Security lighting: what we know and what we don't

Considerations for the designer when approaching a security lighting project

by Peter R. Boyce

A well-designed security lighting system should accomplish one or more of such a system's three essential main purposes:

1). To deter the intruder — the "don't even think about it" message;

2). To help the law-abiding recognize dangerous situations and make an appropriate response — the "something nasty this way comes" message;

3). To help law enforcement personnel, should both deterrence and response fail — the "this is what they looked like" message.

Deterrence

Obviously, there is considerable overlap between these messages. If the criminal believes he or she can be easily seen at a distance and the victim is likely to be prepared, the perpetrator may be deterred. Deterrence is probably influenced by:

1). The brightness of the neighbourhood;

2). The uniformity of the brightness of the area illuminated; and

3). The extent to which anything can be seen beyond the range of the area lit by the security lighting.

Brightness is important because it affects how well the criminal can see and hence how exposed he feels. The uniformity of brightness is important because non-uniform lighting may create dark areas where a criminal can lie in wait. The ability to see beyond the range of the lighting is important because it controls the extent to which the criminal can be sure anybody is watching.

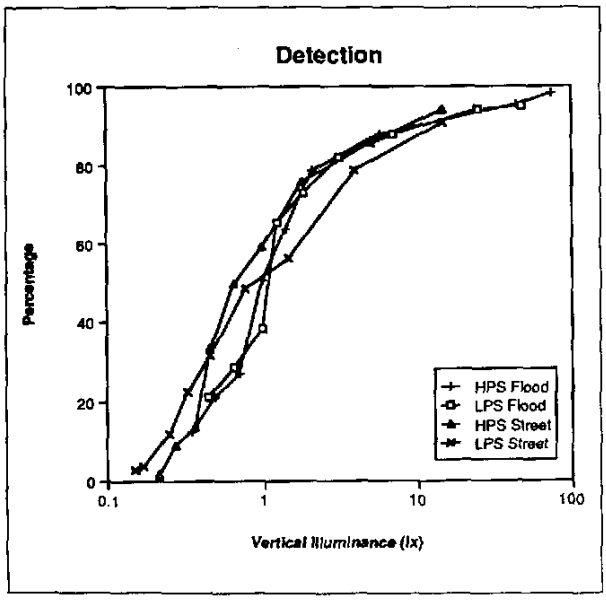

Figure 1: Percentage of guards detecting an intruder, wearing dark clothing and moving over an open field in a manner so as to avoid detection, plotted against the vertical illuminance produced by four different lighting installations (after Boyce and Rea, 1990).

Security lighting can help the law-abiding and law enforcement personnel in two ways. First, security lighting enhances a person's ability to detect potential offenders. Second, security lighting enables a witness to describe the offender.

The brightness and uniformity of the lighting are important because they affect a person's ability to detect and recognize other people. The absence of glare is important because glare reduces a person's ability to detect others around him. Light source colour is important because it can affect the accuracy with which a witness can describe an offender and his equipment.

Specific applications

So far we have looked at what constitutes good security lighting in a general and qualitative way. In order to be more specific and quantitative, it is necessary to discuss particular applications. Two applications we will consider are the lighting of a perimeter fence of a secure area such as a correctional facility, and the lighting of public areas such as around residence halls of a university or college.

The security requirements and the likely criminal activities are very different for these two applications. For the correctional facility, the purpose of the security lighting of the outer fence is to help the guards detect anyone — inmates or outsiders — approaching the fence. The perimeter fence is likely to be permanently guarded.

Areas around residence halls will likely always have people in them and will not be patrolled continually. The purpose of security lighting in this situation is also to enhance detection and recognition, but in this application it is detection and recognition of people moving around at night and who might be a threat.

Guarded areas

Research on security lighting can be used to address the design needs for lighting these two applications. Boyce and Rea (1990) have studied the influence of security lighting on the ability of guards to detect and recognize people moving toward a fence line. Measurements were made of the ability of guards to detect and recognize "intruders" approaching across an open field lit by one of four

different lighting installations. The four installations were made up of either high pressure sodium (HPS) discharge or low pressure sodium (LPS) discharge lamps used in either floodlighting fixtures or street lighting fixtures.

Figure 1 shows the relationship between vertical illuminance and the detection of an intruder, when he was moving over an open field attempting to avoid detection. From Figure 1, it can be seen that 90% detection is achieved at a vertical illuminance of about 10 lux, regardless of the lighting installation. This result suggests that a vertical illuminance of 10 lux is the minimum illuminance for protection of a fence line.

These data were obtained from guards who were adapted to the lighting and who had an unobstructed view of the protected area. Guards who observe the protected area from a brightly lit guardhouse are likely to do relatively badly. Similarly, guards who have to look at the protected area through a fence may not be so effective at detecting intruders. Both these conditions have implications for lighting practice.

If a protected area is to be guarded from a security tower or gatehouse, minimal lighting inside the gatehouse at night is essential. Such minimal lighting allows the guards to become fully adapted to the lighting of the protected area. Further, as an aid to deterrence, minimal lighting will make it difficult for any intruder to know where the guard is and/or if anyone is watching.

If the guard is patrolling a perimeter fence and needs to see through the fence, the brightness of the fence is important. Boyce (1979) showed that when the brightness of the fence is greater than the brightness of the area on the other side of the fence, the ability to detect potential intruders is reduced.

The simplest way to reduce the fence brightness is to use low reflectance fencing, typically a plastic-coated fence rather than galvanized wire mesh. If this is not possible, then extra care in the selection and placement of the security lighting fixtures is essential so that the illuminance on the fence itself is limited. Figure 2 shows a good example of security lighting for an industrial storage yard in which the fence does not mask the view of the yard.

Unguarded areas

The lighting around a residence hall at a university, unlike the correctional facility, must allow people to move around at night. Therefore, the problem for the designer of the security lighting is to enable people present in the area, or overlooking the area from adjacent buildings, to detect the presence of others and recognize their intentions and actions at a distance. Being able to detect the presence of others allows the possibility of "fight or flight" and, if the worst happens, enables the victim to provide an accurate description of the offender.

Figure 3 shows the effect of vertical illuminance on the ability to recognize correctly someone walking toward you in an area lit by street lighting (Boyce and Rea, 1990). For this type of installation, a vertical illuminance of about 10 lux is sufficient to obtain a probability of correct recognition of around 90%.

Rombauts et. al. (1989) studied face recognition at various positions relative to a street lighting fixture. They showed that face recognition is not possible beyond 17 meters because of the size of detail involved. Hall (1966) claims that the minimum distance at which face recognition is required is four meters. This distance forms the boundary between what people perceive as public and private space. Further, Hall states that at this distance people can still take evasive or defensive action. Rombauts et. al. (1989) found that the vertical illuminance required for confident identification was one lux at four meters and 33 lux at 17 m.* These data suggest that vertical illuminance in the range of 10 to 30 lux are required for confident facial identification at night, under street lighting.

As for accurate description of an assailant, a vertical illuminance which allows confident recognition

Figure 2: Security lighting for an industrial storage yard in which the fence does not mask the view of the yard.

** Rombauts et. al. actually used semi-cylindrical illuminance as a measure of the lighting conditions. However, they also found that people considered the lighting of facial features well balanced when the ratio of vertical illuminance to semi-cylindrical illuminance was in the range of 1.1 to 1.5. The vertical illuminances given above are derived from the semi-cylindrical illuminance determined by Rombauts et. al., multiplied by 1.3.*

will be adequate for accurate description. What is not at all obvious is how significant the light source colour is for accurate description. Boyce and Rea (1990) showed that there was no difference in the ability to detect and recognize intruders for high and low pressure sodium discharge lamps producing the same vertical illuminance.

However, it can be argued that an accurate description of an assailant should include colour of clothes, etc. If this is so, a low pressure sodium discharge lamp will not be adequate, but whether high pressure sodium discharge lamps have colour properties sufficient to allow clothing colour to be accurately described remains to be seen.

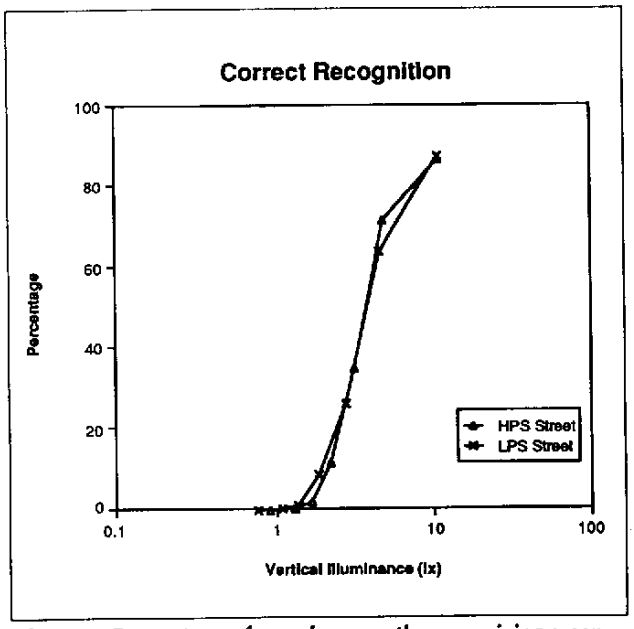

Figure 3: Percentage of guards correctly recognizing a person wearing dark clothing and walking toward them plotted against the vertical illuminance produced by two different street lighting installations (after Boyce and Rea, 1990).

Uniformity, glare

This brief description of some research on the effectiveness of security lighting leaves open several important questions. What are the minimum levels of brightness uniformity? What is the effect of glare on a person's ability to detect, recognize and describe another person? What features of lighting deter? There is no research evidence which directly resolves any of these questions, although there are some hints.

For minimum levels of uniformity, Simons et. al. (1987) recommend an average horizontal illuminance of 5 lux with a minimum of 2.5 lux. These recommendations are based on informal appraisals of street lighting from the point of view of a pedestrian and imply a high level of uniformity for the lighting.

However, in practice, the majority of problems with uniformity do not come from the light distribution per se, but rather from the presence of vegetation or obstructions in the area. If the area to be lit can be kept clear of such obstacles, providing a uniform brightness should pose little problem.

Research on the effects of glare also gives us hints rather than evidence. There is little research directly addressing glare's effects on a person's ability to detect and recognize other people at night. Rombauts et. al. (1989) and Simons et. al. (1987) both explored this question, considering the disability glare produced in typical street lighting installations.

Rombauts et. al. (1989) showed that the disability glare from the street lighting they used, required an increase in vertical illuminance from 0.5 lux to 0.8 lux at a distance of 4 m to maintain confident recognition — hardly a major effect.

Simons et. al. (1987) recommend restricting the luminous intensity of street lighting lanterns at 80 and 90 degrees from the vertical respectively. Again, this is hardly a severe restriction.

The findings of these two studies suggest that disability glare is of limited significance when conventional street lighting is used, although whether this is still the case when some form of floodlighting is used is open to question.

As for deterrence, this is basically a matter of belief. Lighting can deter crime by increasing the uncertainty in the mind of the criminal about whether he or she has been seen and by increasing the criminal's sense of exposure. Conditions which enhance the ability of a law-abiding citizen to detect, recognize, and describe other people will also be evident to the criminal and therefore can be expected to deter.

There is also some indication that light source brightness can deter. Boyce and Rea (1990) found that people playing the role of intruders felt more exposed under high pressure sodium floodlighting than under low pressure sodium lighting, even though the vertical illuminance on the intruder was consistently greater for the low pressure sodium lighting.

The suggested explanation for this feeling was that the high pressure sodium lamps were smaller and thus brighter than the low pressure sodium lamps of similar light output. This finding suggests that it might be possible to use light source size and brightness to increase the criminal's sense of exposure and thereby enhance any deterrent effect.

Differences in brightness associated with different light source colours might also be effective in this respect. Figure 4 shows a security lighting installation around some residence halls, which combines both uniform lighting for easy detection and recognition and high source brightness to increase the sense of exposure.

What is good security lighting?

So what do we really know about what constitutes good security lighting? The answer to this question can be given at three levels: quantitative, qualitative, and speculation.

Quantitatively, we have some clear evidence that vertical illuminances in the range of 10 to 30 lux will enable people who are fully adapted to the lighting to detect and recognize people approaching.

Qualitatively, we have to draw conclusions from what is known

about the effect of lighting on the operation of the visual system. In this category are such aspects as the illuminance uniformity, disability glare and light source colour. For each of these aspects we know the direction of the effect but not the quantitative value at which it becomes critical. For example, we know that the more non-uniform the illuminance becomes, the more likely it is that we will fail to detect someone; this has been shown for the detection of obstacles on a road under different types of road lighting (Narisada, 1971) but we do not know the exact relationship between illuminance uniformity and detection.

Similarly, we know that disability glare will depend on the illuminance the glare source produces at the eye and the position of the glare source relative to the line of sight, but we do not know how significant the consequent deterioration in the ability to see is in a security lighting situation.

The same is true for light source colour. We know that some light sources distort the colours of objects they illuminate, but we do not know what effect that might have on the accuracy of description since we do not know what role colour plays in the description of people and things.

All of these questions can be answered and should be answered if we wish to make security lighting more effective.

As for speculation, here we are basically concerned with the factors which deter, hence the widespread use of the words "may" and "can" in the discussion of deterrence above. The impact of lighting conditions on deterrence of criminals is a much more complicated matter than simple detection and involves other issues besides lighting. Nonetheless, studying the effects of these conditions can change the way we design security lighting.

To use an oft-repeated phrase, "More research is needed". This should be research aimed at identifying the significant parameters of security lighting, significant in the sense that the results of that research would enable more effective security lighting to be designed. Until we have more quantitative knowledge and we rely less on qualitative knowledge and speculation, security lighting will not be the potent weapon it should be in the fight against crime. □

Figure 4: Security lighting around some residence halls, combining both uniform lighting for easy detection and high source brightness to increase the sense of exposure.

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