1	40	40	200	1.15	4.62
4	400w HPS	Flood	.32	2.49	1	40	40	180	1.28	5.14
5	250w HPS	Flood	.26	2.52	1	30	30	140	1.25	5.42
6	180w LPS	Flood	.458	2.28	1	50	0	140	1.51	7.11
7	400w HPS	Roadway	.5	1.8	1	50	40	225	1.16	5.02
8	400w HPS	Roadway	.52	2.8	1	40	20	175	1.43	6.02
9	400w HPS	Roadway	.53	2.58	1	[illegible]	20	120	2.12	7.99
10	180w LPS	Flood	.769	2.4	2	50	0	160	2.22	9.62
11	180w LPS	[illegible]	1.0	2.3	1	40	10	80	2.73	13.00
12	400w HPS	Roadway	1.07	2.4	1	40	20	100	2.50	10.54
13	400w HPS	Roadway	[illegible]	1.77	4	37	20	170	3.62	10.38
14	180w LPS	Flood	2.0	1.9	1	21	10	50	3.14	13.43
15	180w LPS	Flood	2.07	1.44	2	40	6	90	3.36	14.07
16	400w HPS	Roadway	2.15	1.46	2	35	5	80	3.86	12.34

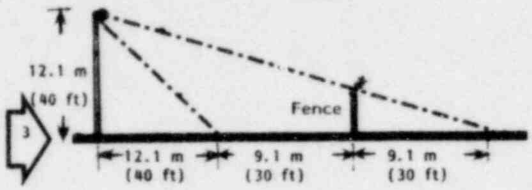
Cost Shown is Per Linear Foot

(Feet) ÷ (3.28) = (Meters)

(FC) (10.76) = (Lux)

ISOLATION ZONE LIGHTING CONFIGURATION SUMMARY

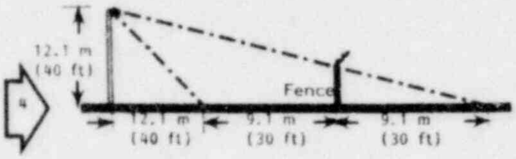
Figure 47



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 12.1 m (40 ft)
Pole Height: 12.1 m (40 ft)
Spacing: 61 m (200 ft)

Luminaire: Floodlight GE P-400C
Min FC: .19
Avg-Min: 3.76
Max-Min: 7.59

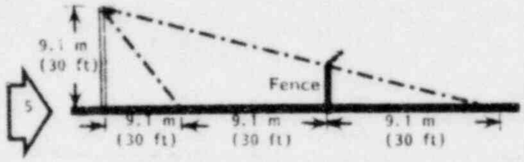
Initial Cost Per Meter (Foot): $15.18 ($4.62)
*Annual Cost Per Meter (Foot): $ 3.77 ($1.15)
Photometric data provided by G.E.



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 12 m (40 ft)
Pole Height: 12 m (40 ft)
Spacing: 55 m (180 ft)

Luminaire: Floodlight GE P-400C
One Per Pole
Min FC: .32
Avg-Min: 2.49
Max-Min: 4.57

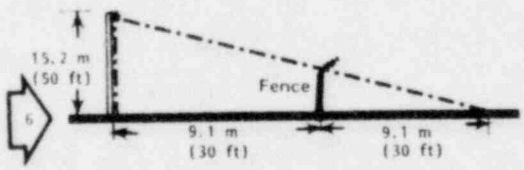
Initial Cost Per Meter (Foot): $16.87 ($5.14)
Annual Cost Per Meter (Foot)*: $ 4.19 ($1.28)
Photometric data provided by G.E.



Lamp: 250w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 9.1 m (30 ft)
Pole Height: 9.1 m (30 ft)
Spacing: 43 m (140 ft)

Luminaire: Floodlight GE P-400C
One Per Pole
Min FC: .26
Avg-Min: 2.52
Max-Min: 5.35

Initial Cost Per Meter (Foot): $17.78 ($5.42)
Annual Cost Per Meter (Foot)*: $ 4.10 ($1.25)
Photometric Data Provided by G.E.



Lamp: 180w LPS
LDD: .81
LLD: 1.05
Maintenance Factor: .85
Set Back: 0
Pole Height: 15.2 m (50 ft)
Spacing: 42.7 m (140 ft)

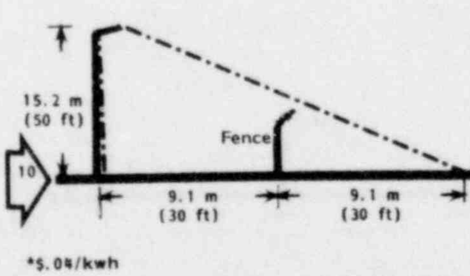
Luminaire: Cutoff Assymmetrical
Quality Lighting 9718
One Per Pole
Min FC: .458
Avg-Min: 2.285
Max-Min: 4.101

Initial Cost Per Meter (Foot): $23.3 ($7.11)
Annual Cost Per Meter (Foot)*: $ 4.94 ($1.51)
Photometric data provided by Quality Lighting

*$.04/kwh

ISOLATION ZONE FLOODLIGHT CONFIGURATIONS FOR 2.15 LUX (.2 FC)

Figure 48



Lamp: 180w LPS
LDD: .81
LLD: 1.05
Maintenance Factor: .85
Set Back: 0
Pole Height: 15.2 m (50 ft)
Spacing: 48.8 m (160 ft)

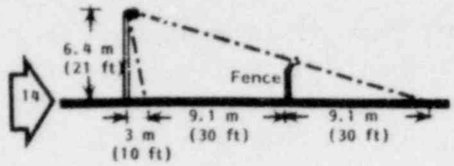
Luminaire: Assymetrical Cutoff
Quality Lighting 9718
Two Per Pole
Min FC: .769
Avg-Min: 2.406
Max-Min: 4.73

Initial Cost Per Meter (Foot): $31.57 ($9.62)
*Annual Cost Per Meter (Foot): $ 7.29 ($2.22)
Photometric data provided by Quality Lighting

*$.04/kwh

ISOLATION ZONE FLOODLIGHT CONFIGURATION FOR 5.4 LUX (.5 FC)

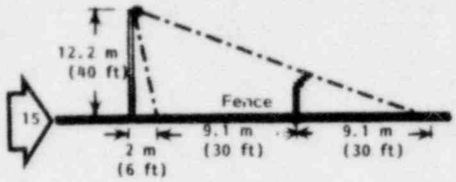
Figure 49



Lamp: 180w LPS
LDD: .8
LLD: 1.05
Maintenance Factor: .84
Set Back: 3 m (10 ft)
Pole Height: 6.4 m (21 ft)
Spacing: 15.2 m (50 ft)

Luminaire: Flood Norelco SFL-33885
One Per Pole
Min FC: 2
Avg-Min: 1.9
Max-Min: 3.13

Initial Cost Per Meter (Foot): $44.04 ($13.43)
Annual Cost Per Meter (Foot)*: $10.32 ($3.14)
Reference No. 25



Lamp: 180w LPS
LDD: .8
LLD: 1.05
Maintenance Factor: .84
Set Back: 2 m (6 ft)
Pole Height: 12.2 m (40 ft)
Spacing: 27.4 m (90 ft)

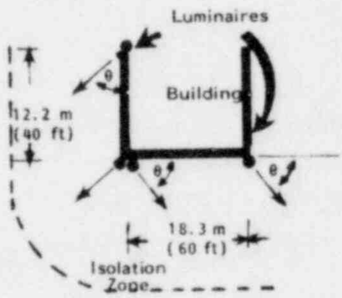
Luminaire: Flood Norelco SFL-33885
Two Per Pole
Min FC: 2.07
Avg-Min: 1.44
Max-Min: 1.95

Initial Cost Per Meter (Foot): $46.16 ($14.07)
Annual Cost Per Meter (Foot)*: $11.03 ($3.36)
Reference No. 25

* $.04/kwh

ISOLATION ZONE FLOODLIGHT CONFIGURATIONS FOR 21.5 LUX (2 FC)

Figure 50

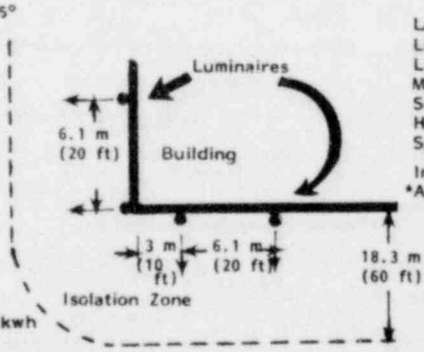


Lamp: 400w HPS
LDD: .73
LLD: .86
Maintenance Factor: .63
Setback: 0
Height: 9.1 m (30 ft)
Spacing: as shown

Luminaire: Flood NEMA 4 x 4
GE P400C Powerflood
One Per Mounting
Min FC: .71
Avg-Min: 2.94
Max-Min: 15.1

Initial Cost/Meter (Foot): $119.00 ($35.61)
*Annual Cost/Meter (Foot): $ 29.70 ($ 8.91)

θ = 45°



Lamp: 250w HPS
LDD: .73
LLD: .86
Maintenance Factor: .63
Set Back: 0
Height: 4.6 m (15 ft)
Spacing: 6.1 m (20 ft)

Luminaire: Flood GE Versa Flood 2
One Per Mounting
Aimed Perpendicular to Building Face
Min FC: .6
Avg-Min: 3.4
Max-Min: 8.5

Initial Cost/Meter (Foot): $46.50 ($14.16)
*Annual Cost/Meter (Foot): $12.93 ($ 3.94)

*$.04/kwh

SECURITY LIGHTING FROM A BUILDING -- 5.4 LUX (.5 FC)

Figure 51

In configurations with more than one luminaire per pole, the luminaires are aimed at different locations. In these cases, there will be some glare within the protected area if the security guard is in a position which requires looking down the row of luminaires. Any luminaire which has a lens which protrudes beyond the plane of the opaque part of the fixture will also create some side or backwash glare.

7.2.3 Roadway Lighting of the Isolation Zone

The advantage of roadway type lighting for the isolation zone is that it normally is more economical since roadway luminaires are designed for this purpose. The disadvantage is that roadway luminaires project a backwash light (light to the side and rear of the luminaire) which is undesirable from the standpoint of glare projected into the eyes of security personnel on patrol. Figures 52 through 56 provide several configurations of luminaires and spacing for consideration.

Roadway luminaires with "cutoff" features or flat lenses may create significantly less side or backwash glare. "House side" shields are available as an option on many roadway luminaires which minimize backwash glare into the projected area. These shields cost from $25 to $30 each.

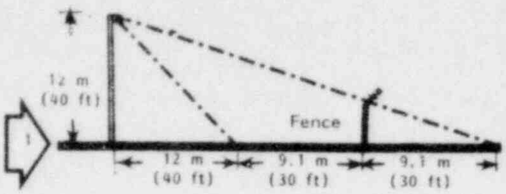
The costs shown in the figures are for comparative purposes only and do not include design, contractor markup, items common to all systems and other contingencies. Many other configurations were reviewed which did not meet the lighting uniformity criteria and therefore are not included.

7.2.4 Area Lighting of the Isolation Zone

The use of area lighting for the isolation zone is possible by adjusting the location of the protected area lighting to include the isolation zone. Configurations of area lighting are included in Section 7.3 The locations of the poles and masts illustrated can be adjusted to include the isolation zone.

The advantage of doing this is that the overall cost of lighting may be reduced by using high mast configurations.

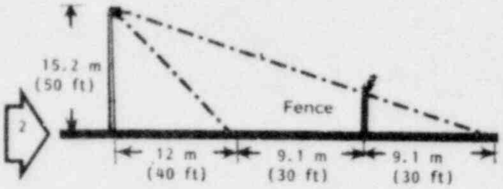
The disadvantage is that glare projection away from the protected area is not possible. Selective higher lighting levels at the isolation zone may be



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 12 m (40 ft)
Pole Height: 12 m (40 ft)
Spacing: 107 m (350 ft)

Luminaire: Roadway Holophane Expressway #1230
One Per Pole
Min FC: .19
Avg-Min: 2.8
Max-Min: 7.79

Initial Cost/Meter (Foot): $9.85 ($3.01)
*Annual Cost/Meter (Foot): $2.34 ($ .71)
Photometric data provided by Johns Manville



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 12 m (40 ft)
Pole Height: 15.2 m (50 ft)
Spacing: 107 m (350 ft)

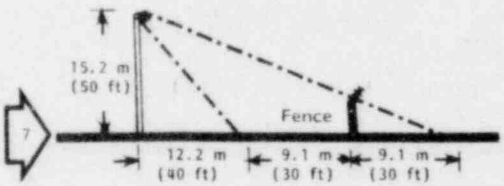
Luminaire: Roadway Holophane Expressway #1230
One Per Pole
Min FC: .23
Avg-Min: 2.3
Max-Min: 5.96

Initial Cost/Meter (Foot): $10.57 ($3.23)
*Annual Cost/Meter (Foot): $ 2.44 ($ .75)
Photometric data provided by Johns Manville

*$.04/kwh

ISOLATION ZONE ROADWAY LIGHTING FOR 2.15 LUX (.2 FC)

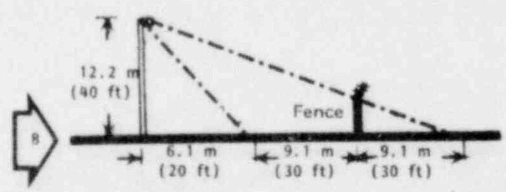
Figure 52



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 12.2 m (40 ft)
Pole Height: 15.2 m (50 ft)
Spacing: 68.6 m (225 ft)

Luminaire: Roadway Holophane Expressway #1230
One Per Pole
Min FC: .5
Avg-Min: 1.8
Max-Min: 3.1

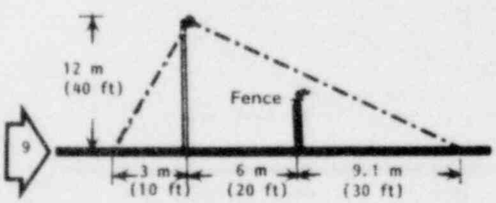
Initial Cost/Meter (Foot): $16.48 ($5.02)
*Annual Cost/Meter (Foot): $ 3.80 ($1.16)
Photometric data provided by Johns Manville



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 6.1 m (20 ft)
Pole Height: 12.2 m (40 ft)
Spacing: 53.3 m (175 ft)

Luminaire: Roadway Holophane Expressway #1230
One Per Pole
Min FC: .52
Avg-Min: 2.8
Max-Min: 5.7

Initial Cost/Meter (Foot): $19.77 ($6.02)
*Annual Cost/Meter (Foot): $ 4.69 ($1.43)
Photometric data provided by Johns Manville



Lamp: 400w HPS
LDD: .8
LLD: .71
Maintenance Factor: .568
Set Back: 6 m (20 ft) from fence
Pole Height: 12 m (40 ft)
Spacing: 36 m (120 ft)

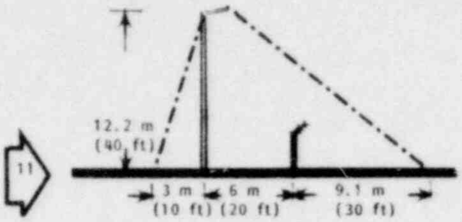
Luminaire: Roadway GE M400A (Cutoff)
One Per Pole
Min FC: .53 fc
Avg-Min: 2.58
Max-Min: 6.15

Initial Cost/Meter (Foot): $26.64 ($7.99)
*Annual Cost/Meter (Foot): $ 7.06 ($2.12)

*$.04/kwh

ISOLATION ZONE ROADWAY LIGHTING FOR 5.4 LUX (.5 FC)

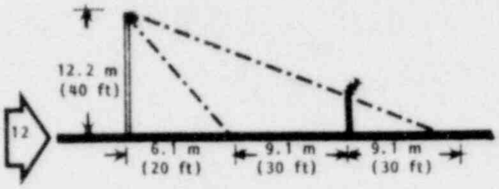
Figure 53



Lamp: 180w LPS
LDD: .9
LLD: 1.0
Maintenance Factor: .9
Set Back: As Shown
Pole Height: 12.2 m (40 ft)
Spacing: 24.4 m (80 ft)

Luminaire: Roadway QL-SOX 180
One Per Pole
Min. FC: 1.0 (approx)
Avg-Min: 2.3 (approx)
Max-Min: 4.0 (approx)

Inital Cost Per Meter (Foot): $42.64 ($13.00
Annual Cost Per Meter (Foot)*: 8.94 ($ 2.73)

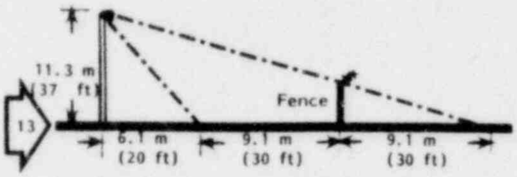


Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor:
Set Back: 6.1 m (20 ft)
Pole Height: 12.2 m (40 ft)
Spacing: 30 m (100 ft)

Luminaire: Roadway Holophane Expressway #1230
One Per Pole
Min FC: 1.07
Avg-Min: 2.4
Max-Min: 4.26

Initial Cost Per Meter (Foot): $35.13 ($10.54)
Annual Cost Per Meter (Foot)*: $ 8.33 ($ 2.50)

Photometric data provided by Johns Manville



Lamp: 400w HPS
LDD: .8
LLD: .71
Maintenance Factor: .568
Set Back: 6.1 m (20 ft)
Pole Height: 11.3 m (37 ft)
Spacing: 51.8 m (170 ft)

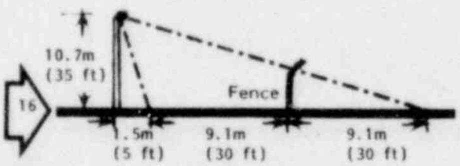
Luminaire: Roadway GE M400
Four Per Pole
Min FC: 1.27
Avg-Min: 1.77
Max-Min: 4.50

Initial Cost Per Meter (Foot): $34.06 ($10.38)
Annual Cost Per Meter (Foot)*: $11.87 ($ 3.62)

*$.04/kwh

ISOLATION ZONE ROADWAY LIGHTING FOR 10.76 LUX (1 FC)

Figure 54



Lamp: 400w HPS
LDD: .8
LLD: .71
Maintenance Factor: .568
Set Back: 1.5 m (5 ft)
Pole Height: 10.7 m (35 ft)
Spacing: 24 m (80 ft)

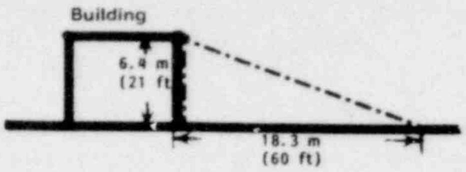
Luminaire: Roadway GE M400
Two Per Pole
Min FC: 2.15
Avg-Min: 1.46
Max-Min: 2.08

Initial Cost Per Meter (Foot): $40.47 ($12.34)
Annual Cost Per Meter (Foot)*: $12.66 ($3.86)
Reference No. 25

*$.04/kwh

ISOLATION ZONE ROADWAY LIGHTING FOR 21.5 LUX (2 FC)

Figure 55



Lamp: 250w HPS
LDD: .8
LLD: .71
Maintenance Factor: .568
Set Back: 0
Height: 6.4 m (21 ft)
Spacing: 18.3 m (60 ft)

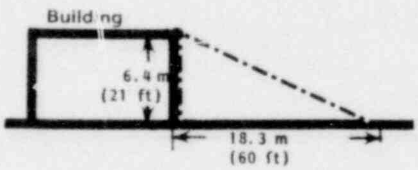
Luminaire: Roadway GE M400A
Two Per Mounting
Min FC: 1.01
Avg-Min: 1.6
Max-Min: 3.4

Initial Cost/Meter (Foot): $34.16 ($10.41)
Annual Cost/Meter (Foot)*: $11.61 ($ 3.54)

*$.04/kwh

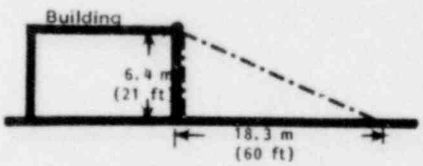
SECURITY LIGHTING FROM A BUILDING -- 10.7 LUX (1 FC)

Figure 56



Lamp: 400w HPS
LDD: .8
LLD: .71
Maintenance Factor: .568
Setback: .0
Height: 6.4 m (21 ft)
Spacing: 18.3 m (60 ft)
Initial Cost/Meter (Foot): $39.25 ($11.96)
Annual Cost/Meter (Foot)*: $18.14 ($ 5.53)

Luminaire: Roadway GE M400A
Two Per Mounting
Min FC: 2.0
Avg-Min: 1.5
Max-Min: 3.4



Lamp: 180w LPS
LDD: .8
LLD: 1.05
Maintenance Factor: .84
Setback: 0
Height: 6.4 m (21 ft)
Spacing: 15.2 m (50 ft)
Initial Cost/Meter (Foot): $38.57 ($11.76)
Annual Cost/Meter (Foot)*: $ 9.51 ($ 2.89)

Luminaire: Floodlight Phillips 180w LPS
One Per Mounting
Min FC: 2.0
Avg-Min: 1.5
Max-Min: 3.1

*$.04/kwh

SECURITY LIGHTING FROM A BUILDING -- 21.5 LUX (2 FC)

Figure 57

difficult if not impossible to achieve without large parts of the protected area having more light than necessary.

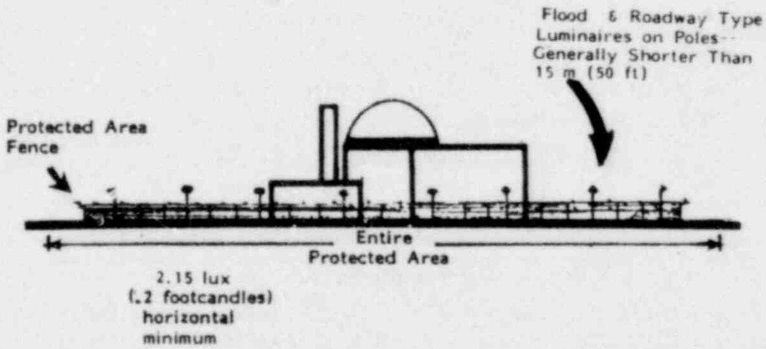
Figures 62 through 67 illustrate a variety of configurations. Note that the costs shown are for comparative purposes and do not include design, contractor markup and items common to all systems and other contingencies.

7.3 Security Lighting for the Exterior Protected Area

7.3.1 General

The NRC requires that all exterior areas within the protected area shall be monitored or periodically checked to detect the presence of unauthorized persons, vehicles, materials or unauthorized activities and provided with sufficient illumination to accomplish this. Figure 58 illustrates this concept.

The protected area requires a minimum illumination level of 2.15 lux (.2 footcandles). As noted in the previous sections, depending on the type of surface being illuminated, the level of illumination should be increased to provide additional assurance of intruder detection.



FLOOD AND ROADWAY LUMINAIRE
SECURITY LIGHTING FOR OUTDOOR PROTECTED AREAS

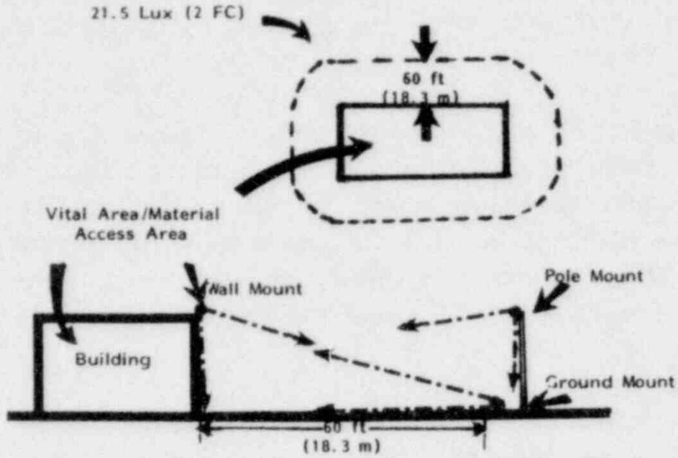
Figure 58

Depending on the site configuration, the security area lighting can be accomplished with floodlights or roadway luminaires (in parking lot illumination configurations), high mast systems or combinations of these.

It is normally not important to have a significant degree of color discrimination in this area. Exceptions can be covered with appropriate lamps in areas required.

Uniformity of illumination within the protected area is perhaps not as critical as in the isolation zone. The uniformity will also be affected by lighting around vital and material access areas, portals and other operating areas which may require illumination well in excess of minimum security requirements. Even so, it is recommended that, where possible, the average to minimum ratio be less than 4-3 to 1 and the maximum to minimum ratio be less than 6-8 to 1.

Figure 59 illustrates the recommended increased illumination levels around vital and material access area buildings. The increased level of illumination in the proximity of these areas will increase the probability of intruder detection and increase the deterrent effect. Although this is not a requirement, it is a practice which is recommended for consideration. As shown in the figure, the illumination can be accomplished from the building wall or roof, the ground level away from the building, or poles mounted away from the building. Section 7.2 provides configurations for building mounted luminaires. The disadvantage of these is that glare is projected away from the building into the eyes of intruders and possibly security guards. Low mounting heights will also cause illumination uniformity problems. Ground mounted luminaires cause glare if security personnel are looking out of the building, make horizontal illumination difficult to achieve, and cause poor uniformity. Ground mounted luminaires do create large shadows if an intruder is in the light beam and standing up. However, this cannot be assured. Lighting of buildings from poles set away from the building can be accomplished with the same configurations of lighting as used for the isolation zone with the building wall assumed to be the outer edge of the zone. This will provide good illumination uniformity. The only disadvantage of this is the glare in the eyes of security guards who may be in the building looking out. This can be minimized by selecting configurations which use poles at least 12.2 m (40 feet) high.



OPTIONAL VITAL AND MATERIAL ACCESS AREA SECURITY LIGHTING

Figure 59

Figure 60 provides a summary of basic security area lighting configuration characteristics which are detailed in subsequent figures.

7.3.2 High Mast Lighting of Protected Areas

High mast or tower lighting for an area generally consists of groups of luminaires mounted on free standing masts or towers at heights of 18 meters (60 feet) to 55 meters (180 feet) or more (Reference Figure 61). There are several significant advantages to high mast lighting: high uniformity of illumination can be achieved with high masts; the number of poles using high mast lighting is significantly reduced which minimizes hazards and maintenance; area as well as perimeter (isolation zone) lighting can be provided with high mast systems; illumination of roofs and other tall structures in the protected area can readily be accomplished with high mast lighting;

No.	Lamp	Luminaire	Min FC	Avg-Min FC	Units/ Pole	Height (Ft)	Set Back (Ft)	Spacing (Ft)	Annual Cost ($/Ft²)	Initial Cost ($/Ft²)
17	1000w HPS	High Mast	.22	3.0	4	90	0	600	.006	.028
18	1000w HPS	High Mast	.22	2.2	5	120	0	700	.007	.032
19	250w HPS	Parking Lot	.26	2.5	2	50	0	150x250	.016	.082
20	1000w HPS	High Mast	.27	2.5	4	140	0	450	.021	.110
21	1000w HPS	High Mast	.53	3.0	12	120	0	700	.011	.043
22	1000 w HPS	High Mast	.52	2.63	4	100	0	450	.016	.081
23	400w HPS	Parking Lot	.71	1.74	2	50	0	150x250	.016	.088
24	250w HPS	Parking Lot	.68	2.1	4	50	0	200	.023	.109
25	1000w HPS	High Mast	1.04	2.5	8	100	0	450	.023	.097
26	1000w HPS	High Mast	1.24	2.15	4	80	0	400	.020	.101
27	400w HPS	Parking Lot	1.13	2.1	4	50	0	200	.026	.113
28	1000w HPS	High Mast	2.55	2.53	12	80	0	450	.029	.115
29	1000w HPS	High Mast	2.4	2.15	12	100	0	400	.038	.147
30	400w HPS	Parking Lot	2.17	1.88	4	40	0	150	.038	.148
31	400w HPS	Parking Lot	2.9	1.3	4	50	0	150	.046	.201

Cost Shown is Per Square Foot

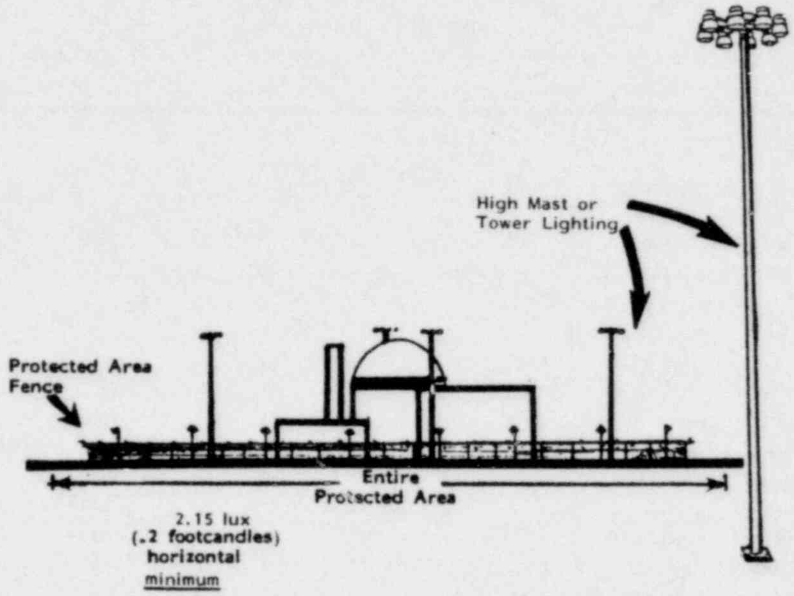
(Feet) (3.28) = Meters

(FC) (10.76) = Lux

PROTECTED AREA LIGHTING CONFIGURATION SUMMARY

Figure 60

gla/ e is almost non-existent at ground level when high mast units are used; th tendency for observation of bright lights and bright areas is minimized a id dark adaption and transition problems are minimized when high mast lighting is used.



HIGH MAST LUMINAIRE
SECURITY LIGHTING FOR OUTDOOR PROTECTED AREAS

Figure 61

Since so much illumination dependence is dedicated to single poles, care should be taken to locate them in areas of minimal damage hazards and maximum observation by security posts. The luminaries and lowering devices can be more complex and maintenance of the units may require special considerations.

Typically, high level illumination lamps are utilized (generally either 400 to 1,000 watt high pressure sodium, 1,000 watt metal halide or 180 watt low pressure sodium). The use of 24-30 meter (80-100 foot) masts is common for large area illumination.

Generally, the cost of high mast illumination decreases as higher masts are utilized. Even though the cost of the mast goes up significantly, the area covered goes up as a function of the square of the mounting height. The break-even point varies between 18-30 meters (60-100 feet). For example, a 12 meter (40 foot) pole will illuminate 3700 square meters (1 acre) and a 45 meter (150 feet) mast will illuminate 37,000 square meters (10 acres). A mast system will cover in width at least 4 to 4.5 times its height and the spacing between masts will be at least 4 to 4.5 times the mast height.

Figures 62 through 65 provides several high mast lighting configurations for consideration. Many other configurations reviewed did not meet the lighting uniformity criteria and therefore were not included.

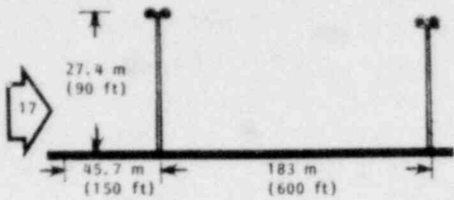
Height and marking (beacon) limitations or requirements should be checked with the local Federal Aviation Administration (FAA) office as a part of high mast illumination planning.

7.3.3 Non-High Mast Lighting of Protected Areas

Non-high mast lighting of protected areas is similar to "parking lot" lighting. Although more poles are required for this type of lighting, it can be more efficient for smaller areas. Luminaires are more widely spread and therefore they do not have illumination dependence on only a few poles. Lower level luminaires are generally easier to maintain and service. A disadvantage is that the lower level luminaires create glare within the protected area which can be a distraction to security personnel on patrol. For this reason, a minimum height of 12.2 meters (40 feet) is recommended (Reference Figure 58). Figures 66 through 69 provide several configurations of luminaires and spacings which will provide the 2.15 lux (.2 footcandles) required as a minimum within the protected area. Several configurations are also provided for higher levels should they be desired.

7.4 Security Lighting at Personnel and Vehicle Access Portals

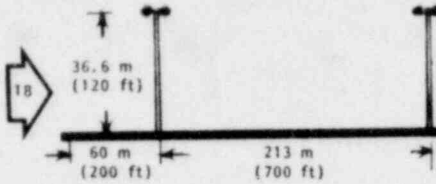
Since security functions other than just surveillance are required at site portals, it is necessary to increase the quantity and quality of light in these areas. Therefore an intensity level of 21.5 lux (2 footcandles) horizontal minimum is recommended of a light type which will permit accurate color distinction. Figure 70 illustrates the areas over which this



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 27.4 m (90 ft)
Spacing: 183 m (600 ft)

Luminaire: High Mast Holophane HMS #1171
Four Per Pole
Min FC: .22
Avg-Min: 3.0
Max-Min: 8.04

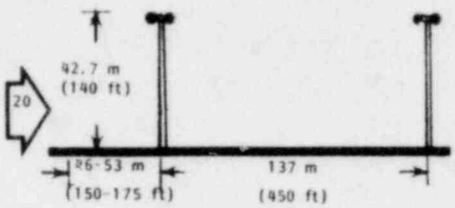
Initial Cost Per m² (ft²): $ .29 ($.028)
*Annual Cost Per m² (ft²): $ .069 ($.006)
Photometric data provided by Johns Manville



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 36.6 m (120 ft)
Spacing: 213 m (700 ft)

Luminaire: High Mast Holophane HMS #1171
Five Per Pole
Min FC: .22
Avg-Min: 2.2
Max-Min: 5.6

Initial Cost Per m² (ft²): $ .424 ($ .032)
*Annual Cost Per m² (ft²): $ .074 ($ .007)
Photometric data provided by Johns Manville



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 42.7 m (140 ft)
Spacing: 137 m (450 ft)

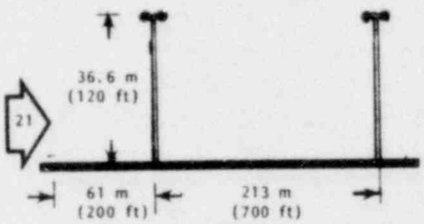
Luminaire: High Mast GE HM-1000 S
Four Per Pole
Min FC: .27
Avg-Min: 2.5
Max-Min: 5.1

Initial Cost Per m² (ft²): $1.19 ($.110)
*Annual Cost Per m² (ft²): $ .223 ($.021)
Photometric data provided by G.E.

*$.04/kwh

HIGH MAST PROTECTED AREA LIGHTING 2.15 LUX (.2 FC)

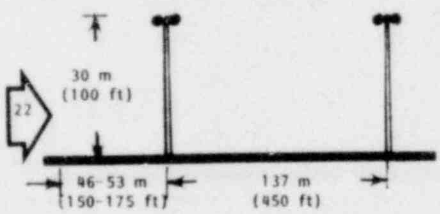
Figure 62



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 36.6 m (120 ft)
Spacing: 213 m (700 ft)

Luminaire: High Mast Holophane HMS #1171
Twelve Per Pole
Min FC: .53
Avg-Min: 3.
Max-Min: 5.63

Initial Cost Per m² (ft²): $ .589 ($.043)
*Annual Cost Per m² (ft²): $ .123 ($.011)
Photometric Data provided by Johns Manville



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 30 m (100 ft)
Spacing: 137 m (450 ft)

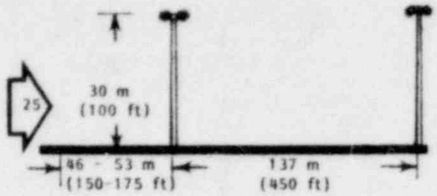
Luminaire: High Mast GE HM 1000 S
Four Per Pole
Min FC: .52
Avg-Min: 2.63
Max-Min: 5.39

Initial Cost Per m² (ft²): $.874 ($.081)
*Annual Cost Per m² (ft²): $.175 ($.016)
Photometric Data provided by G.E.

*$.04/kwh

HIGH MAST PROTECTED AREA LIGHTING 5.4 LUX (.5 FC)

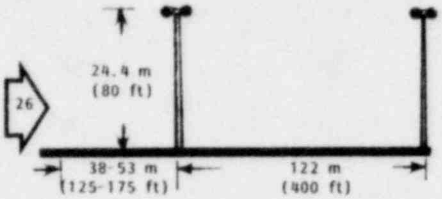
Figure 63



Lamp: 1,000w HPS
LDD: .99
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 30 m (100 ft)
Spacing: 137 m (450 ft)

Luminaire: High Mast GE HM-1000 S
Eight Per Pole
Min FC: 1.04
Avg-Min: 2.5
Max-Min: 5.19

Initial Cost Per m² (ft²): $1.05 ($.097)
*Annual Cost Per m² (ft²): $ .246 ($.023)
photometric data provided by G.E.



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 24.4 m (80 ft)
Spacing: 122 m (400 ft)

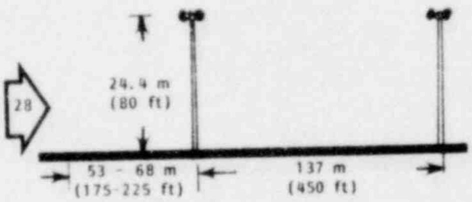
Luminaire: High Mast GE HM-1000 S
Four Per Pole
Min FC: 1.24
Avg-Min: 2.15
Max-Min: 3.62

Initial Cost Per m² (ft²): $1.082 ($.101)
*Annual Cost Per m² (ft²): $ .218 ($.020)
Photometric Data provided by G.E.

*$.04/kwh

HIGH MAST PROTECTED AREA LIGHTING 10.76 LUX (1 FC)

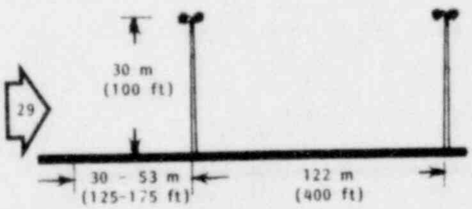
Figure 64



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 24.4 m (80 ft)
Spacing: 137 m (450 ft)

Luminaire: High Mast GE HM 1000 S
Twelve Per Pole
Min FC: 2.55
Avg-Min: 2.53
Max-Min: 5.18

Initial Cost Per m² (ft²): $1.23 ($.115)
*Annual Cost Per m² (ft²): $ .319 ($.029)
Photometric Data Provided by G.E.



Lamp: 1,000w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 30 m (100 ft)
Spacing: 122 m (400 ft)

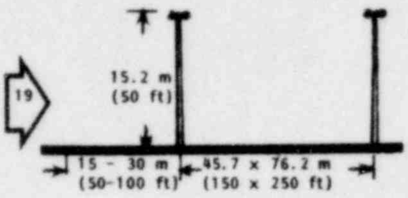
Luminaire: High Mast GE HM1000 S
Twelve Per Pole
Min FC: 2.4
Avg-Min: 2.15
Max-Min: 3.6

Initial Cost Per m² (ft²): $1.58 ($.147)
*Annual Cost Per m² (ft²): $ .405 ($.038)
Photometric Data Provided by G.E.

*$.04/kwh

HIGH MAST PROTECTED AREA LIGHTING 21.5 LUX (2 FC)

Figure 65



Lamp: 250 HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 15.2 m (50 ft)
Spacing: 45.7 x 76.2 m
(150 x 250 ft)

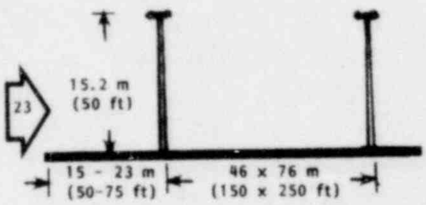
Luminaire: Roadway GE M400
Two Per Pole
Min FC: .26
Avg-Min: 2.5
Max-Min: 6.42

Initial Cost Per m^2 (ft^2): $.902 ($.082)
*Annual Cost Per m^2 (ft^2): $.170 ($.016)
Photometric Data Provided by G.E.

*$.04/kwh

"PARKING LOT" LIGHTING-PROTECTED AREA 2.15 LUX (.2 FC)

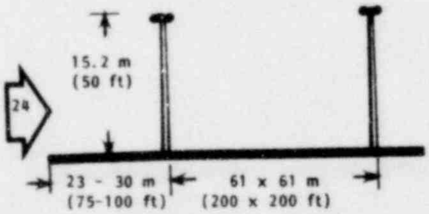
Figure 66



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 15.2 m (50 ft)
Spacing: 46 x 76 m
(150 x 250 ft)

Luminaire: Roadway GE M400
Two Per Pole
Min FC: .71
Avg-Min: 1.74
Max-Min: 3.97

Initial Cost Per m^2 (ft^2): $.951 ($.088)
*Annual Cost Per m^2 (ft^2): $.169 ($.016)
Photometric Data Provided by G.E.



Lamp: 250w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 15.2 m (50 ft)
Spacing: 61 m (200 ft)

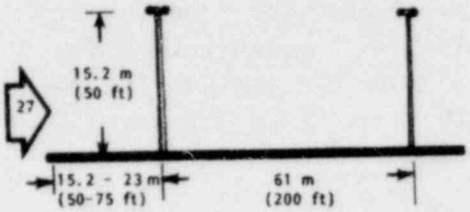
Luminaire: Roadway GE M400
Four Per Pole
Min FC: .68
Avg-Min: 2.1
Max-Min: 4.9

Initial Cost Per m^2 (ft^2): $1.18 ($.109)
*Annual Cost Per m^2 (ft^2): $ .247 ($.023)
Photometric Data Provided by G.E.

*$.04/kwh

"PARKING LOT" LIGHTING-PROTECTED AREA 5.4 LUX (.5 FC)

Figure 67



Lamp: 400w HPS
LDD: .95
LLD: .73
Maintenance Factor: .69
Set Back: 0
Height: 15.2 m (50 ft)
Spacing: 61 m (200 ft)

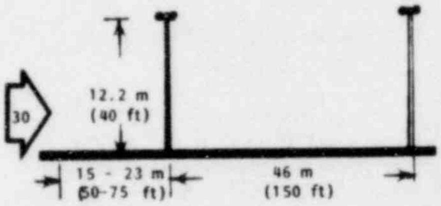
Luminaire: Roadway GE M400
Four Per Pole
Min FC: 1.13
Avg-Min: 2.1
Max-Min: 5.5

Initial Cost Per m² (ft²): $1.21 ($.113)
*Annual Cost Per m² (ft²): $ .277 ($.026)
Photometric Data Provided by G.E.

*$.04/kwh

"PARKING LOT" LIGHTING-PROTECTED AREA 10.76 LUX (1.0 FC)

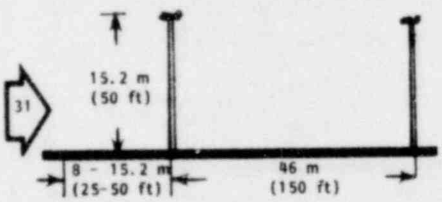
Figure 68



Lamp: 400w HPS
LDD: .95
LLD: .75
Maintenance Factor: .69
Set Back: 0
Height: 12.2 m (40 ft)
Spacing: 46 m (150 ft)

Luminaire: Roadway GE M400
Four Per Pole
Min FC: 2.17
Avg-Min: 1.88
Max-Min: 4.08

Initial Cost Per m² (ft²): $1.59 ($.148)
*Annual Cost Per m² (ft²): $ .406 ($.038)
Photometric Data Provided by G.E.



Lamp: 400w HPS
LDD: .95
LLD: .75
Maintenance Factor: .69
Set Back: 0
Height: 15.2 m (50 ft)
Spacing: 46 m (150 ft)

Luminaire: Roadway GE M400
Four Per Pole
Min FC: 2.9
Avg-Min: 1.3
Max-Min: 2.17

Initial Cost Per m² (ft²): $2.160 ($.201)
*Annual Cost Per m² (ft²): $ .492 ($.046)
Photometric Data Provided by G.E.

*$.04/kwh

"PARKING LOT" LIGHTING-PROTECTED AREA 21.5 LUX (2 FC)

Figure 69

level should be applied. The vehicle gate is illuminated to provide complete coverage of a tractor/trailer for search purposes. The area includes 15.2 meters (50 feet) either side of the center of the roadway, 30.5 meters (100 feet) into the protected area and 30.5 meters (100 feet) outward from the gate. If a "sally port" gate is used, the area will be 30.5 meters (100 feet) square. The pedestrian gate/door is illuminated in an area which will allow viewing and identification of small groups of people. This area is 9.1 by 9.1 meters (30 x 30 feet).

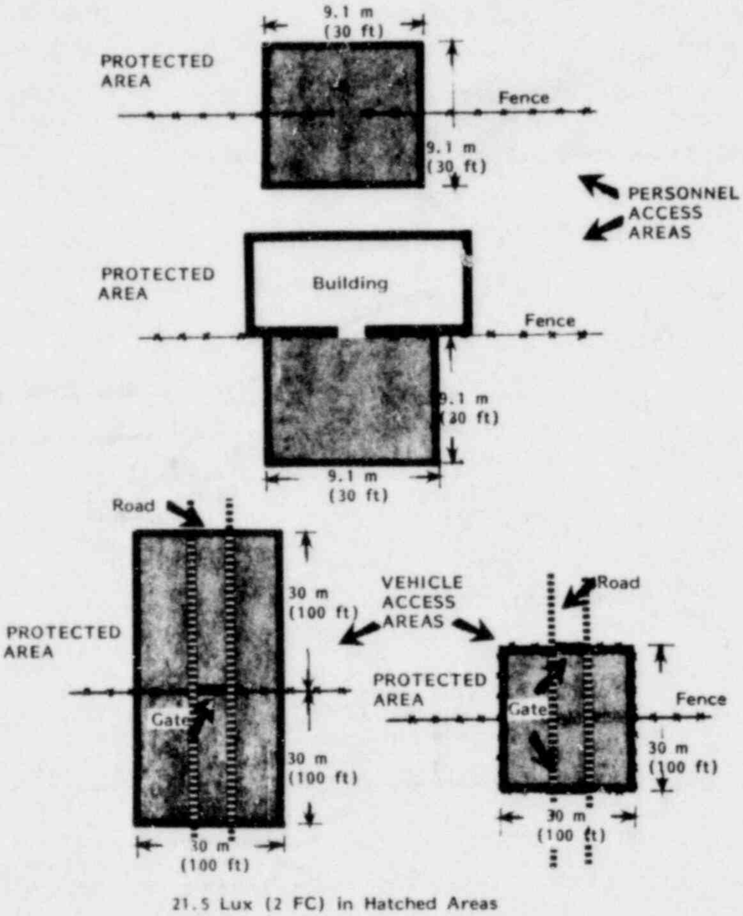
At gate areas where vehicles are to be searched, concrete with or without reflective beads embedded can be used or the road surface can be painted white to assist with lighting available for inspection/search of the underside of vehicles. Reflective paint such as that utilized for highway marking should last up to two or more years. Both the area inside and outside the gate or the area between gates ("sally port") should be painted the full width of the pavement or at least 7.3 m (24 feet) and for a distance of 30.5 m (100 feet). See Figure 71. As shown in Figure 71, recessed lighting ("pit lights") can also be installed for this purpose.

Lighting at gate areas should not create glare for the security personnel. The security personnel's position should utilize the concepts shown in Figure 72.

It is very important to have color discrimination capability at gate areas. Typical lighting configurations to accomplish this are shown in Figure 73. Note that the small quartz floods on the building are aimed not to create a dangerous level of glare in the vehicle area but to provide illumination for document checking and personnel identification. Other combinations of luminaires and distribution configurations may also be acceptable.

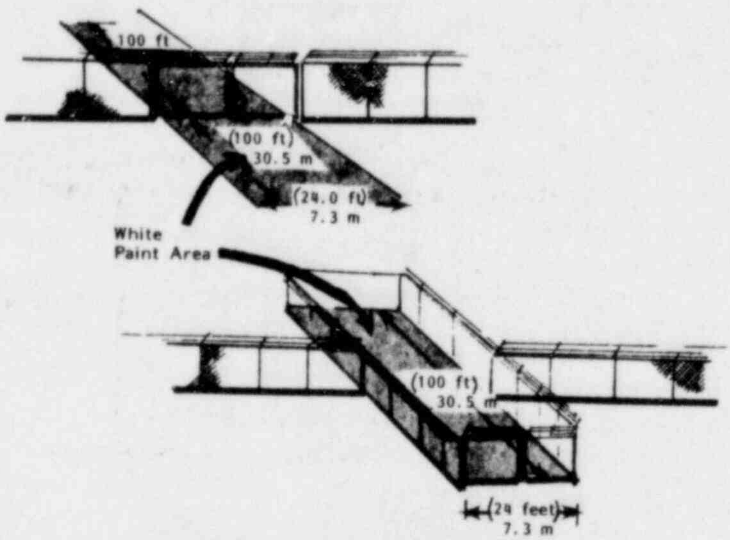
7.5 Security Lighting for Interiors

It is not important to continuously illuminate the interior of all buildings within the protected area perimeter for security purposes. Lighting for areas requiring continuous direct visual surveillance should be illuminated from 21.5 to 54 lux (2-5 footcandles) minimum. This is not only adequate for personnel identification but also for safety as recommended in Nuclear Power Plant Lighting (Reference No. 17). Areas requiring CCTV or utilizing other electro-optical detection, surveillance or assessment devices may require additional illumination. Interior security lighting for safety purposes should permit accurate identification of colors. If a security

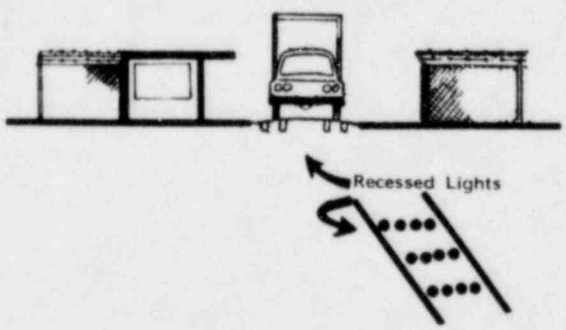


SECURITY LIGHTING AT ACCESS PORTALS

Figure 70

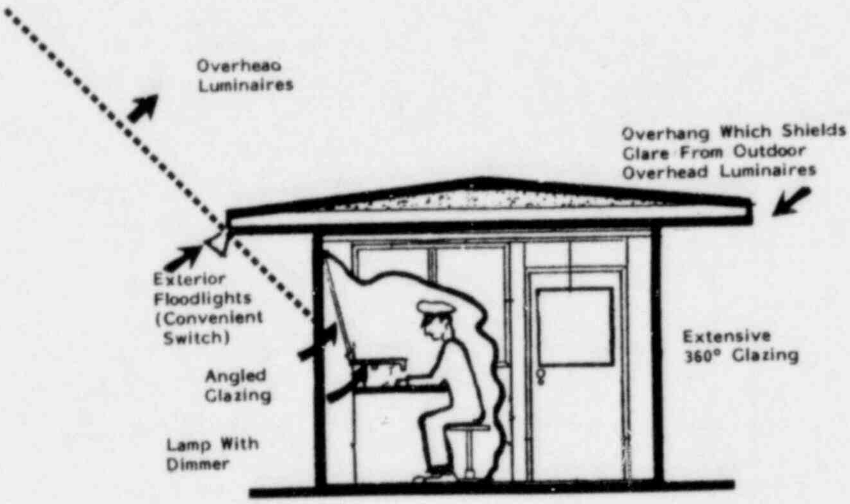


VEHICLE GATE AREA [illegible] H WHITE SURFACE



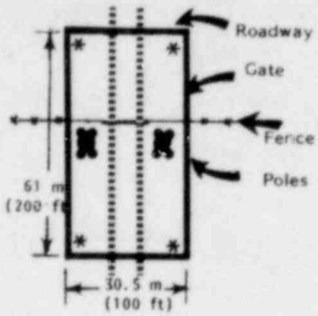
VEHICLE GATE AREA RECESSED LIGHTING

Figure 71



PROTECTED AREA GATEHOUSE LIGHTING

Figure 72

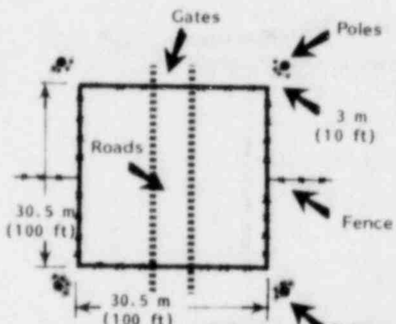


Lamp: 1500w Quartz
LDD: .96
LLD: .8
Maintenance Factor: .77
Set Back: 8 ft/Fence
Height: 9.1 m (30 ft)
Spacing: 24.4 m (80 ft)

Luminaire: Floods
2 NEMA 6 x 2/pole
2 NEMA 6 x 5/pole
Four Per Pole
Min FC: 2.0 (approx)
Avg-Min: 2.24 (approx)
Max-Min: 5.07 (approx)

Initial Cost/Meter² (Foot²): $1.22 ($.113)
Annual Cost/Meter² (Foot²): $1.50 ($.140)

* Note: One each quartz 150w Flood can be installed in each of the four corners with a switch within the Protected Area. These are used for illuminating the back of vehicles.

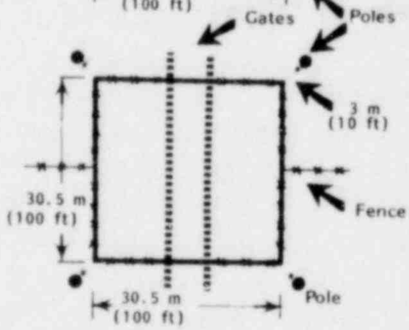


Lamp: 150w HPS
LLD: .73
LDD: .86
Maintenance Factor: .63
Set Back: 3 m (10 ft)
Height: 9.1 m (30 ft)
Spacing: (as shown)

Luminaire: Flood GE Versa Flood
NEMA 6 x 7
Four Per Pole
Min. FC: 2.18
Avg-Min: 1.98
Max-Min: 4.36

Initial Cost/Meter² (Foot²): $8.74 ($.813)
* Annual Cost/Meter² (Foot²): $2.02 ($.187)

Note: Hot Restrike Feature Should Be Used



Lamp: 1500w Quartz
LDD: .96
LLD: .8
Maintenance Factor: .77
Set Back: 3 m (10 ft)
Height: 12.2 m (40 ft)
Spacing: (as shown)

Luminaire: Flood GE 1500A
Quartz NEMA 6 x 4
One Per Pole
Min FC: 2.67
Avg-Min: 2.08
Max-Min: 3.37

Initial Cost/Meter² (Foot²): $2.88 ($.268)
* Annual Cost/Meter² (Foot²): $1.75 ($.163)

*$.04/kwh

SECURITY LIGHTING FOR VEHICLE ACCESS AREAS 21.5 LUX (2 FC)

Figure 73

guard is expected to patrol the area in the protective low light environment, low pressure sodium luminaires may not be appropriate in some areas. Switches are normally available which provide full working illumination for the security guard to use on scheduled or random patrols or alarm assessment responses.

Additional cautions on the use of lighting for security or other purposes in material access or vital areas include:

- Count Rooms--Equipment in these areas may be sensitive to line feedback or direct radiation from fluorescent luminaires (Reference No. 17).

- Count Rooms and Other Areas--Security lighting should not be of such intensity that it washes out low output neon, LED or other small instrumentation luminaires.

- Critical lighting circuits wherever possible should be run in different conduits and raceways to maintain integrity of backup capability.

- Aluminum and galvanized zinc use in reactor containments is restricted. (Reference No. 17.) This is because of potential hydrogen production resulting from reactions with deluge chemicals. Substitute materials or coatings may be required for lighting fixtures in environments subject to these chemicals in critical areas.

- High pressure sodium, mercury vapor, metal halide and fluorescent lamps all contain certain quantities of mercury. Mercury and its compounds have been known to be restricted in areas such as reactor buildings, fuel handling buildings, and auxiliary buildings to minimize the possibility of contaminating and corroding primary stainless steel piping systems. (Reference No. 17.)

- Polyvinyl chloride use may also be restricted in the containment area. (Reference No. 17.)

- Some facilities are concerned with the use of materials with a flame spread rating of greater than 25 (Reference No. 17). Plastics commonly used in lighting such as acrylic and polystyrene may require substitute materials such as steel or glass.

If there are areas in which continuous lighting for security purposes only is desired, this can be accomplished with separate circuits providing low cost low level illumination. Information is provided which illustrates these possibilities. They are based on using a luminaire with wide angle light distribution (spacing to mounting height ratio of 1.8 - 2.0 to 1). The information provides for the spacing of the luminaires as shown in Figure 74.

	CEILING HEIGHT			
	3.8 m (12.5 ft)		9.1 m (20 ft)	
	21.5 lux (2 fc)	54 lux (5 fc)	21.5 lux (2 fc)	54 lux (5 fc)
70w HPS	7.6 m (25 ft)	4 m (13 ft)	7.6 m (25 ft)	4 m (13 ft)
175w MV	—	—	—	8.2 m (27 ft)
100w HPS	—	—	—	8.8 m (29 ft)

HPS = High Pressure Sodium
MV = Mercury Vapor

INTERIOR SECURITY LIGHTING SPACING CONFIGURATIONS

Figure 74

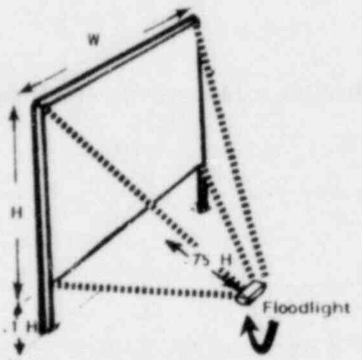
Systems are also available to turn on lights remotely through hardwire switching, radio control, remote control or by utilizing the alarm system to activate lights.

7.6 Sign Illumination

Security related signs at vehicle and pedestrian gates should be illuminated to assure they can be read. The American Association of State Highway and

Transportation Officials (Reference No. 10) recommend a minimum illumination of 108-215 lux (10-20 footcandles) at the sign's surface. Sign illumination should be arranged such that it does not create glare for security posts or patrols.

Figure 75 illustrates typical arrangements for floodlight illumination of signs. (Reference No. 16.)



Sign Size	107.6 Lux (10 Footcandles)
3 x 3 m 10 x 10 ft	(1) 175 Watt Mercury Vapor Flood
3 x 5 m 10 x 15 ft	(1) 175 Watt Mercury Vapor Flood
3 x 6 m 10 x 20 ft	(2) 175 Watt Mercury Vapor Floods

SIGN LIGHTING CONFIGURATIONS

Figure 75

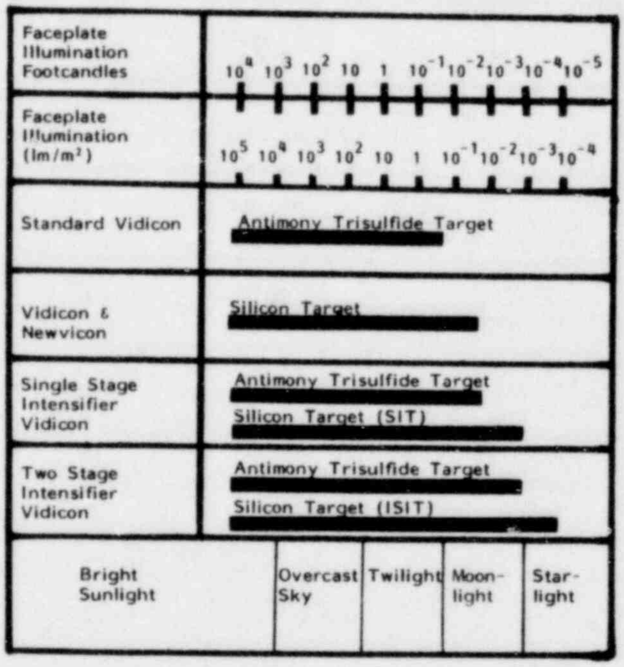
7.7 CCTV Lighting

7.7.1 General

Closed-circuit television (CCTV) plays an important role in the security field. The lighting requirements for human observation are not necessarily adequate for CCTV. It is important to choose the more cost-effective combinations of lighting and CCTV cameras. NUREG 0178, Basic Considertions for Assembling a Close-Circuit Television System (Reference No. 26) provides an excellent guide for CCTV planning. If CCTV Systems are to be installed in the future, it is best to recognize the CCTV lighting requirements in designing lighting systems to minimize future cost and problems. This should include type of lighting fixtures, width of the isolation zone, pole placement, etc.

Key planning factors for CCTV lighting include camera selection, lens selection, lighting level, lighting color and placement of lights and cameras.

As shown in Figure 76, camera systems have different sensitivities to light.



FACEPLATE ILLUMINATION FOR COMMON CCTV CAMERAS

Figure 76

Lens selection determines the amount of available light reaching the light sensing part of the camera imaging device. This is determined by the lens transmission efficiency, focal length of the lens and the maximum lens opening.

The lighting level must be measured as scene reflectance or luminance. Figure 4 provides the reflectance factors for various surfaces. These factors multiplied by the available illumination as measured horizontally provide an approximation of the scene luminance.

CCTV cameras are selectively sensitive to light color. Figure 77 illustrates the relative sensitivity of cameras to the light spectrum. Figure 78 illustrates the relative signal strength per watt of electrical power for various lamp and camera combinations. This takes into account luminaire efficiency and camera sensitivity to the lamp's lumen output and color spectrum (Reference No. 25). Note the greater sensitivity of cameras to light provided by low pressure sodium lamps.

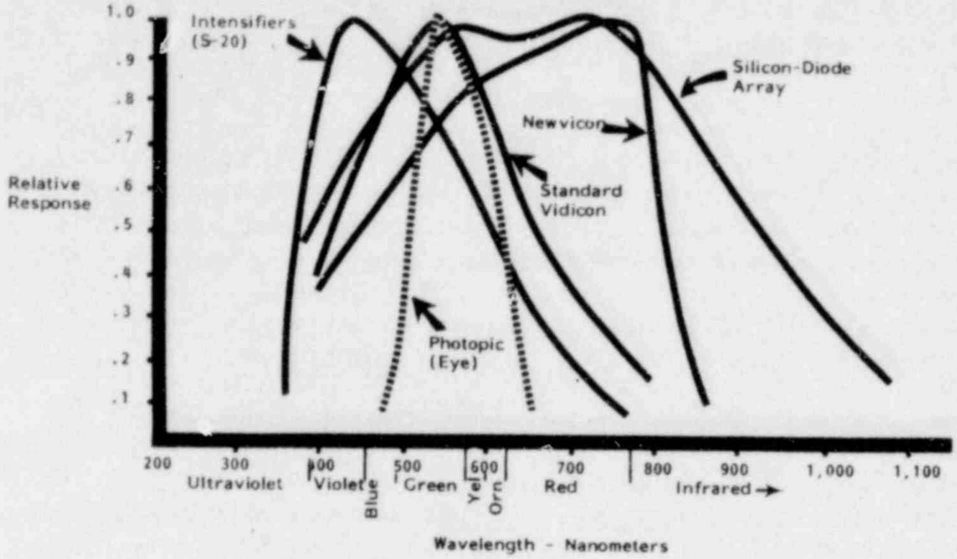
7.7.2 Outdoor CCTV Lighting Application Configurations

The security lighting system must provide light levels high enough to illuminate the scene, reflect from the scene and maintain the level required for the faceplate illumination necessary for the CCTV system to register a useful image. The scene illumination required to provide the faceplate illumination can be calculated by:

$$\text{Scene Illumination} = \frac{(4)\,(\text{Required Faceplate Illumination})\,(\text{Lens Speed})^2}{(\text{Scene Reflectance})\,(\text{Transmissibility of Lens})}$$

For a camera which requires 0.2 lux (0.02 footcandles) faceplate illumination (an average Low-Light-Level silicon array camera), that has a lens speed of 1.4 (F/1.4), a scene reflectance of .25 (graded and smooth background) and .7 transmissibility of lens (average lens value), a scene illumination of 9.6 lux (.896 footcandle) is required to provide sufficient illumination for good Low-Light-Level camera resolution.

A light/dark ratio (the ratio of illumination level between the brightest area in the scene and the darkest area) of less than 6 to 1 is recommended for exterior lighting. The light/dark ratio should apply as much as possible to the full field of view of the camera and not just the area of interest.



CCTV CAMERA SENSITIVITY TO THE LIGHT SPECTRUM

Figure 77

Camera	LAMPS				
	LPS 180w	HPS 400w	Tung. Halogen 500w	Clear Mercury 400w	Metal Halide 400w
Silicon Diode Vidicon	1.54	1.29	1.00	.57	1.36
New Vicon	2.25	1.90	1.14	.774	1.20
Standard Vidicon	.243	.202	.066	.122	.244
(SIT) Silicon Target	188.0	165.0	59.0	127.0	239.0
(ISIT) Two Stage Silicon Target	6903.0	6095.0	2323.0	3838.0	7821.0

Source Reference No. 25

RELATIVE SIGNAL STRENGTH PER WATT OF ELECTRICAL POWER FOR CCTV CAMERAS

Figure 78

A report of The Engineering and Economics of Lighting for Closed Circuit Television (CCTV) Security Alarm Assessments was recently completed for the Department of Energy (Reference No. 25). This study reviewed combinations of lighting sources for perimeter CCTV systems (Reference Figure 79) including low pressure sodium, high pressure sodium, metal halide, mercury vapor and tungsten halogen with cameras including silicon diode array vidicon, new vicon, standard vidicon (sulphide), silicon intensified target and intensified silicon intensified target. The applications studied were for perimeter surveillance and assessment of alarms using CCTV. From this study, several optimum lighting configurations were derived as shown in Figure 80. The minimum specification was for 10.76 lux (1 footcandle) horizontal, uniformity of 3:1 average to minimum and 6:1 maximum to minimum. Note that the importance of lighting uniformity for CCTV systems should not be underestimated. The "C" system shown is provided as an indication of the most economical high pressure sodium floodlight configuration and has the advantage of minimal backwash glare into the protected area which is distracting to security personnel. The "B" system has a higher initial cost than "A" or "C" but becomes competitive from an annual operating cost basis when power cost is just over \$.04 per kwh. At \$.06 per kwh "B" has an annual cost of 5 percent less than "C" and at \$.10 per kwh its annual cost is 16 percent less than "C". This analysis was based on multiple fixed CCTV cameras located along the perimeter. The silicon vidicon was the selected camera since it is relatively inexpensive and capable of operation in daylight as well as low light (Reference Nos. 25, 26, and 27). Note that the isolation zone for CCTV lighting is 25 meters (83 feet) to provide better camera/lense adaptation.

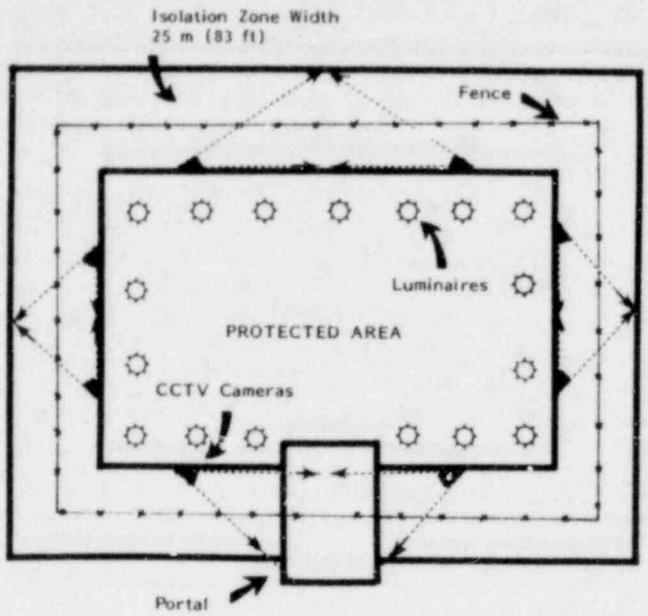
If surveillance is to be accomplished from one or more pan-tilt-zoom cameras, it may be economical to install a more sensitive and expensive camera (5 to 10 times the cost of a silicon diode vidicon) without providing the minimum of 10.76 lux (1 footcandle). In this case, if the illumination available is 2.3 lux (.2 footcandle), then for a zoom lens set-up the faceplate illumination minimum can be computed by:

$$\text{Faceplate Illumination} = \frac{(\text{Scene Illumination})\ (\text{Reflectance})\ (\text{Transmission})}{4\ (\text{Lens Opening})^2}$$

$$= \frac{(.2)\ (.25)\ (.7)}{4\ (2.5)^2}$$

$$= .0014 \text{ Footcandle } (.015 \text{ lux})$$

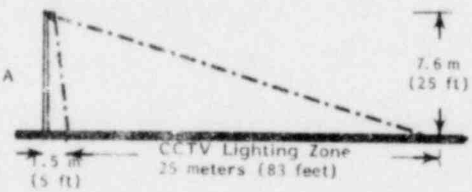
This is a very marginal amount of illumination for a silicon target vidicon camera (.01 footcandle required) and would therefore require a more sensitive silicon intensified target camera or equivalent. This assumes that the isolation zone and all other protected area zones have



ISOLATION ZONE CCTV AND LIGHTING CONCEPT

Figure 79

A

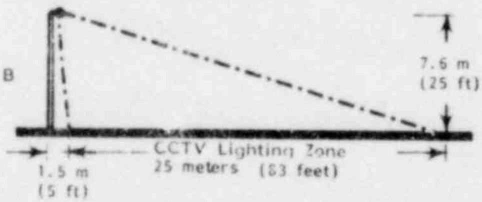


Lamp: 400w HPS
LDD: .8
LLD: .71
Maintenance Factor: .568
Set Back: 1.5 m (5 ft)
Pole Height: 7.6 m (25 ft)
Spacing: 24 m (80 ft)

Luminaire: Roadway GE M400
Two Per Pole
Min FC: .996
Avg-Min: 2.61
Max-Min: 5.94

Initial Cost Per Meter (Foot): $36.37 ($11.09)
Annual Cost Per Meter (Foot)*: $12.66 ($3.86)
Reference No. 25

B

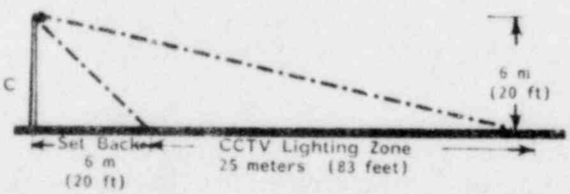


Lamp: 180w LPS
LDD: .8
LLD: 1.05
Maintenance Factor: .84
Set Back: 1.5 m (5 ft)
Pole Height: 7.6 m (25 ft)
Spacing: 27 m (90 ft)

Luminaire: Flood Norelco SFL-33885
Two Per Pole
Min FC: 1.116
Avg-Min: 2.39
Max-Min: 5.89

Initial Cost Per Meter (Foot): $46.15 ($14.07)
Annual Cost Per Mete: (Foot)*: $11.03 ($3.36)
Reference No. 25

C



*at $.04/kwh

Lamp: 400w HPS
LDD: .8
LLD: .71
Maintenance Factor: .568
Pole Set Back: 6 m (20 ft)
Pole Height: 11.3 m (37 ft)
Spacinq: 61 m (200 ft)

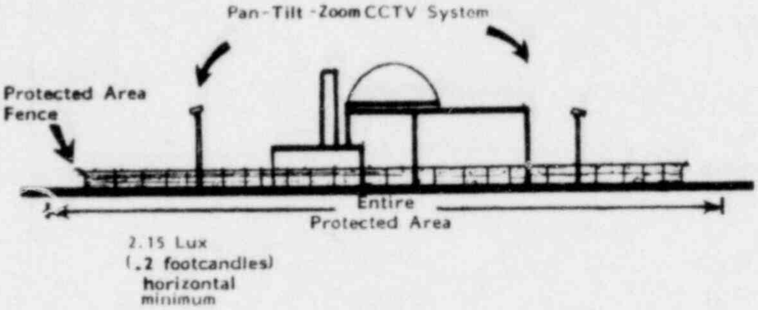
Luminaire: Flood Infranor Sterner 535-N-400 S
Four Per Pole
Min FC: 1.054
Avg-Min: 1.73
Max-Min: 5.94

Inital Cost Per Meter (Foot): $31.90 ($9.73)
Annual Cost Per Meter (Foot)*: $10.58 ($3.22)
Reference No. 25

CCTV PERIMETER LIGHTING CONCEPTS

Figure 80

a minimum of 2.15 lux (.2 footcandles) measured horizontal. This concept is illustrated in Figure 81. Lighting systems to provide this level of illumination are covered in the previous section.



PAN-TILT-ZOOM CCTV LIGHTING OPTION

Figure 81

Other combinations of illumination levels and cameras for outdoor use can be selected using the camera sensitivity, the previous equation and other illumination levels as provided in the previous section. Due to the variety of areas and requirements it may be appropriate to utilize several combinations and configurations.

When utilizing pan-tilt-zoom cameras to cover large areas it is important to keep in mind that the camera may have to function with a wide variety of illumination levels. Additionally, a fixed camera can provide immediate assessment and pan-tilt-zoom camera may require several seconds to minutes to aim at a suspect area. Even systems which are alarm system computer directed require time to aim or reaim.

7.7.3 Indoor CCTV Lighting Applications

Indoor lighting for CCTV is usually based on the available illumination. It is usually much more constant and uniform as well as having a higher illumination level than outdoor nighttime illumination. As such, standard vidicon cameras can be utilized as long as a minimum of 54-108 lux (5-10 footcandles) is available. If lower levels of light are available, cameras can be selected to match. If a continuous minimum of illumination for patrol and CCTV coverage is required in relatively small areas such as vault doors, access points, or other areas, high efficiency, high pressure sodium or low pressure sodium luminaires can be installed as wall or ceiling mounts.

8. OPERATION/CONTROL

8.1 General

To be effective, a security lighting system must be properly operated. Operational considerations include the use of lighting fixtures and security personnel lighting support during routine and contingency conditions. A coordination of properly maintained fixtures and trained, alert security personnel insures a more effective protective lighting and security system.

8.2 Routine

8.2.1 General

Routine operation is classified as the regular effort extended under normal circumstances. This includes start-up, operation and shutdown of the lighting fixtures and the visual tasks of the security personnel during nighttime post and patrol assignments.

8.2.2 Start-up and Shutdown

Outdoor lights will be switched on approximately 15 - 30 minutes after sunset and remain on until about 15 - 30 minutes before sunrise. The lighting schedule will vary depending on site location. This may be accomplished manually, by use of a timing system, or by use of a photoelectric system. If photoelectric switches are utilized they should be located such that they cannot be accessed and deactivated by an adversary's light. Manual override switches should be available for emergency use. The switching system should be located in a secure area. Only those personnel necessary to insure effective practices should have access to the switch area. Switches should be lockable. Consideration should be given to the time required for HID luminaires to reach adequate light output level (Reference Section 6). On and off schedules should be set such that minimum illumination requirements are met at all times.

8.2.3 Operation/Visual Search

With the lighting fixtures on and properly maintained, the observer is able to complete his visual tasks. There are several standard techniques used in the visual search task which include: (1) fixating one's vision on predetermined locations in a set pattern over the observation area, (2) random visual search over the observation areas, and (3) a combination of both. The observer should use a technique that will avoid eye fatigue. The assumed physiological and psychological characteristics of the observer are that they be healthy, alert, without visual impairments, highly motivated and possess a positive attitude toward the visual task (Reference No. 1).

Observers can be used in a fixed location to insure constant surveillance over a particular area or they can be on patrol to perform random observations of particular areas. The higher the risk of intrusion and the higher the potential danger from a successful intruder, the greater should be the observation effort.

The work of the observer at night can be repetitious and boring. If the visual task is boring and does not stimulate the security guard, the guard will fail to extend eye focus. A dark adapted observer typically focuses at a distance of about 2 m (6 feet) in front of the eyes. Physiologically, this is normal. It is called night myopia. The dark adapted observer will possess a higher sensitivity for peripheral vision and therefore will possess an extended range of observation area (Reference No. 5).

For visual search, it has been experimentally found that if the visual field is reasonably free from glare sources, the peripheral and general visual alertness of the dark adapted observer is greater without the use of a directable searchlight. The use of the searchlight raises the adaptation level of the observer which conditions the observer to the higher luminance of the beam and prevents seeing low contrast objects outside the beam. The peripheral vision of the observer is far more acute when dark adapted than when light adapted (Reference No. 5). The general approach to night visual search would therefore be to observe without searchlight aid until there exists reason to investigate an area with use of more illumination.

As shown in Figures 6 and 7 in Section 4.6 and 4.7, to perform a good visual search for targets which include still targets, the person should patrol within 80 m (260 feet) of areas included for casual patrols and within 15 m (50 feet) during assessment patrols to assure good search coverage. The time of search is also important, particularly in areas with low level illumination. Typically normal or casual patrols should spend 20 to 25 seconds observing each "scene" before continuing on to the next observation point. When an alarm assessment patrol is being performed, a search of a minute or more will be required for an effective search of each "scene."

Training, motivation and fatigue are some factors that effect the visual performance of an observer in the performance of duties (Reference No. 28). The degree of training can, of course, be determined by facility policies and the attentiveness of those who are responsible for the security of the site. The motivation of an individual cannot be estimated at a particular point in time, but steps may be taken to choose an individual for the observer position who will be generally motivated. This can be accomplished, as an example, in the hiring process. Fatigue also has the potential to be controlled. When a high standard of security lighting is used, the observer is less likely to experience extremes in luminance, glare or other eye fatigue circumstances.

8.3 Security Lighting Contingencies

U.S. Nuclear Regulatory Commission Regulatory Guide 5.55, March 1978, "Standard Form and Content of Safeguards Contingency Plans for Fuel Cycle Facilities" covers events which may require security lighting considerations. These events include acts of adversaries of all types, "Acts of God" (weather, etc.) or other incidents and accidents. Lighting is a very important aspect of contending with situations such as these during nighttime operating hours. (Reg.Guide 5.54 covers power plants.)

For contingency assessment and management the following are recommended:

- Each guard should have available a portable flashlight or lantern as described in Section 6.6.2.
- Each vehicle should have available a search/spot light as described in Section 6.6.3.
- Each fixed post (gate/mobile/observation) should have a searchlight/spotlight. A flashlight or lantern for each guard should be available at the post.
- Guards should know where all light switches are located and the switches should be properly labeled.
- Guards should know where all emergency light sources are located, have access to them and know how to operate them.
- All facilities/buildings should have emergency lighting in accordance with State, Federal and NRC requirements.
- Isolation Zones, Protected Areas, Vital Areas and Material Access Areas should be provided with security lighting systems having backup power supplies as noted in Sections 4 and 7.

- Each site should have a portable floodlight system which is self-sustaining for 12 hours of operation (truck or trailer mounted typically).

- Each site should have emergency flares or strobe beacons available.

- Each site should have an inventory of lighting equipment available from other sources such as rental agencies, mutual use agreements, power and utility companies, etc. which can be drawn upon short term as well as extended basis. These items should include floodlight systems, self-sustaining portable floodlight systems and emergency generator sets.

8.3.1 Adversary Contingencies

Adversary contingencies include events such as an attack threat, bomb threat, civil disturbance, attempted or accomplished intrusion, evidence of an intrusion or suspect intrusion, intrusion alarm annunication, or suspicious personnel observation. In most of these cases, it is essential to dispatch a patrol toinvestigate or control the situation or assess the situation with other remote visual means such as CCTV or direct observation from a fixed post.

For lighting, adversary related contingencies should be assessed and illuminated as noted below:

- Patrols with flashlights or vehicle spotlights should be dispatched to assess the contingency or the assessment should be accomplished by CCTV or direct observation from fixed post if the contingency is within the visual range of observation.

- Patrols should travel in the least lighted areas and use their flashlights, vehicle lights and spot/searchlights as little as possible to minimize highlighting themselves as targets and to remain as dark adapted as possible.

- If a group of demonstrators collect at any point along the protected area perimeter, portable floodlights may be moved to the area to enhance observation capability or photographic capability.

- If pickets are established because of labor relations problems, portable floodlights in the area of picketing can minimize hazards and potential destruction and harassment.

- If hazards are found to exist such as downed power lines, ruts, obstructions, etc., flares, blinking caution lights or floodlights should be installed to mark or illuminate the hazard.

- If there is any interruption in security lighting continuity, patrols should be dispatched to perform a check of the material access areas, vital areas, protected areas and protected area fence/barrier to assure security. Although no adversary action may have occurred, it is necessary to assume that it may have until properly assessed.

- If contingency situations have the appearance of persisting or if there are additional lighting needs, lighting equipment from alternate sources should be brought in.

8.3.2 Acts of God Contingencies

Contingencies resulting from Acts of God would include damage resulting from floods, storms, earthquakes or reduced security capability due to vision limitation resulting from snow, rain, fog or dust. Backup power systems provide power for protection when the primary or off-site power source is interrupted. However, there may be some situations where no primary power supply is available for the basic security lighting circuits or the lighting circuits may be damaged. In these types of situations, some of the following actions may be appropriate.

- Dispatch the portable security lighting equipment to the points of greatest need. This may be a site of dire emergency or the main gate/portal.

- Utilize vehicle lighting systems at points of greatest need. Vehicles can illuminate emergency areas, gates or fence line. A vehicle and guard positioned in a corner of the fence/isolation zone can illuminate a significant length of fence with headlights in one direction and with a spotlight in another direction.

- Increase patrols and establish temporary post as required. This is also appropriate when visibility is limited by rain, snow or dust.

- If the need for lighting persists, equipment should be brought in from alternate sources.

- Include the above appropriate actions in the site security and contingency plan, guard orders and guard training.

8.3.3 Fire and Incident Contingency Lighting

When fires or other incidents occur during nighttime adequate lighting is most essential.

- Portable self-sustaining floodlight systems are most valuable at incident sites.
- Vehicles may be used effectively to provide incident site auxiliary lighting.
- If the need for lighting persists, equipment can be called in from the alternate sources.
- Fire and incident planning and training should address lighting use and availability.

9. MAINTENANCE AND TESTING

9.1 General

Security lighting systems require maintenance and testing to assure contingency readiness and day-to-day performance to specification. Scheduled preventive maintenance and testing is as important as breakdown or repair type maintenance. A complete maintenance program would include poles or standards, mast arms and hangers, lamp-housings and fixtures, wiring and controls, ballast, lamps, power supplies (backup/emergency) and application areas.

Factors which directly effect the general lighting level available at any point in time include:

- Luminaire Dirt Depreciation (LDD)--Light performance degraded by dirty lamp, lenses or reflectors.
- Lamp Lumen Depreciation (LLD)--Light output reduction resulting from normal in-service aging.
- Equipment Factors--Light output variables based on low voltage, or accumulation of various component performance tolerances.
- External Factors--Lighting output performance degrading resulting from weather conditions, vegetation growth, reflective background changes (paint peeling) or other indirect factors.
- Alignment and Leveling--Misalignment due to wind loads, damage or erosion.
- System Failure--Lighting system component failure or breakdown.

Considerations which assure continued operation and maximum economic service life of lighting equipment include:

- Mechanical Inspection--Inspection and protection of mechanical components.
- Electrical Inspection--Inspection and protection of electrical components.

9.2 Maintenance Scheduling

Security lighting maintenance will be normally scheduled as a result of routine and casual observations, a preventive maintenance and inspection specific schedule or as a result of a major lighting system breakdown. The quality and type of equipment, the service requirements and exposure will influence the frequency of maintenance. In all cases the manufacturer's recommendations should be followed at a minimum.

9.2.1 Routine and Casual Observations

Routine and casual observations are the responsibility of all of the site's employees as well as the maintenance and security organizations. Deficiencies noted in the security lighting system by any employee should be brought to the attention of the security organization to provide for timely review and correction. Maintenance personnel are normally observant of not only what they may be servicing but also peripheral equipment and should report any security lighting system deficiencies.

Since guards, regularly or at random, patrol areas which utilize security lighting, it is appropriate for their orders to include observation of the security lighting systems. Any deficiencies should be called in to the designated shift security supervisor for immediate action or follow-up maintenance as appropriate. The guard's daily log should record the observation.

9.2.2 Repair or Breakdown Maintenance Scheduling

Major breakdowns in security lighting systems may require immediate correction which may or may not require application of premium guard or maintenance personnel services. All repairs should be of a quality at least equal to National Electrical Code requirements.

9.2.3 Preventive and Scheduled Maintenance

Preventive and scheduled maintenance programs are required to assure the most economical operation of specified security lighting systems. Predetermined schedules, procedures and good records are essential to preventive maintenance programs. Schedules and procedures can be derived from the manufacturer of the lighting equipment.

Some components of the security lighting system may require periodic inspection. Othersmay not require attention until output becomes marginal as determined by testing for example. The following describes some of the recommended activities.

9.2.3.1 Cleaning

The accumulation of dirt or other particulate material on lamps, lenses and reflectors will vary depending upon the type of fixture and its locale with respect to dirt roads and agricultural or industrial activity. Besides attenuating the light output, excessive accumulation can cause abnormal heating resulting in failure of components or cracking of glass.

The frequency of cleaning various types of fixtures can be established as a somewhat arbitrary level until experience or surveys determine the actual expected loss of lighting relative to time. The schedule might also be influenced by the frequency of relamping (lamp replacement). Cleaning during normal relamping may be adequate. The effect of cleaning is illustrated in Figure 83. The American Association of State Highway Transportation Officials (Reference No. 29) recommends that luminaires other than those with mercury vapor lamps may be cleaned each time they are relamped at a minimum and mercury vapor luminaires be cleaned at midlife and relamping time. Unusually dirty environments or non-sealed luminaires will require more frequent cleaning. Luminaire dirt depreciation for sealed and filtered fixtures is estimated at 95 percent and 80 percent for unfiltered units between relamping.

Most modern fixture lenses can be removed with relatively simple clamps. When this is the case, the lens can be taken down for safer and more convenient cleaning. If a spare is available, a clean unit can be installed at the same time without an extra trip up the pole (if this is required).

Cleaning of lenses and reflectors should be in accordance with the manufacturer's recommendations. Generally, the unit can be immersed in a container of detergent solution with scrubbing accomplished with a soft sponge or brush. A large "plastic" trash can may work well and minimize potential damage to the glass components. Simply wiping out the lens and reflector with a soft cloth or brush may suffice in many cases.

Strong chemicals, acids or alkaline solutions should not be used on aluminum reflectors. Gritty cloths, steel wool, or abrasive cleaning powders should not be used on glass lenses or reflectors since permanent hazing and transmission or reflective degradation may result.

When fixtures cannot be removed, a glass cleaning agent which does not require rinsing and a soft cloth may be used to clean the fixture in place (or simply a soft cloth or brush).

9.2.3.2 Relamping

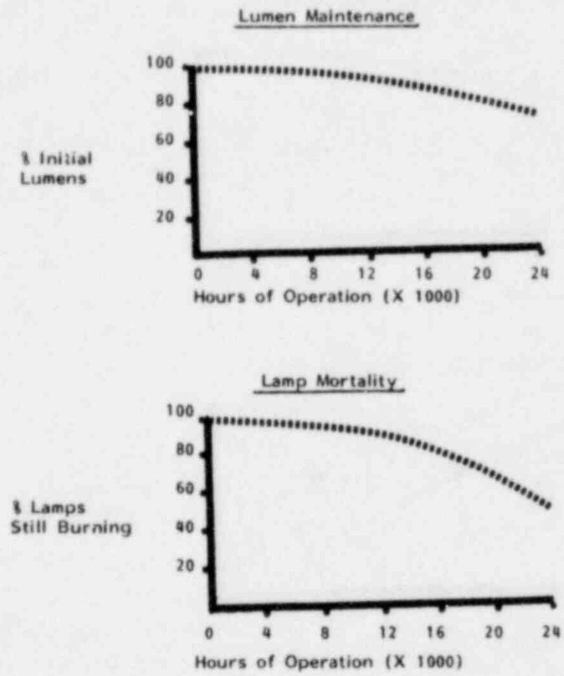
A relamping program should be developed for the site's specific security lighting system. The selected strategy will depend upon the type of lighting utilized, how it is applied, access to maintenance equipment or services and other unique installation or cost factors. Relamping may result from measured lamp output, lamp failure, or a schedule which anticipates the economic breakeven for replacement. In all cases, burned out lamps in high intensity discharge luminaires should be replaced as soon as possible. High pressure sodium lamps should be replaced to avoid possible damage to the ballast starting aid.

Manufacturers of lamps usually provide performance information relative to lamp lumen depreciation or lumen maintenance as shown in Figure 82. This is normally the average for a specific sample of lamps and individual lamps may vary somewhat. They also provide a lamp mortality curve or rated average life. The rated life is an indication of the life of 50 percent of the lamps, as shown in Figure 82. Obviously many of the lamps do not reach the rated average life.

Relamping must also consider the effects of cleaning if dirt and lumen depreciation are both allowed to accumulate. The lamp output will reach an unacceptable level very quickly (after for example 14,000 hours) as illustrated in Figure 83. Two cleanings will allow the lamp to reach its rated average life.

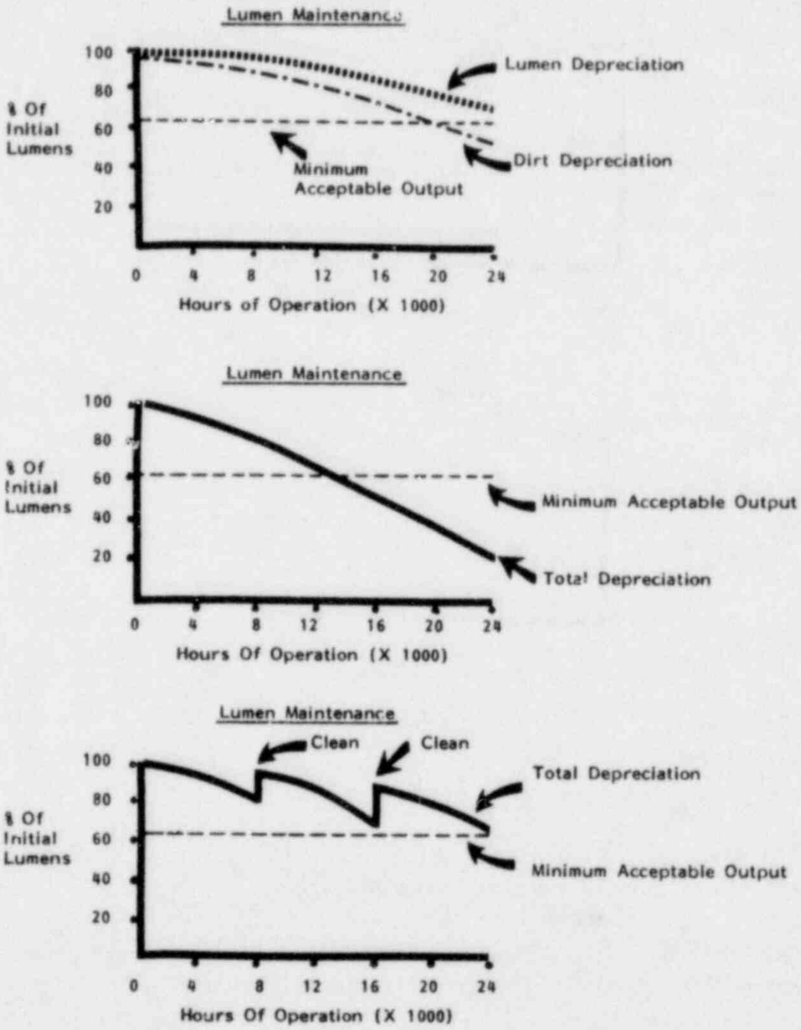
Relamping strategies include spot replacement and group replacement. Spot replacement would occur when the lamp fails or when by testing the area lamp it is determined to have a lumen output which is below the minimum acceptable level and cleaning is not an adequate corrective measure. Group replacement strategies are those in which all of the lamps in a specified area are replaced at one time at regular intervals. Group replacement can significantly reduce the number of failures between replacements. Group replacement would permit a more consistent level of illumination and thereby minimize consumption by eliminating some overspecification to compensate for deterioration but would require more lamps for replacement and more replacement labor. Without testing and a group replacement program, it is possible for incandescent and some high intensity discharge lamps to operate at a level far below their rated output and far beyond their rated average life. (Reference No. 29)

Far more important from a security standpoint is to minimize holes in the security lighting system due to failed lamps. The American Standard Practice for Protective Lighting (Reference No. 3) recommends that lamps should be group replaced at 70-80 percent of normal rated life which should reduce the number of random replacements



TYPICAL HPS LAMP MORTALITY AND
LUMEN MAINTENANCE CURVES

Figure 82



LUMEN AND DIRT DEPRECIATION

Figure 83

between group replacements to about 15 percent of the total installation.

The American Association of State Highway and Transportation Officials Maintenance Manual (Reference No. 29) recommends that fluorescent and halide lamps in a group replacement program should be replaced every two years; sodium vapor lamps every two and one-half to three years; and mercury vapor every five years (based on 24,000 hour rated lamps). AASHTO further recommends other types of lamps to be replaced at 90 percent of their average rated life. For security lighting purposes the AASHTO recommendations would be considered a minimum requirement. FM-19-30 (Reference No. 30) recommends group replacement schedules based on 80 percent of the lamps rated life. It is also noted that functional lamps removed from security lighting circuits can be used in less sensitive locations.

For security lighting purposes at the isolation zone, portals to the protected area, and material access and vital areas where the loss of one lamp could significantly degrade the security lighting, it is recommended that a program be established to replace lamps at 80 to 90 percent of their rated life. In other areas where multiples of lamps/luminaires are available and loss of a single lamp does not significantly reduce the illumination level, a relamping program which is economically justified should be utilized by the licensee.

9.2.3.3 Mechanical Inspection

At the same time lamps are replaced or cleaned or on an established separate schedule, the luminaire should be inspected for mechanical problems. This inspection should include:

- Gaskets--Missing, worn or broken gaskets should be replaced or repaired to minimize cleanliness and moisture problems.
- Hardware-- Fasteners, springs, clips, screws and bolts should be inspected to assure operability. Assure mountings are tight and secure.
- Insulators--Broken, cracked or otherwise deteriorated insulators should be replaced or repaired.
- Glass--All glass and transparent enclosures should be checked for cracks, discoloration or deformation (primarily plastic components).
- Electrical--Check sockets, receptacles and wiring. Check for loose connections, damaged insulation, corroded terminals and cracked sockets or receptacles.

- Poles and Brackets--Check paint or coating for indications of rust, corrosion or rot as appropriate. Clean, prime, repaint as appropriate.

- Periodically an aiming guide should be utilized to assure proper fixture alignment. This quite often is a major problem in maintaining lighting uniformity and levels in specified areas.

9.2.3.4 Circuits and Controls

Circuits and controls should be maintained in accordance with manufacturer's recommendations at a minimum.

- Constant Current Transformers--Clean, adjust and check mechanical operation. Check oil for moisture and sludge and replace oil if required. The inspection should be accomplished annually.
- Relays--Annually check contacts for excessive corrosion or burning. Burnish contacts if required. Check and clean the magnets and assure magnets lack of excessive noise.
- Oil and Other Switches--Check leads for corrosion and tightness. Check gaskets and inspect parts for cracks. Check oil level and dielectric strength. Filter oil or replace as required for oil switches. These inspections should be accomplished annually.
- Photoelectric Controls and Time Clocks--Annually check time clocks, terminals and contacts. Clean or burnish as required. Clean the photoelectric control "windows" semiannually and recalibrate. Experience with certain units and areas may indicate that annual servicing of the photoelectric controls is adequate.
- Power Circuits--Underground power circuits should have a megohm test annually to assure there is no leakage, shorting and deteriorating condition.

9.2.3.5 Backup Power Supplies

Backup power supplies both battery and generator based should be maintained in accordance with the manufacturer's specifications. Maintenance procedures should be prepared and included in the site's maintenance system. Refer to Regulatory Guides listed in Section 6.5.4, Backup Power Sources.

- Internal Combustion Engine Driven Generators--Basic checks of coolant, oil, fuel, heaters, lubrication and starting power source (batteries) should be made during normal test operation (See Section 9.3). Other maintenance relative to coolant, filters or oil changes, etc. should be accomplished in accordance with manufacturer's specifications.

- Battery and Uninterruptable Power Supplies should be checked during testing operations (See Section 9.3). Normally they will be inspected for charge level, electrolyte level and potential corrosion problems. Maintenance should be in accordance with manufacturer's recommendations.

- Switch Gear should be inspected during each test exercise (see Section 9.3) and in accordance with the manufacturer's recommendations.

9.2.3.6 Maintenance of Lighted Zones

Maintenance of the lighted zone should consist of at least an annual inspection to assure that vegetation (tree limbs, weeds, etc.) are not blocking luminaires such that the protected area is not illuminated to specification. Vegetation changes, can also cause significant changes in reflectance of both horizontal and vertical surfaces. Impairments should be trimmed and removed. Additionally, an inspection should be made to assure that clear areas have not been turned into parking lots, storage areas or otherwise reassigned such that security lighting is degraded.

9 2.3.7 Maintenance Safety

In addition to standard electrical maintenance practices, the following should be considered.

- When maintaining the system, remember that the voltages to start high pressure sodium vapor lamps are in excess of 4,000 volts AC. Assure that the main power, as well as any backup power source, is turned off and locked off. Do not remove lamps with power on.

- Remember that local photocell control at the fixture or elsewhere does not assure that the total system is turned off. The photocell switch should not be relied upon as shut off.

- Mercury vapor lamps contain mercury. A disposal program keeping this in mind is recommended to eliminate environmental or health hazards. High pressure sodium, fluorescent and metal halide lamps also contain small quantities of mercury.

- Sodium lamps contain small quantities of sodium which develop heat when in contact with moisture. As a result some lamps are provided with disposal instructions. These instructions typically require breaking the lamps, no more than 20 at a time, in a steel bucket or container. The container is then filled with water from a rubber hose with the operator at a safe distance. After soaking for a few minutes the sodium is rendered harmless. (Reference No. 25)

9.3 Testing

9.3.1 Testing Illumination Levels

Most luminaires commonly used for security lighting, including high intensity discharge lamps, do not deteriorate in lumen output rapidly. Fixture design and environmental consideration such as dust varies from site to site. Except in perhaps the most severe conditions, it would not be anticipated that lumen depreciation would be more than 25 percent per year. It is therefore recommended that the light levels in the protected lighting areas be tested at least once each year at a minimum and more frequently if lighting levels are very marginal or the combined dirt and lumen depreciation is particularly high. In areas with vegetation or other unusual problems, certain aspects of testing and inspection may be more frequent.

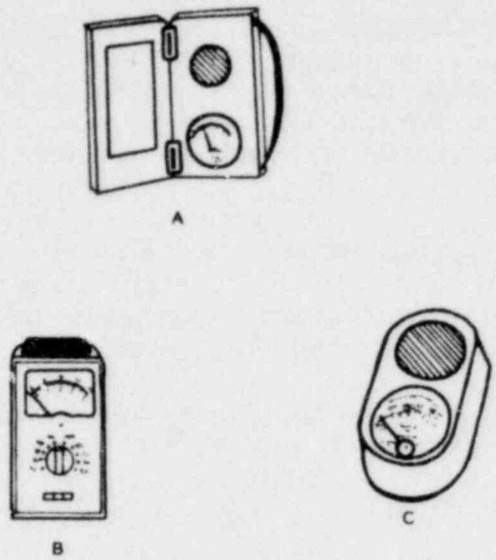
9.3.2 Testing Procedure

The overall inspection program should consider instrumentation used, metnods of measurement, location of measurements and records of measurement.

9.3.2.1 Illumination Testing Instruments

Portable instruments for photometric measurements are available which were developed primarily for roadway illumination evaluation. Since security lighting requires measurement to levels as low as 2.15 lux (.2 footcandles) the choice is somewhat limited. A meter with a range of 2.15 to 54 lux (.02 to 5 footcandles) would be appropriate for most exterior security lighting measurements. This can be augmented with a low cost meter for illumination levels above 54 lux (5 footcandles).

Figure 84 illustrates several illumination test instruments which can be used for testing. Item (A) is a Weston Model 615 broadrange light meter. It has scales of 0-1.2, 3, 12, 30, 120 and 300. Color and cosine filters are included. The unit costs approximately $450 to $500. Many other light meters are available which cost from $50 to $200. However, they may not include color correction or cosine correction and may not have scales which are effective in the range of a few lux (fractions of a footcandle). Figure 85"B" and"C" illustrate typical lower cost units which may be sensitive enough for low light level testing above 21.5-54 lux (2-5 footcandles).



ILLUMINATION LEVEL TEST INSTRUMENTS

Figure 84

The color correction filters filter the light and correct it to match the sensitivity of the human eye. When working with high intensity discharge luminaires in particular, it is important to recognize that the color of the light varies significantly between lamps. Therefore it may be necessary to have a special filter for each type of lamp if the lighting levels are to be critically tested for licensee performance. Another option is to have the instrument which has a common color correction filter calibrated for each type of lamp. In this case the correction factor would be applied to the direct instrument reading. Still another option is for the licensee to provide illumination with a significant safety factor of 50-100 percent to assure minimal problems in any case.

Since the light at some measurement locations will be from relatively large angles of incidence, the meter should be of a cosine corrected type and the light sensing device leveled accurately before each reading.

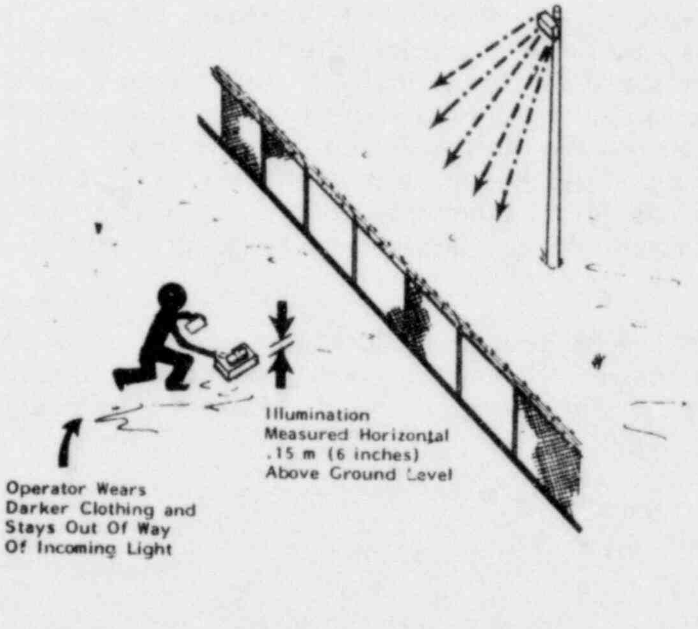
9.3.2.2 Method of Measurement

Illumination measurements should be horizontal and taken .15 meters (6 inches) above the ground. The reading should be color corrected and angle of light incidence corrected if not already compensated by the instrumentation.

The person taking the measurement should be sure that his or her body and clothing does not influence the meter reading by reflecting or interferring with the light source/sources. The use of darker colored clothing would be appropriate. (Reference Figure 85).

Testing in the proximity of buildings and other facilities should be accomplished in a manner which will not block reflected light from the building. This is because reflected light from fixed facilities is an actual or preplanned part of the available illumination.

Fences will exert some shadow effect especially if luminaires are mounted at low levels or have extensive set back. Testing in this area (fence shadow) should be accomplished in a manner which does not put the test device in the shadow of a fence post or small sign.



ILLUMINATION LEVEL MEASUREMENT

Figure 85

Points within the areas to be tested should be predetermined and noted on a site map. Records of the readings may be useful to help ascertain cleaning or relamping schedules. Points designated for measurement can be marked with small steel or plastic stakes in the soil, nails in the pavement or other unobstrusive marking. Other points can be checked at random to test for luminaire light depreciation problems.

If the lighting system was properly designed, the uniformity of illumination should not require periodic testing (that is, the ratio of average illumination level in the area to the minimum level).

Areas which are particularly sensitive and which should be measured include points on the extreme boundary of the designated protected lighted area, corners, mid-points between luminaires and other general points in the area (Reference Figure 86).

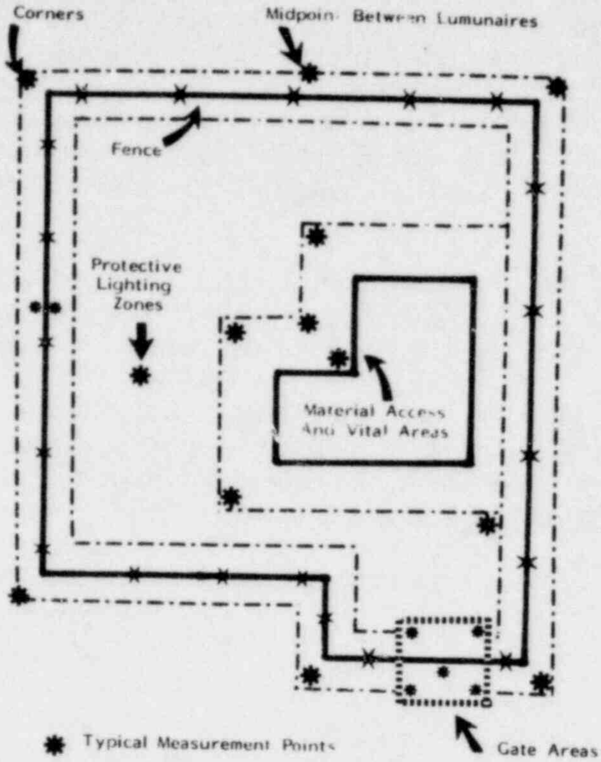
Test results which indicate the illumination level to be below the minimum requirements can be caused by a variety of factors several of which may not be a result of a deficient system. Some of these include:

- Inappropriate testing procedure
- Instrument out of calibration
- Line voltage other than rated
- Random lamp manufacture deficiencies
- Random lamp excessive depreciation
- Random ballast manufacture deficiencies
- Mis-aimed luminaires
- Height or spacing of luminaires not to specification
- Lamp replacement or cleaning required
- Luminaire damage
- Luminaire focus or reflectivity not to specification

Any apparent system deficiencies should be studied closely to determine the cause and most economical corrective measure.

9.3.2.3 Testing Support Equipment

Testing of the support equipment primarily applies to testing backup power supplies and other auxiliary lighting equipment.



ILLUMINATION TEST POINTS

Figure 86

9.3.2.3.1 Testing of Backup Power Supplies

The testing of backup power supplies or sources is covered in existing regulatory guides. The applicable guides are listed in Section 6.5.4.1.

Other applicable information may also be found in Section 6.5.4 which covers backup power in general. Generator sets used for security lighting should be tested (started) weekly and run under load at least once a month. (including a test of any switching and transfer functions). Generally, the weekly test includes running until operating temperature is reached.

9.3.2.3.2 Testing Auxiliary Lighting Equipment

Backup lighting equipment such as trailer mounted power generators, search and spot lights and other portable lighting equipment should be tested monthly. The testing should be functional and assure that the equipment operates to specification. As appropriate, the test should be on the security or maintenance organization's preventive maintenance/inspection schedule.

10. SUMMARY AND RECOMMENDATIONS

Security lighting is a requirement at nuclear fixed site facilities. As a result of a wide selection of lighting concepts and equipment, the requirements can be met in a variety of ways. Sites have different physical characteristics and may already have established security lighting. Other sites may be in the planning, design or improvement stage. This planning guide highlights application methods and considerations which will result in meeting or exceeding the NRC requirements. Comparative cost estimates for the various lighting configurations allow the security planner to select basic concepts which will provide security lighting for a specific site in the most economical manner.

As noted in several sections, due to site configuration differences, a variety of the provided concepts may be required to best utilize existing lighting or accommodate unique site features. Lighting concepts and designs for sites will ordinarily be highly customized and will require design by qualified and experienced engineering organizations or personnel.

Lighting equipment is being improved and made more efficient as a result of energy cost and availability limitations. It is important that security lighting users remain aware of new developments and take advantage of them at every opportunity.

In summary:

- At present, high and low pressure sodium lamps are the most efficient available.
- Low pressure sodium lamps do not provide light which allows color discrimination, but when properly controlled,provide better CCTV illumination as energy costs increase.
- Glare in the eyes of on-site security guards can be minimized by using floodlights at the protected area perimeter (isolation zone) with protected area lighting using poles which are as high as economically and practically possible.
- The minimum of 2.15 lux (.2 FC) horizontal required by NRC is not generally adequate to assure good detection capability. For this reason, it has been recommended that within the isolation zone, portal areas and in the proximity of vital and material access areas, the lighting level should be increased to 21.5 lux (2 FC) horizontal.
- All lighting plans should consider the present or future use of CCTV systems and related requirements.

- HID luminaires, including high and low pressure sodium, do not start instantly and do not necessarily restart (restrike) instantly. This must be taken into account where continuous illumination is required. It is recommended that lighting at portals and in material access and vital areas have instant restrike and continuous lighting capability. In the isolation zone, restrike should not require longer than approximately 10 seconds. In the protected area, in general, interruptions should not exceed 60 seconds. Generally, the NRC accepts 60 seconds restrike time for protected area and isolation zone lighting. However, the recommended restrike times will improve assessment and detection capability.

- Backup power systems or emergency power supplies should be available for security lighting at protected areas, material access areas, vital area portals, the protected area isolation zone, in the proximity of material access and vital areas, and general protected area.

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APPENDIX

Partial List of Equipment Suppliers

Emergency Power Systems and Generators

Allis Chalmers	Box 563 Harvey, Illinois 60426 312-339-3300
Caterpillar Tractor Co.	Peoria, Illinois 61629 309-578-6859
Detroit Diesel Engine Div.	Detroit, Michigan 48228
Dual Lite Inc.	P. O. Box 468 Newtown, Connecticut 06470 203-426-2585
Emerson Electric	8106 W. Florissant Avenue St. Louis, Missouri 63136 314-553-2000
Exide	101 Gibraltar Road Horsham, Pennsylvania 19044 215-674-9500
Generac Corp.	Waukesha, Wisconsin 53186
General Electric	Schenectaday, New York 12345
Homelite-Textron	14401 Carowinds Blvd. Charlotte, North Carolina 28217
Kohler	Kohler, Wisconsin 53044 414-457-4441
Obrien Machinery Co.	206 Green Street Dowington, Pennsylvania 19335 215-269-6600
Onan	1400 73rd Avenue, N.E. Minneapolis, Minnesota 55432

Teledyne	290 E. Prairie Street Crystal Lake, Illinois 60014 815-459-6100
Topaz Electronics	3855 Ruffin Road San Diego, California 92123 714-279-0831
Westinghouse Electric Corp.	Pittsburgh, Pennsylvania 15222
Winco Division Dyna Technology	Sioux City, Iowa 51102
Worthington Corp.	Harrison, New Jersey 07029

<u>Flash Blindness Devices</u>

GTE Sylvania (Distress Flash)	West Main Street Hillsboro, New Hampshire 03244 606-464-5533
Law Enforcement Associates, Inc. (Intruder Flare)	88 Holmes Street Belleville, New Jersey 07109 201-751-0001
Local Photographic Equipment Suppliers	

<u>Lighting (Lamps, Luminaires and Poles)</u>

Alco Electronic Products, Inc.	North Andover, Massachusetts 01845
Arrem Plastics, Inc.	502 Vista Avenue Addison, Illinois 60101
Benjamin Electric Manufacturing Co.	P. O. Box 180 Sparta, Tennessee 38538
Bright Star Industries	600 Getty Avenue Clifton, New Jersey 07015
Burkey Colortran	1015 Chestnut Street Burbank, California 91502

Crouse-Hinds Co.	Syracuse, New York 13221
Electro Life, Inc.	P. O. Box 396 131 N. Island Avenue Batavia, Illinois 60150
GE Lighting Systems Department	Spartanburg Highway Hendersonville, North Carolina 29739
GE Lamp Division	Nela Park Cleveland, Ohio 44112
Hubbell Lighting Division Harvey Hubbell, Inc.	Electric Way Christianburg, Virginia 24073
ITT Landmark Lighting	P. O. Box 100 Southhaven, Mississippi 38671
Johns-Manville Holophane Division	Greenwood Plaza Denver, Colorado 80217
Joslyn	4000 E. 116th Street Cleveland, Ohio 44105
Justrite Mfg. Co.	2061 Southport Avenue Chicago, Illinois 60614
Killark Electric Mfg., Co.	P. O. Box 5325 St. Louis, Missouri 63114
Lesair, Inc.	8859 Balboa Avenue Suite C P. O. Box 23053 San Diego, California 92123
Lightron of Cornwall	195 Hudson Street Cornwall-on-Judson, New York 12520
Logitek, Inc.	40 Dentral Avenue Farmingdale, New York 11735
Lustra Lighting Corp.	180 Getty Avenue Clifton, New Jersey 07013
Luxor	Empire State Building 350 Fifth Avenue New York, New York 10001

Moldcast Lighting	Interstate 80 at Maple Avenue Pine Brook, New Jersey 07058
Optronics, Inc.	350 N. Wheeler St. Ft. Gibson, Oklahoma 74434
Perfect-Line Mfg. Co.	80 East Gates Lindenhurst, New York 11757
Permavolt, Inc.	P.O. Box 2582 1901 South Lafayette Blvd. South Bend, Indiana 46613
Power-Lite Industries, Inc.	Lindenhurst, New York
Quality Outdoor Lighting	3535 Commercial Avenue North Brook, Illinois 60062
Siltron Illumination, Inc.	1960 W. 139th St. Gardena, California 90249
Spectronics Corp. BLE Division	29 New York Avenue Westbury, New York 11590
Sterner Lighting Systems	Winsted, Minnesota 55395
Streamlight Inc.	1010 W. 8th Avenue Suite C King of Prussia, PA 19406
Sylvania Lighting Center	Danvers, Massachusetts 01923
Tork Inc.	Mount Vernon, New York 01551
Ultra-Violet Products Inc.	5100 Walnut Grove Avenue San Gabriel, California 91778
Verd-A-Ray Corp.	615 Front Street Toledo, Ohio 43605
Vicon Industries Inc.	125 East Bethpage Road Plainview, New York 11803
Voight Lighting Industries	135 Port Lee Road Leonia, New Jersey 07605

Westinghouse Electric Corp. Lamp Division	Bloomfield, New Jersey
Widelite Corp.	P. O. Box 606 San Marcos, Texas 78666

Laser Target Designator

York Arms	50 W. State Street Hurricane, Utah 84737 801-635-4867

Portable and Mobile Lighting and Power Systems

Alliance Electric Products Co.	6272 W. North Avenue Chicago, Illinois 60639 312-626-8454
American Construction Equipment Company	Los Angeles, California 90016
Appleton Electric Co.	1701 Wellington Avenue Chicago, Illinois 60657 312-327-7200
Carpenter Lighting Products	Charlottesville, Virginia 22901
Cregier Electric Mfg. Co.	New Orleans, Louisiana 70130
Emergency Lighting Systems Inc.	Hingham, Massachusetts 02043
Kato Engineering Co.	1415 First Avenue North Mankato, Minnesota 56001 507-625-4011
Koehler Mfg. Company	Marlboro, Massachusetts 01752
Lincoln Electric Co.	22810 St. Clair Avenue Cleveland, Ohio 44117 216-481-8100
Majol Portable Power Systems	Nanuet, New York 19054
McCulloch Mite-E-Lite	Wellsville, New York 14895

Speciality Lighting Co.	926 Arlee Place Anaheim, California 92805 714-778-1840
Sun Electric Corp.	Chicago, Illinois 60631

Searchlights

Brass Products	Marblehead, Massachusetts 01945
Carlisle & Finch Co. (Complete Line of Searchlights)	4562 W. Mitchell Avenue Cincinnati, Ohio 45232 513-681-6080
Crouse-Hinds Co.	Syracuse, New York 13201
Gulf & Western Mfg.	23100 Providence Drive Southfield, Michigan 48037 313-424-4313
Rowe Co., Inc.	66 Holton St. Woburn, Massachusetts 01801 617-729-7860
Spectrolab	12500 Gladstone Avenue Sylmar, California 91342 213-365-4611
Teledyne	290 East Prairie Street Crystal Lake, Illinois 60014 815-459-6100
Varian Associates	611 Hansen Way Palo Alto, California 94303 415-591-1627
Local Automotive and Industrial Equipment Suppliers	

Unitized Emergency Lights

Chloride Systems	Mallard Lane North Haven, Connecticut 06473 203-624-7837

Direct Safety Co.	511 Osage Kansas City, Kansas 66110 800-255-4416
Dual Lite Inc.	Newtown, Connecticut 06470 203-426-2585
Elan Industries, Inc.	1024 Shary Circle Concord, Connecticut 94518 415-671-7260
GTE Sylvania	21 Penn Street Fall River, Massachusetts 02724 617-678-3911
Sentry-Lite	P. O. Box 199 Rockville Center, New York 11570 516-678-2272
Teledyne	290 East Prairie Street Crystal Lake, Illinois 60014 815-459-6100

Infrared Scopes, Lights and Devices

Eastman Kodak Company	Kodak Apparatus Division Special Products Sales 901 Elmgrove Road Rochester, New York 14650 716-726-3579
Edmund Scientific	1887 Edscorp Building Barrington, New Jersey 08007 609-547-3488
F.S.W. Industries	215 East Prospect Avenue Mount Prospect, Illinois 60056 312-259-8100
Hughes Aircraft Company	P. O. Box 92927 Los Angeles, California 90009 213-534-2121
Law Enforcement Associates Inc.	88 Holmes Street P. O. Box 128 Belleville, New Jersey 07109 201-751-0001

Spectrolab	12500 Gladstone Avenue Sylmar, California 91342 213-365-4611
Xedar Corporation	2500 Central Avenue Boulder, Colorado 80301 303-443-6441
Local Industrial Equipment Suppliers	

NOTE: The above lists are not meant to exclude other manufacturers or suppliers but are provided as typical sources of information and hardware.

GLOSSARY

ADAPTATION - The process by which the eye adapts itself to changes in light.

BALLASTS - A circuit element used to produce the starting voltage and to limit the electric current in electric discharge lamps.

BRIGHTNESS - The characteristic of light that gives the visual sensation of more or less light. Also known as luminance.

CANDELA - The unit of luminous intensity.

CANDELA PER METER SQUARED (Cd/m^2) - SI equivalent of footlambert. Is equal to 3.426 footlamberts.

CANDLEPOWER - The luminous intensity expressed in candelas.

CHEMILUMINESCENCE - The emission of light as a result of chemical reaction.

CONTRAST SENSITIVITY - The ability to detect the presence of a contrast border.

CREST FACTOR - The ratio of the maximum lamp current to root-mean-square current.

DISABILITY VEILING BRIGHTNESS (DVB) - A method used to determine the veiling glare effect of lighting systems.

EFFICACY - The ratio of the total luminous flux (lumens) to the total power input (watts).

Ev - The vertical footcandles at the eye.

FLASH BLINDNESS - The disabling effect of the eye's ability to see due to a short exposure of a much higher intensity light.

FOOTCANDLE - A unit of illuminance on a surface that is everywhere one foot from a uniform point source of light of one candle and equal to one lumen per square foot.

FOOTLAMBERT - The English unit of luminance (brightness). The uniform luminance of a perfectly diffusing surface emitting or reflecting light at the rate of one lumen per square foot. It is equal to $1/\pi$ candela per square foot.

GLARE - A brightness within a visual field which causes discomfort or vision impairment.

HETEROCHROMATIC - Light of different color or wavelengths.

HIGH INTENSITY DISCHARGE (HID) - Lamps which operate by passage of electric current through a gas or vapor (such as mercury vapor, metal halide, high pressure sodium or low pressure sodium).

HORIZONTAL FOOTCANDLES - Illumination measured on the horizontal plane. Normally measured .15 m (6 in.) above the ground.

ILLUMINANCE - Luminous flux or light per a given area from a given point in a given direction.

INCANDESCENT - Light produced by a filament heated by current flow.

IRRADIANCE - The density of radiant flux on a given surface.

LAMP DIRT DEPRECIATION (LDD) - Lumen output decreases due to dirt accumulation on lamps and lenses.

LAMP LUMEN DEPRECIATION (LLD) - Change in lumen output of a lamp during its lifetime.

LIGHT - Visually observed radiant energy.

LUMEN - Luminous flux equal to one candle .

LUMINAIRE - The lighting fixture including lamp, reflector, mounting and electrical socket and wiring.

LUX - A unit of illuminance on a surface that is everywhere one meter from a uniform point source of light of one candle and equal to one lumen per square meter.

MATERIAL ACCESS AREA - Areas in which strategic quantities of special nuclear material are located.

MONOCHROMATIC - Light of a single wavelength or color.

PHOTOTROPIC - Tendency for the eye to direct itself to the brightest object or area.

PORTALS - Gate or access areas into material access areas, vital areas or protected areas.

POWER FACTOR - The ratio of active power to the product of volts and amperes. A measure of power use efficiency.

PROTECTED AREA - The area inclusive of vital and material access areas requiring controlled access.

REFLECTANCE - The ratio of light (flux) reflected by a surface to the incident light.

REFLECTORS - Devices used to reflect or direct light

SECURITY LIGHTING - Lighting utilized for security purposes as required by 10CFR Part 73.

STROBOSCOPIC - Pulsed light. Light which varies in output such as a blinking light. Undulating or oscillating light.

UNIFORMITY - The uniformity of brightness of areas within the visual field. Maximum to minimum ratio is the ratio of the maximum brightness to the minimum brightness in the visual or measured field. Average to minimum ratio is the average brightness to minimum brightness in the visual or measured field.

VERTICAL FOOTCANDLES - Illumination measured on the vertical plane.

VISUAL ACUITY - The ability to define details

VITAL AREAS - Areas which contain vital equipment.

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This document has been prepared as an aid in planning security lighting at nuclear fixed site facilities. While the recommendations enclosed cover the minimum requirements established in Title 10, Code of Federal Regulations (CFR), Part 73, additional suggestions are made for further enhancing a facility's security lighting and related security capabilities. Planning considerations and information are provided for lighting of the isolation zones, protected areas, portals, vital areas and material access areas. Recommendations are made relative to indoor, outdoor, fixed, portable and other unique applications of security lighting.

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