Light Trespass and Light Pollution

- Practical Approaches to Dealing with Problems

By

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Introduction

There is increasing concern for the problems created by unwanted light at night. This light may take numerous forms and result in various types of complaints. Particularly with increasing awareness of environmental problems of all types, it is important that lighting designers recognize the need to control problems related to the general subjects of "Light Pollution" and "Light Trespass."

Numerous local communities, cities, counties, and states have developed ordinances to control unwanted light. These ordinances vary in the aspects of lighting which they seek to control. This creates problems for the lighting designer, who must deal with the many factors involved to satisfy all of the requirements.

In the 1970's, a particular form of unwanted light was identified, that of "sky glow" caused chiefly in urban areas. The rapidly increasing problem had a major effect on the ability of astronomers to use ground-based telescopes in proximity to urban areas. The term used to describe these effects is "Light Pollution." However, not only astronomers are affected. As a result of sky glow, or the gradual brightening of the night sky, the stars are disappearing. People in our cities today do not normally experience the wonderful view of the Milky Way that used to be so common. Only in remote locations can the heavens still be viewed as nature intended. This may be even more important to our society than the effects of such light pollution on astronomy.

Astronomers and others active in the effort to control the spread of light pollution have successfully lobbied for the development of light pollution ordinances. These started in Arizona and California but are now in place in many areas,. Looking back over twenty years, these ordinances have been seen to be beneficial in reducing the spread of light pollution. As a result also of environmental awareness, lighting design techniques and luminaires have changed in a manner generally believed to be better for all.

Sky glow, however, is only one aspect of unwanted nighttime light. Just as widespread are problems associated with spill light encroaching onto properties adjacent to the area intended to be lighted. Additionally, viewing of bright light sources is a major source of complaints with which municipalities and power companies must cope.

Light Trespass

"Light Trespass" includes several effects which are generally objectionable, and which should be considered by the designer. These are well-known and are very common. We can define light trespass, or "obtrusive light" as it is sometimes called, as follows:

"Unwanted light which causes annoyance, discomfort, distraction, or a reduction in visibility."

A lighting system is intended to produce useful light. Light trespass is an all-too-common by-product of the lighting system, generally caused by poor lighting design or inadequate optical control in the fixtures. Figure 1.

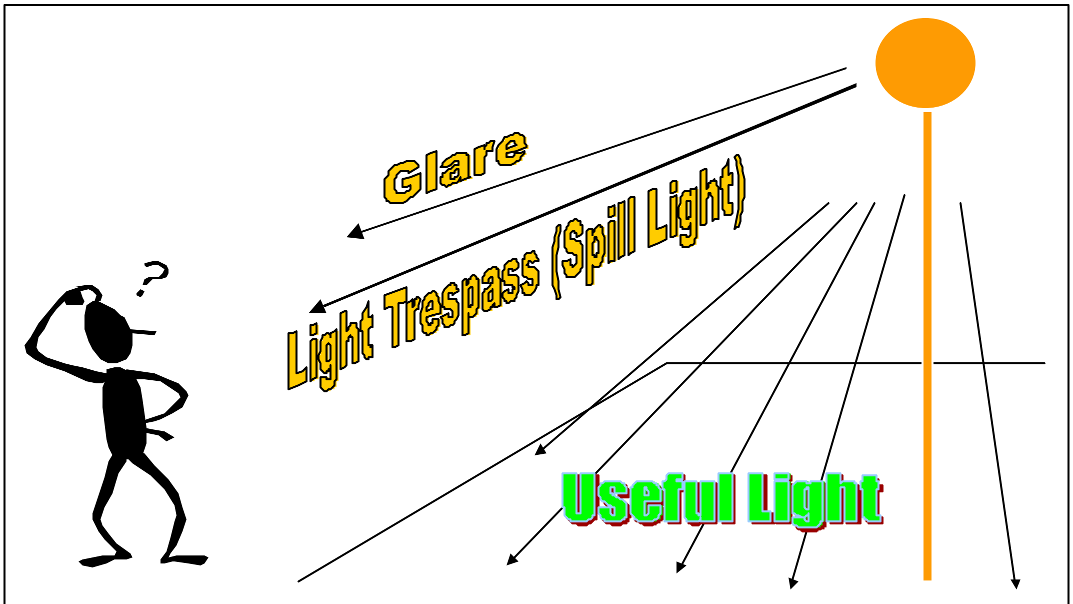


Figure 1.

Light trespass can be caused by several characteristics of nighttime lighting. These include:

- Spill Light. The presence of lighted area(s) beyond the primary area which the source is intended to light. Illuminance is produced outside of the property line containing the lighting system.

- Brightness. The presence of bright source(s) within the observer's field of view which are objectionable. This includes direct viewing of luminaires which may cause discomfort (discomfort glare), and/or a reduction in the visibility of significant visual tasks (disability glare).

Light trespass may be particularly objectionable to:

- Neighborhood residents. Encroachment of light over a residential property line, or "spill light", may be found objectionable. Entry of unwanted light into a residence, for example a bedroom window, is a commonly mentioned problem. Direct viewing of bright light sources also is frequently objectionable, particularly in neighborhoods where a low level of ambient light is considered desirable.

- Drivers. Bright light sources may seriously affect a driver's visibility because of disability glare. In addition, visual confusion created by extraneous light sources can effect the ability to locate and recognize signal lights.

Controlling light trespass may present considerable problems because of the frequent conflict between the intended useful purpose of the lighting and its unwanted by-products. Very often this is because of an attempt to provide esthetically pleasing fixture appearance by day, but creating a nighttime lighting system which does little to light the area by night. Figures 2 and 3 illustrate day and nighttime photographs of a group of

Figure 2.

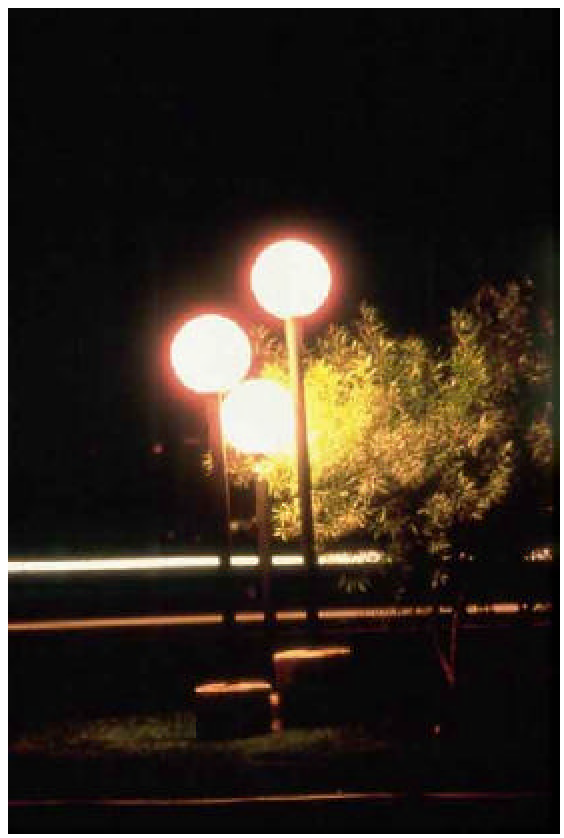


Figure 3.

lights designed with no thought given to good optical control. The result is a night lighting system which produces mainly glare, very little light on the surrounding area, and wastes more than 50% of its output in upward directions.

The Sources of Offending Light

Surveys have been conducted to determine what forms of outdoor lighting are considered to be the most serious sources of light trespass.[1] Respondents also were queried about the nature of light trespass, and what creates the offending conditions. Greatest offense was caused by directly viewed glare sources, although spill light from adjacent properties onto their surroundings also was rated as highly offensive.

The survey requested information regarding the types of lighting equipment and lighting practice which create these problems. Problems were outlined as follows:

Very important:	Dusk-to-dawn lights Street lights with inadequate optical control Sports field lighting Commercial lighting
Moderately important:	Use of lamps of excessively and unnecessarily high lumen output Incandescent floodlights, improperly aimed Not extinguishing lights when not required

Figure 4.

Figure 5.

This information immediately identifies areas where improvements in lighting equipment and lighting design are needed.

Figure 6.

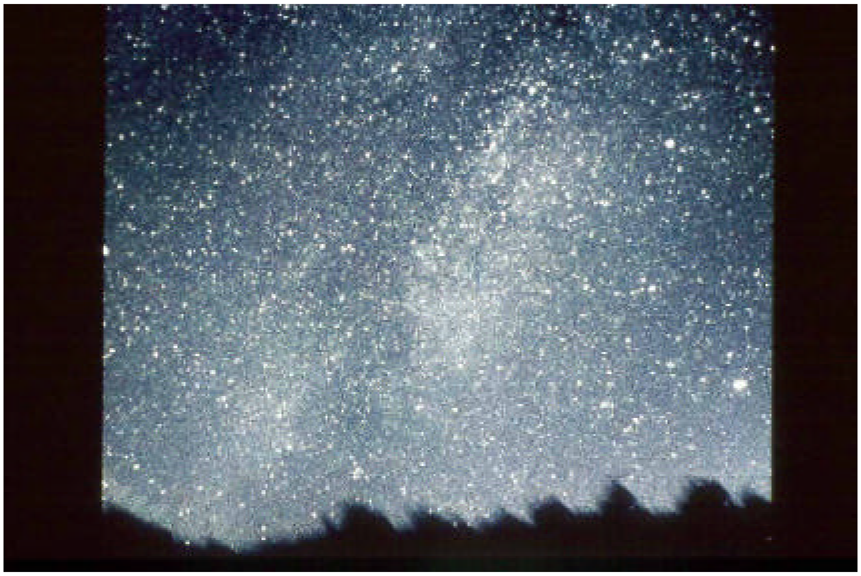


Figure 7.

Light Pollution

Nighttime viewing of the objects in space, whether by astronomers using telescopes or by the general public looking directly at the stars, requires seeing through the earth's atmosphere. On a cloudy or foggy night, this is not possible. Even on a clear night, particularly in urban areas, natural and man-made particulates in the air scatter light rays rising from outdoor lighting. This in effect creates an artificial fog which obscures our view. This is particularly serious for astronomers: space-based telescopes are extremely expensive and therefore most work must be done using ground-based observations, which cannot be used in many areas of the country because of light pollution. Astronomy is a key part of the country's economy, as it involves satellites, telecommunications and all of NASA's projects.

Figure 4 shows the nighttime sky photographed from near a major city, with outdoor lighting visible. Figure 5 shows an identical part of the sky, but in this case photographed

Figure 8.

from rural Arizona. The same major stars are visible in each, but note the vast differences between the photographs.

Figure 6 and 7 capture identical parts of the sky, again photographed from urban and rural viewpoints respectively. In the urban scene, the view of the stars is almost completely obscured.

Figure 8 is a satellite photograph of Australia and New Zealand taken from space. Note the urban areas where light is rising into the sky.

Figure 9 is an historical photograph of Los Angeles, taken in 1908 from Mount Wilson observatory. Figure 10 is a more recent photograph of the same area, recording the vast change in the night environment.

If no light from outdoor lighting enters the atmosphere, the problem is solved. However, this is not possible where such lighting is needed for safety and security. Even light from well-designed lighting systems will reflect from the objects it is illuminating, and some of this light will enter the atmosphere. Many luminaires, however, emit light above the horizontal and therefore project rays directly into the night sky. If we control this problem we will greatly reduce the amount of light pollution created.

Note that this is not just a factor related to lighting. The amount of atmospheric pollution will in turn affect the amount of scattering of light rays. A cleaner atmosphere will itself reduce light pollution, a long term goal for our society.

While this is primarily an urban problem, the effect reaches suprisingly far into rural areas. The sky glow from our major cities can be clearly seen from vantage points of over a hundred miles away.

Another point is important: Light which is emitted by lighting equipment directly into the atmosphere is basically wasted light. Such light uses electricity for its generation just as

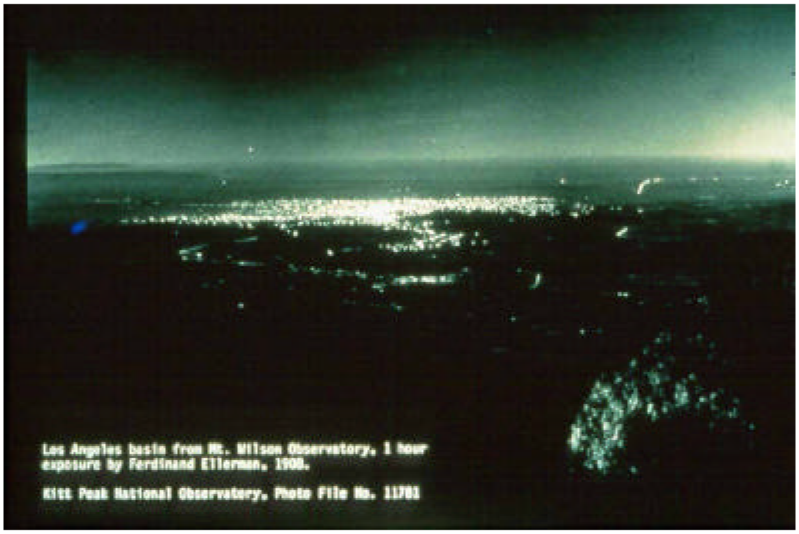


Figure 9

Figure 10.

does useful light. By improving the design of lighting equipment so that the light emitted in useful directions is increased and upward light is eliminated, power can be saved.

Detailed information on this subject is provided by the Illuminating Engineering Society of North America,[2] and in many publications by the International Dark Sky Association.[3]

Ordinances for Light Trespass Control

Light trespass control ordinances typically require one or both of the following:

- A limitation of the spill light at or just beyond the area being lighting, usually expressed in footcandles (or lux).
- A limitation on the luminance (physical brightness) of the luminaires when viewed from outside the primary area being lighted.

In addition, many ordinances limit the types of lighting equipment to be used. These are discussed later under "ordinances for light pollution control", as the limitations are often similar for the control of light trespass and light pollution.

Ordinances based on a luminaire luminance limit produce difficulties for both the designer and the enforcer. Luminance values for outdoor lighting equipment are not generally available from photometric data. In addition, the measurement of luminance under field conditions is quite difficult, even with a skilled operator and a sophisticated meter, therefore compliance checking is not feasible. Intensity of the luminaire in potentially offensive directions may be used in place of luminance.

The amount of spill light which may be allowed by an ordinance can vary tremendously depending upon the authority. Questions also arise regarding how to measure the light: on the ground or at eye height? On a horizontal plane, on a vertical plane, or on a plane facing the luminaires? Recent research has investigated practical methods of evaluating light trespass and specifying its control.[1]

Proposed Method for Light Trespass Specifications in the USA

There is a great advantage to having ordinances be generally similar between jurisdictions. Research has been conducted to review this subject with the intention of providing a common framework for light trespass controls. The work is reviewed in detail in reference 1. In summary, findings of the work are as follows:

- Both luminaire brightness and illumination caused by spill light are objectionable under many circumstances.
- Different viewers have different needs and desires in terms of light trespass control. Individuals differ in their sensitivity to this issue. (This is why we will never satisfy everyone!)
- The higher the luminance of the source, the greater the likely degree of objections. Also, the larger the source (for a given luminance), the greater the objections.
- Bright luminaires may be objectionable at a considerable distance from the viewer, but in general, increasing distance gives a decrease in the objection to the luminaire or lighting system.
- In dark surroundings, the same luminaire is likely to be more objectionable than in urban areas where there is a higher ambient light level.

Taking the above into account, it was concluded that measurement of the lighting level at the eye from an offending luminaire is a good approximation of how objectionable the source of light is to a viewer. Figure 11. The rationale for this is detailed in reference 1.

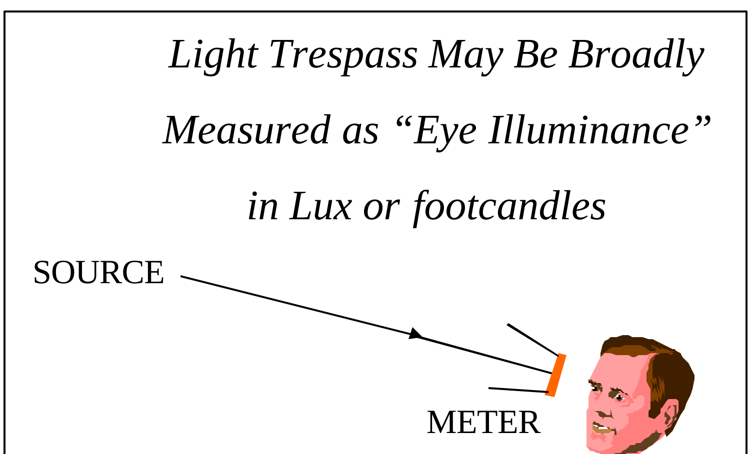


Figure 11.

A system of specification, therefore, has been developed which suggests limitations based upon the light level at the eye. These can be calculated and measured in footcandles, (or lux). This is a logical approach: brighter sources produce higher light levels, larger area sources (for a given brightness) produce greater light levels, and the light level reduces with increasing distance from the viewer to the source.

Thus we can place an upper limit on "eye illuminance", the allowable light level to be produced at the eye. As noted, however, the limit used should be related to the general lighting environment. To allow this, environmental classifications of areas with regard to ambient lighting have been developed. Table 1 provides a summary of the four classified areas E1 through E4. The specified limiting eye illuminance should be dependent on the environmental zone.

Table 1
Environmental Area Classifications
Based on Ambient Lighting

E1	Areas with intrinsically dark landscapes. Examples are national parks, areas of outstanding natural beauty, or residential areas where inhabitants have expressed a strong desire for strict limitation of light trespass.
E2	Areas of low ambient brightness. These may be outer urban and rural residential areas. Roadways may be lighted to typical residential standards.
E3	Areas of medium ambient brightness. This will generally be urban residential areas. Roadway lighting will normally be to traffic route standards.
E4	Area of high ambient brightness. Normally this category will include urban areas with mixed residential and commercial use with a high level of nighttime activity.

A further factor to be considered is a lighting curfew. Some authorities may wish to specify a turn-off time, probably in late evening. Lower eye illuminance values may be mandated after the curfew time than earlier.

Table 2 provides a summary of suggested levels being reviewed in the USA.

Table 2
Recommended Light Trespass Limitations
Illuminance at the Eye

Environmental Zone	Pre-Curfew Limitations		Post-Curfew Limitations	
	Lux	Footcandles	Lux	Footcandles
E1	1.0	0.10	0.0*	0.00*
E2	3.0	0.30	1.0	0.10
E3	8.0	0.80	3.0	0.30
E4	15.0	1.50	6.0	0.60

* Where safety and security are issues, nighttime lighting is needed. Such lighting should meet IESNA recommendations for the particular property being lighted. Lighting should be designed, however, to minimize light trespass, and it is suggested that under such conditions, eye illuminance should not exceed 1 lux, (0.1 fc). This is identical to the E2 level.

Australia/New Zealand Standards

Publication AS4282 covers "Control of Obtrusive Effects of Outdoor Lighting," although it primarily addresses light trespass rather than astronomical light pollution. It specifies limitations based on curfew and non-curfew conditions. Curfew, unless otherwise defined, is from 11 pm to 6 am.

For pre-curfew situations, a limitation is placed on the intensity of light which can be emitted in a particular direction, termed the "control direction." The vertical angle of the control direction is either 7 or 10 degrees below horizontal, depending on the size of the area being lighted. This intensity limit is applicable to the vertical plane which contains the maximum intensity. The actual limiting values of intensity are dependent upon the size of the lighted area and the level of control, which itself is dependent upon the environment of the area.

For curfew hours, stricter intensity limitations apply. However, rather than limiting intensity in the control direction, actual sight lines must be established based on the potential viewer and lighting system geometry. The intensity limits apply to these sight lines. The limits are dependent upon the type of area, commercial or residential. In case of residential, limits change depending on whether surrounds are dark or light.

For both curfew and pre-curfew conditions, there are also limitations on the vertical illuminance at the boundaries of the properties involved. Height of the points is commensurate with the height of the potentially affected buildings. In the case of curfew hours, lower illuminance levels apply, and the calculation points are the windows of dwellings in the area.

If roadways are present in the area, a limiting value of threshold increment also applies. Designers may use the curfew type of calculation rather than pre-curfew for pre-curfew conditions if desired. Curfew limitation can be ignored if it can be shown that no-one will be affected.

The calculations involved in designing and showing compliance may be quite arduous, especially if there are many potentially affected locations. To assist, lighting trespass software has been developed by Lighting Sciences Inc. of Scottsdale, Arizona, USA to perform the required computations.

Ordinances for Light Pollution Control

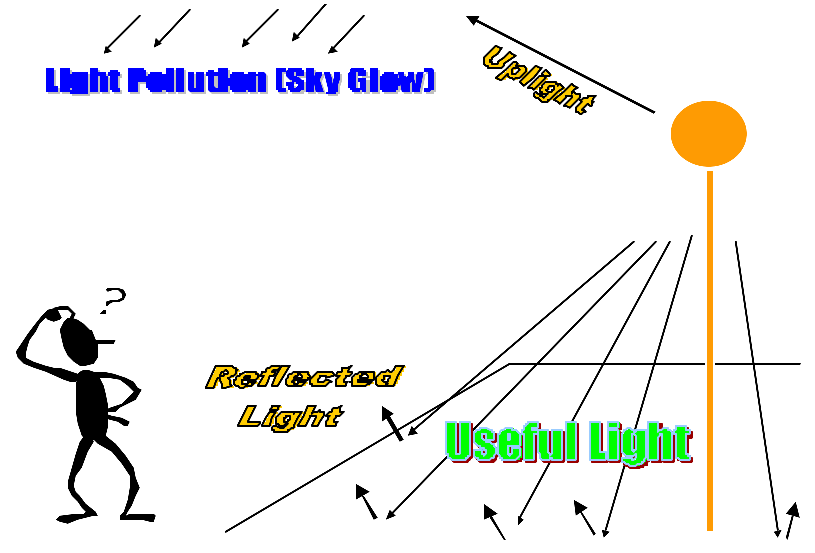


Figure 12.

Light Pollution ordinances generally address the control of uplight from the luminaires. Some may place a limitation on the ground lighting level as a means of reducing reflected light. Figure 12.

There are numerous ordinances in North America which vary widely, but in general contain several of the following requirements:

- A requirement for luminaires to be shielded, (no light above horizontal), or partially shielded, (limited light above horizontal).
- Specification of a particular light source type, possibly low pressure sodium.
- A turn-off time, perhaps 11 pm, for certain forms of lighting.
- A maximum amount of light for a real estate development, expressed in lumens per acre. i.e. A lighting "budget."

Light sources of a type preferred by astronomers (typically sodium) may be given less stringent requirements in terms of shielding. Mercury and Metal Halide sources may require an enclosure which absorbs some proportion of the ultra-violet emission.

Certain forms of lighting may be exempt from some or all ordinance requirements. For example, roadway lighting is often excluded.

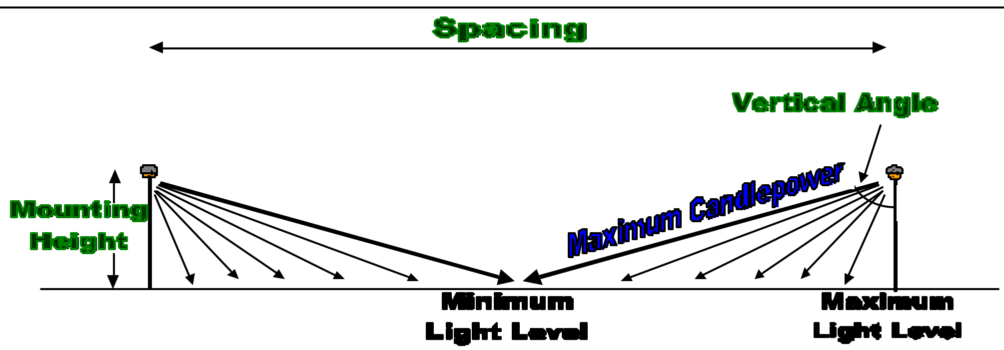


Figure 13.

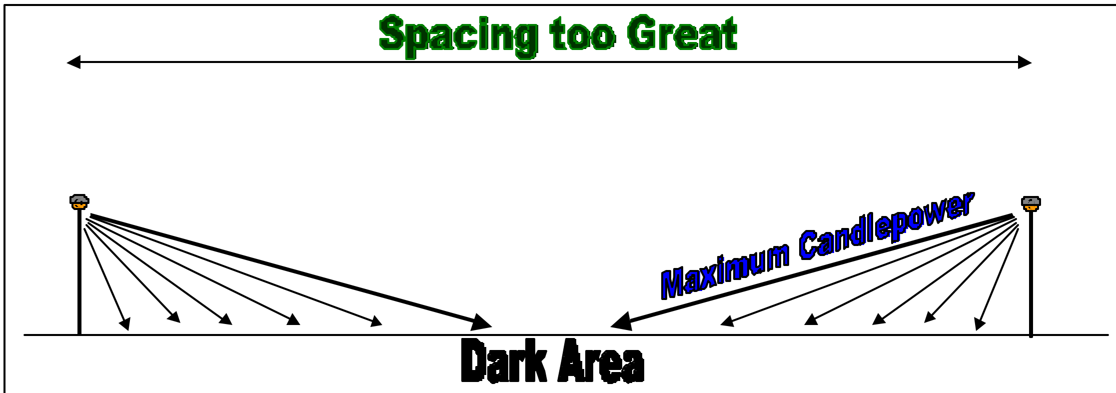
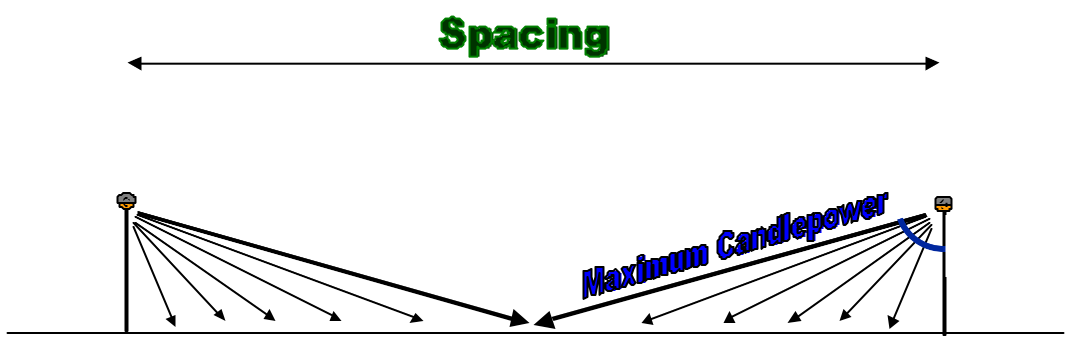


Figure 14

Designing to Meet the Ordinances

As each ordinance is different, lighting designs to meet the ordinance's goals will vary. However, there is a general similarity amongst all and therefore broad design principles can be reviewed.



68 Degree Beam:

Spacing = approx. 5x Mounting Height

Figure 15

Luminaire Light Distribution and Shielding

Properly designed outdoor lighting equipment will have maximum candlepower values, or beams, at a fairly high angle from the downward vertical. Figure 13. The beams are directed to the mid-point between poles to build up the minimum light level which occurs there. This allows broad area coverage and a wide spacing of poles. A typical angle of maximum candlepower is usually in the range of about 65° to 72°, allowing pole spacings of 5 to 6 times the mounting height. The maximum pole spacing is usually dictated by the requirement to meet uniformity specifications (average/minimum ratio). When the poles are too far apart, the minimum light level between the poles may be very low and the ratio for uniformity cannot be met. Figure 14.

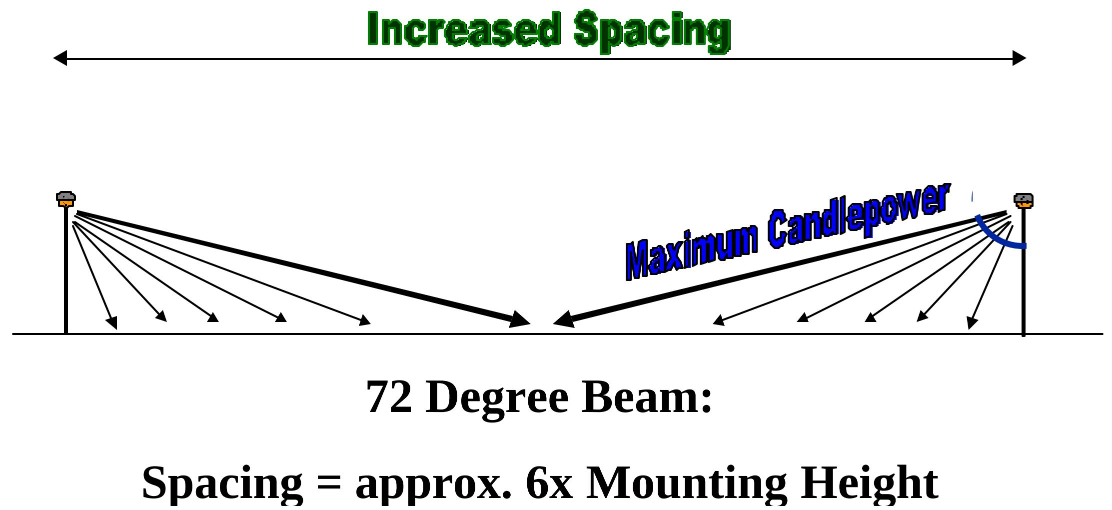


Figure 16

Higher angles of maximum candlepower can provide greater pole spacings. For example, an angle of maximum candlepower of 68° (measured from the vertical) may allow a pole spacing of 5 times the mounting height, figure 15, while an angle of 72° may allow a spacing of 6 mounting heights, figure 16. However, raising the angle of maximum candlepower will also create glare to the pedestrian and driver, as such light is directed into the eyes of the viewer. At very high angles, it is desirable to sharply reduce the light intensity in order to minimize glare, figure 17. Well designed outdoor lighting equipment will have a strong maximum candlepower, occurring at an angle of no greater than 75° and usually several degrees lower, and a sharp candlepower "run-back" such that low

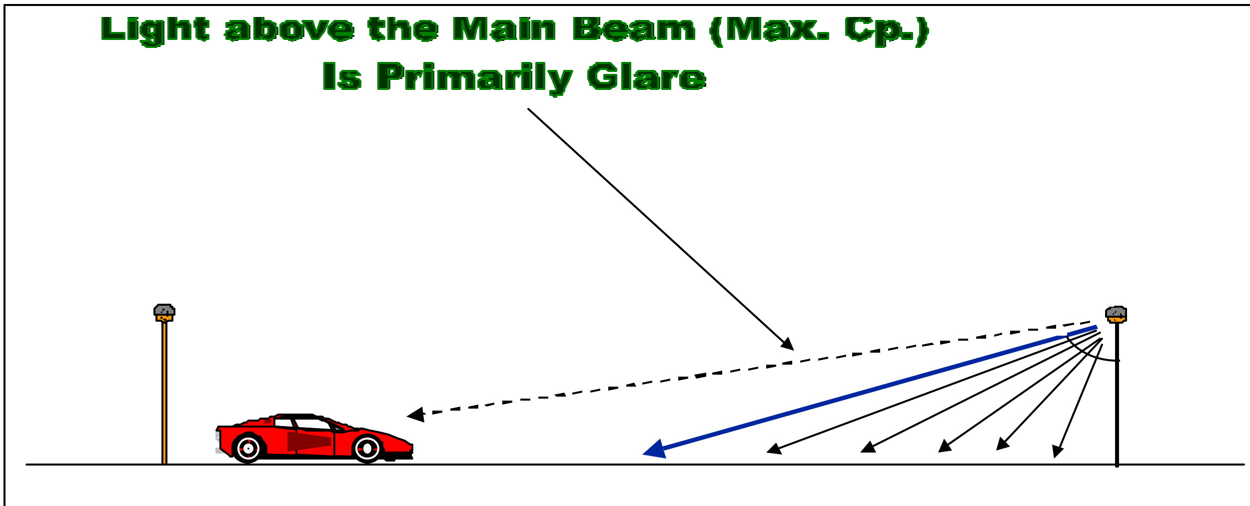


Figure 17

intensities are produced above the beam up to the 90° vertical angle. (90° corresponds to a horizontal plane through the luminaire.)

The IES has defined the terms "non-cutoff", "semi-cutoff" and "cut-off" as a means of expressing the amount of reduction in intensity above the beam of an outdoor light. A further term, "full cutoff" has recently been IES approved. The classifications are based on how much light the fixture emits at angles of 80° and 90° vertical angle, (at any horizontal angle around the luminaire.)

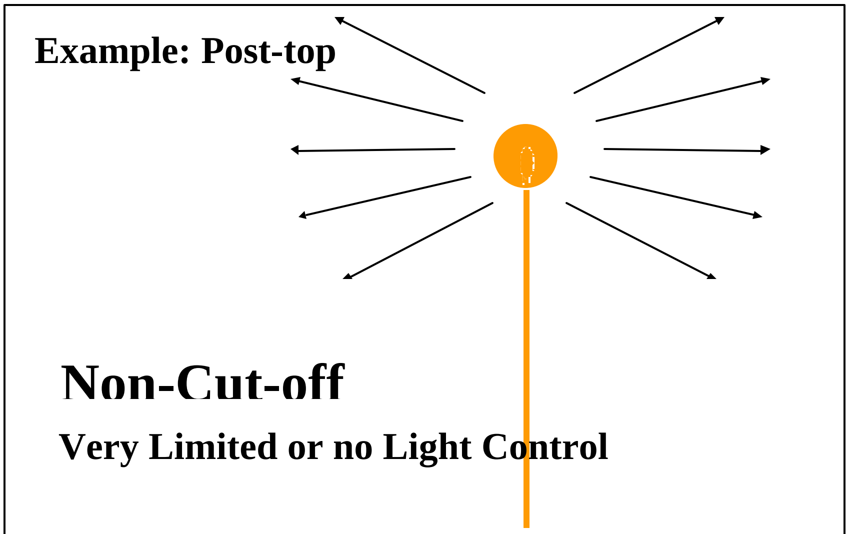


Figure 18

Non cutoff

No limitations on candlepower distribution. Example: Post-top luminaires, figure 18.

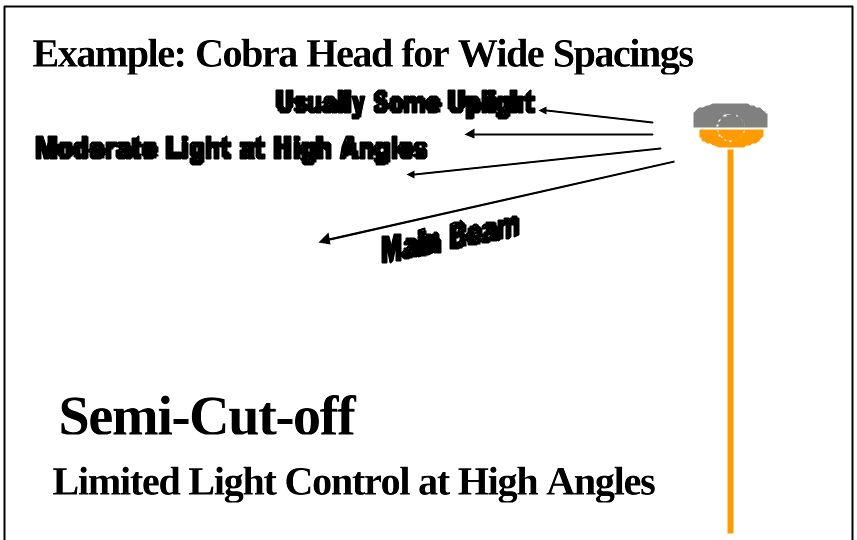


Figure 19

Semi-cutoff

Limited light at 80°, and less at 90°. May have some uplight. Example: Certain types of cobra-head fixtures, especially those designed for wide spacings. Figure 19.

Cutoff	Limited light at 80°, and very low intensity at 90°. May have some uplight. Examples: cobra-head fixtures designed for normal spacings. Figure 20.
Full cutoff	Limited light at 80°, no light at 90°, no uplight. Examples: Flat glass cobra-head and "shoe-box" fixtures. Figure 21. May also be called "sharp cutoff."

Ordinances often use the term "shielded" in the same sense as the IES term "full cut-off." Full cut-off ensures that no light is emitted above the horizontal, thus reducing sky glow. Full cut-off, however, also contributes to ensuring that light trespass is reduced, as the angular range which contributes to light trespass is stringently limited in its allowable light output. Figure 1.

Not only is light trespass in terms of spill light generally reduced by the use of full cut-off fixtures, but the associated glare will also be greatly reduced because the causes are similar (fig. 1). Lower glare produces a more comfortable lighting system. Of perhaps greater importance, the reduction in nighttime visibility caused by high angle brightness, termed "disability glare", is itself reduced. As a result, better seeing conditions are created and the outdoor lighting becomes more effective in achieving its intended purpose.

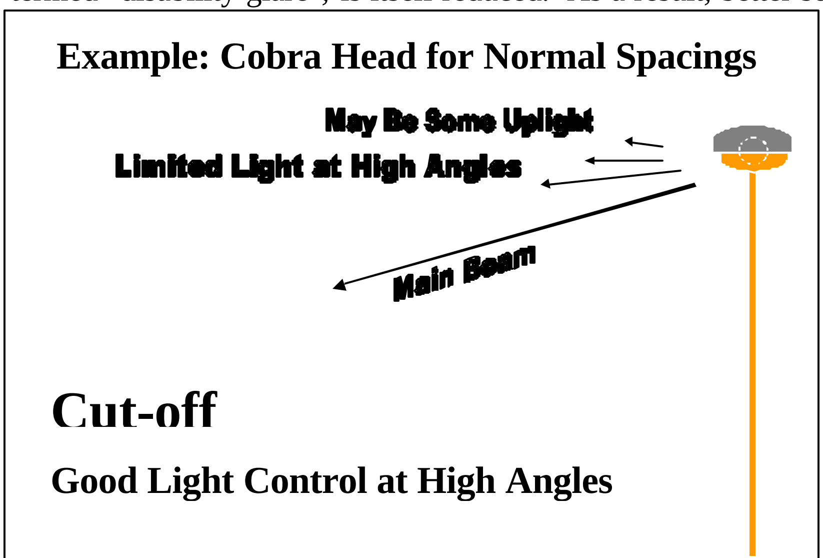


Figure 20

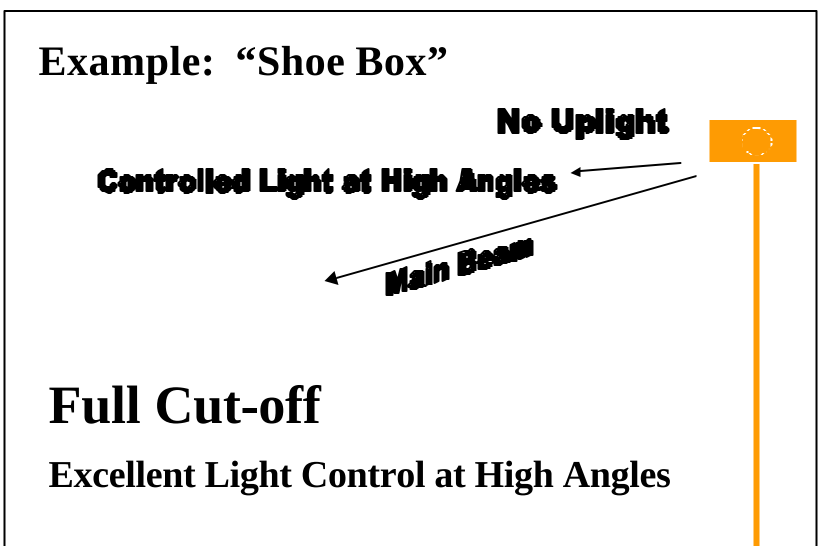


Figure 21

A possible disadvantage of full cut-off lighting is that the spacing between poles which might be achieved with other distributions may not always be attainable. Exceeding an allowable spacing can cause unacceptable lighting uniformity. However, well designed full cut-off fixtures with good beam control will still allow very desirable spacing with good uniformity. In any case, a small reduction in the maximum allowable spacing is usually regarded as a small price to pay for the numerous attendant benefits.

Full cut-off luminaires are available from most outdoor lighting manufacturers in a wide

Figure 22.

Figure 23.

variety of types. Use of this type of fixture is the first major step towards meeting the requirements of most light pollution and light trespass ordinances.

Examples of bad lighting design are widespread. Figures 22, 23. Well-designed lighting, fortunately, can also be found more and more as the benefits become understood. Figures 24, 25.

Esthetics also must be considered. Many luminaire styles, even ornamental, can be provided with efficient optics. Control of light trespass and light pollution does not preclude the use of attractive fixtures. Imaginative solutions to combining esthetics and lighting performance, however, are necessary.

Lamp Type

Outdoor lighting usually employs HID (High Intensity Discharge) lamps. Modern sources most widely used are High Pressure Sodium and Metal Halide. Mercury lighting, although still widely seen, is almost obsolete for new installations because of low lamp efficacy (lumens per watt). The use of Low Pressure Sodium (LPS) is often encouraged by astronomers and may be mandated by light pollution ordinances, particularly near observatories.

A short summary of the characteristics of the three source, LPS, HPS and Metal Halide is given below.

Low Pressure Sodium

- Very limited use in the USA. Has been widely used in Europe though few new installations now occur. No US manufacturers.
- Deep yellow color. Color perception under LPS is very poor.
- Preferred by astronomers. (The narrow color band can be removed at the telescope by use of a color filter which absorbs sodium's primary wavelengths, reducing the effect of light pollution.)
- High "photopic" lumens per watt.
- Low "scotopic" lumens per watt. *Photopic and scotopic lumens are discussed below.*
- Lamps are physically large and require large fixtures.
- Lamps are expensive.
- Long lamp life (although State authorities have commented on lamp life not being as anticipated from published data).
- Excellent lumen maintenance over life, (although wattage may rise over life.)
- Power losses in ballast are larger than for other lamp types.
- Large size of the discharge tube makes optical control of the light more difficult than other sources. Light therefore cannot be so well directed to areas where it is needed, reducing the Utilization Factor of the luminaire.
- Visibility produced for the eye's peripheral vision under low lighting levels may be very poor, due to lamp color.[4,5]

High Pressure Sodium

- Most common roadway lighting source.
- Yellow or pinkish-yellow color. Color perception under HPS is not good. Improved color versions are available but have lower lumens and shorter life.
- High photopic lumens per watt (although not as high as LPS.)
- Low scotopic lumens per watt.
- Lamps are compact. Good optical control is possible.
- Long lamp life.
- Very good lumen maintenance
- Relatively low cost
- Visibility under many conditions at night is reduced by the yellow color of the source.[4,5]

Figure 24

Metal Halide

- Widely used for outdoor lighting other than for roadways. Some roadway usage now occurring due to recent lamp improvements.
- White light. Excellent color rendition. Particularly good for grass and foliage.
- High photopic lumens per watt, although not quite as high as HPS.

- Very high scotopic lumens per watt.
- Lamps are compact. Arc tube lengths are shorter than HPS. Excellent optical control possible.
- New range of pulse-start lamps have good lumen maintenance.
- Lamp life can be moderate to long, depending on lamp wattage and type.
- Relatively low cost, although slightly higher than HPS, lower than LPS.
- Excellent nighttime visibility.[4,5]

Figure 25

It can be seen that HPS and Metal Halide have numerous advantages over LPS. LPS therefore tends to be used in the USA only if absolutely required by a light pollution ordinance. The claims of high lumens per watt are severely diluted when the higher ballast losses are included, and when the poorer utilization of the light because of limited optical control is considered. A comprehensive study of LPS versus HPS for an Arizona power company concluded that there was no clear energy advantage to the general use of LPS versus HPS for roadway lighting, primarily for these reasons.

Nighttime visibility as it relates to the color of the light source is too long a subject for coverage here. Briefly, however, the eye consists of two types of sensors, rods and cones. Only cones are used during daytime and for other high light level vision. Lamp lumen ratings are always established on the basis of how the cones of the eye respond to the light. These are referred to as "photopic" lumens. For cone vision, the low pressure sodium lamp produces the highest efficacy (lumens per watt.) At night under low light levels, the rods of the eye "switch on," the cones reduce in their contribution, and vision is achieved using a combination of rods and cones. For rod vision, *white sources produce higher visibility than yellow sources.* This is because rods respond very strongly to blue and green wavelengths of light. The ranking of the lamp types in terms of lumens based on rod vision, or "scotopic" lumens, is:

Best:	Metal Halide
Moderate:	High Pressure Sodium
Worst:	Low Pressure Sodium

This information, however, is not reflected in published lamp lumen ratings, as only the cone response is considered.

This may be especially important in security lighting where very low light levels are common. Use of metal halide, which provides the highest visibility for nighttime rod vision at low light levels, may increase security even though the light level is very low. Not suprisingly, therefore, this source has been shown to be the most cost effective under many circumstances.[6]

References 4 and 5 cover the subject of visibility at night as related to lamp color in detail.

"Lumens per Acre"

If the ordinance calls for a certain maximum light usage in terms of lumens per acre, it is particularly important to perform good lighting design. Bad design likely will not allow the lumens per acre budget to be met while providing the desired lighting levels. (Of course, there are many other reasons to avoid bad lighting design.)

For nighttime security, IES recommendations advise a minimum illuminance at all points in the area being lighted. In order to achieve a typically required level within a stringent lumens per acre limit, very good lighting uniformity is necessary. *It is only by reducing the lighting levels at the maximum points that sufficient lumens can be made available at the minimum points.* Excellent optical control therefore becomes mandatory, using high quality lighting equipment which has been engineered to produce high uniformity with high efficiency.

Computerized lighting design also becomes necessary in order to optimize the layouts and performance. This will allow the review of different luminaire types and the optimization of pole heights and locations. Very often, the manufacturer will provide this service for you, or supply software for your own use.

Meeting "Eye Illuminance" Limits

It is essential to analyze a proposed lighting design before installation to ensure that ordinance limitations for spill light will be achieved. Too often, great expense has been incurred to modify offending lighting systems after installation. Even if ordinances are not in effect, complaints may still occur, and designers should be sensitive to this issue.

Calculation of the footcandle (or lux) level at the eye can be performed quite simply. Reference 1, appendix A, provides the method. Computer software is available where the illuminance on any plane at any specified location can be determined. This should be found for points around the perimeter of the area being lighted, as created by luminaires which may possibly be offensive. Software which is equipped with the ability to compute vertical footcandles will usually give a very close approximation to the footcandle level on a plane perpendicular to the eye’s line of sight.

Eye illuminance levels should not exceed these given in table 2, or whatever values are required by a local ordinance.

Checking of potentially offending light sources should eliminate the possibility of most light trespass problems later. File the calculations with the lighting plans to serve as a record of your work should future problems occur.

Other Considerations

Good lighting design requires thought in planning and execution. In addition to the above, consider:

- A site review before the design. Gauge sight lines and judge possible sources of future complaints.
- Be very familiar with local ordinances. Remember that they are likely to change from one jurisdiction to another, even in the same general area.
- If there are no ordinances, keep light trespass and light pollution in mind. Lack of an ordinance will not prevent future complaints.
- Select the luminaire type very carefully. Be particularly aware of light intensity at angles near the horizontal. Evaluate whether the equipment will produce significant uplight. Check lighting uniformity and do not waste light.
- Consider luminaire shields in special circumstances. Remember, however, that external shields may increase wind-loading, and that internal shields may reduce efficiency and lighting uniformity.
- Study several design alternatives.
- Consider the use of timers and dimmers.

Conclusion

High quality outdoor lighting design is in everyone's best interest. The ordinances have been developed not to make life difficult but to make life better. Starry nights not seen are a legacy we do not wish to leave for the next generation, but only by taking action now can we prevent the situation from worsening. Light pollution and light trespass rob us of nighttime experiences which should be enjoyed by all. No one loses when we pay attention to the environment in our lighting design practices.

Acknowledgements

Figures 2 through 10 are provided courtesy of the International Dark Sky Association, IDA, Tucson, Arizona.

References

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