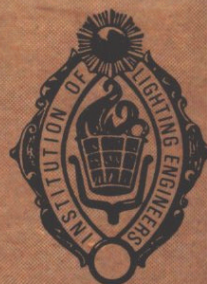




A Manual of
ROAD LIGHTING
in Developing Countries



Institution of Lighting Engineers

ROAD LIGHTING IN DEVELOPING COUNTRIES

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1.0 INTRODUCTION

Driving in towns and cities is a demanding task, even in broad daylight. At night-time, the task is even worse. The demands put upon the conscientious driver are reflected in the accident statistics, which show that accident rates on unlit roads can be twice as high as the daytime levels. Accident records and years of research in many countries show that fixed roadway lighting can reduce the number of night-time accidents by some 30% ⁽¹⁾.

This is an average, and refers to lighting installations of modest quality. A detailed survey from the United Kingdom shows that improving the quality of an existing installation can bring further benefits-up to 35% improvement for a doubling of the overall light level⁽²⁾. Although these improvements have been recorded in industrialised countries, there is no reason to think that they would not be found in developing countries as well. In fact, roadway lighting could be even more beneficial where there are greater numbers of pedestrians and two-wheelers, and where road surfaces are in poorer condition.

Relying on vehicle headlights alone is a poor and ineffective alternative.

Road lighting is not concerned solely with reducing road accidents. Even modest amounts of lighting can reduce general public anxiety of robbery and assault, enhance the quality of life after dark for everyone and add considerably to the attractiveness of inner city areas for visitors and residents alike. Coupled with the floodlighting of public buildings and national monuments, road lighting can play its part in boosting tourism.

This manual is intended to help the local engineer understand the basics of good roadway lighting and achieve some of its benefits; it is not addressed to the professional lighting engineer or consultant. It cannot give definitive 'best buys' for the enormous range of conditions and situations which the engineer has to face. Instead, it sets out the various options, and their strengths and weaknesses, so that he can make the most of his scarce budget and equipment.

Although road lighting is only one of the many services provided by engineers, it is one that can make a positive and highly visible contribution to the community's welfare. Its effects are seen and appreciated immediately by drivers and pedestrians alike, and in the longer term there are measurable improvements in road safety and general security. It is hoped that this manual will help in this worthwhile process.

2.0 FUNDAMENTALS

This section deals with fundamental facts about roadway lighting and defines the terms and quantities which the engineer might encounter when dealing with an existing or new lighting installation.

2.1 GENERAL PRINCIPLES

2.1.1 The Driver's Requirements

All objects are seen by contrast, either dark against a light background (e.g., words on a page) or light against dark. Our ability to see objects depends upon this contrast, and we need more of it at lower lighting levels and when we need to see smaller detail. Thus, a *driver* needs more light at higher speeds as his safe stopping distance increases, and he has less time to see the edges and even the state of the road surface itself.

In order to reveal objects on the road, it is uneconomic to try to make an object appear bright against its background. Consequently, a technique is used whereby the object appears dark against a bright road surface, or in silhouette. The bright road surface is obtained by directing beams of light up and down the road in such a way that sufficient light is reflected off the surface to reveal objects or uneven surfaces. At the same time, light coming directly into the eyes (glare) has to be kept to a minimum, as it reduces the sensation of contrast.

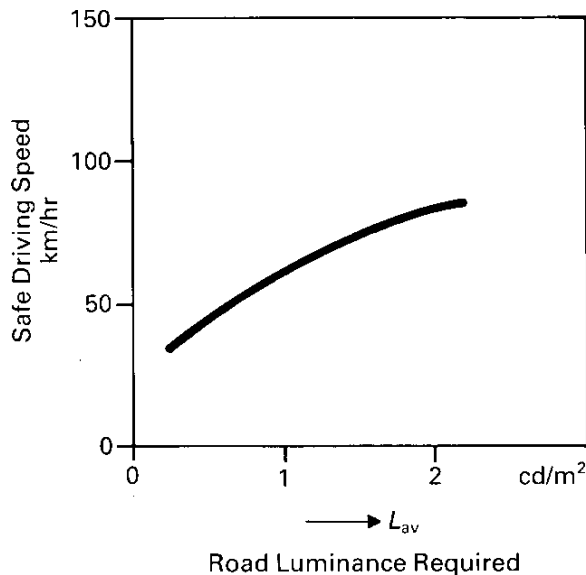


Fig. 1
Road Luminance.

Curve showing relationship between driving speeds and required road luminance. Based on a driver, without headlights, seeing a standard obstacle in his path and having a reaction time of 2 sec and a deceleration rate of $4m/S^2$ (ref.2a).

2.1.2 The Pedestrian's Requirements

Pedestrians, whilst still concerned with the problem of objects on the ground, also need to see other people and objects. They do not have to react so quickly to distant objects as do the drivers and, therefore, overall lighting levels can be lower. The light has to be directed towards vertical, rather than horizontal, surfaces-particularly for viewing other pedestrians.

2.1.3 Lighting of the Surrounds

This is important for all road users. For the driver it provides a background against which stationary objects at the side of the carriageway can be seen. For the pedestrian it helps create a pleasant visual scene by night, revealing the buildings and surroundings. It also helps to identify landmarks by which strangers can recognise areas. The eye is remarkably versatile; it can adapt readily to a wide range of lighting levels from moonlight to a bright sunny day. A well-lit street is typically 300 times 'brighter' than a moonlight scene, but is still only some 0.1% of daylight levels.

2.2 LIGHTING

In this next section the lighting process is followed through from light source to eye, so that various terms can be defined and the rather special units used by lighting engineers explained.

2.2.1 Lamps

The LAMP is the basic source of light and converts electrical energy into radiation. Some or all of this is in the narrow band of wavelengths to which our eyes respond. Lamps function in three basic ways:

- (i) heating a small wire or filament to a high temperature, in a container sealed to exclude the air. (TUNGSTEN lamp, designated GLS).
- (ii) passing an electric current through a gas or mixture of gases in a sealed tube (DISCHARGE lamp). This can be at low pressure (e.g., low pressure sodium, designated SOX) or high pressure (high pressure mercury, MBF, HPL-N, or high pressure sodium, SON).
- (iii) a special type of discharge lamp emits ultraviolet radiation (which the human eye cannot 'see') and this then causes a phosphor powder to glow (Fluorescent lamp, designated as MCF & TL; the compact version is designated SL & PL).

2.2.2 Lumens

The radiation or 'luminous flux' which comes from a lamp is measured in *lumens* (lm). This measure allows for the fact that the eye responds differently to radiation of different wavelengths.

2.2.3 Efficacy

The *efficacy* of a lamp is the number of lumens it produces for a given amount of power fed into it. The unit is *lumens per watt*. The most sensitive part of the visible spectrum is in the green/yellow range, so a low pressure sodium lamp has a high efficacy of 200 lumens/watt, whereas a tungsten lamp which emits much of its radiation in the 'invisible' infra-red range has a low efficacy of 14 lumens/watt. This is dealt with further in Section 4.

2.2.4 Intensity

The flux from a lamp is emitted in all directions. The amount emitted in a given direction within a very small solid angle divided by the solid angle is called the INTENSITY in that direction. Thus, if flux F is emitted within the small solid angle ω' surrounding the particular direction, the intensity I in that direction is defined by

$$I = \frac{F}{\omega'}, \text{ and the unit is the } \textit{candela} \text{ (symbol cd)}$$

2.2.5 Luminaire

To direct the light from the basic lamp to where it is wanted, the flux is either reflected or refracted by mirrors or prisms, which, together with the lamp housing and some of the electrical fittings, is called the LUMINAIRE (Fig. 2).

2.2.6 Lantern

In some countries, a luminaire specifically designed for use on roads is referred to as a LANTERN. It is the intensity distribution of the luminaire or lantern, rather than the basic lamp, which is of interest to the lighting engineer.

2.2.7 Colour Temperature and Colour Rendering

Roadway lighting engineers are not usually concerned with colour, but should be aware of two terms. COLOUR TEMPERATURE describes the appearance of a lamp, compared to the appearance of a standard tungsten lamp. A warm appearance corresponds to a *low* colour temperature (say, 2700 K) and a *cool* appearance to a *high* colour temperature (say, 4000 K). COLOUR RENDERING is a measure of the ability of a light source to reproduce colours. It is measured on a scale of 0 to 100, with a tungsten lamp being the reference at 100.

2.2.8 Illuminance

If we look at point A on the road surface in Fig. 3, it receives light from the lantern emitted at intensity I . The illuminance (E) at point A on a plane perpendicular to the intensity direction is

given by $\frac{I}{d^2}$ lumens per square metre, or lux (lx), where d is the distance from the lantern to point A.

Usually, the plane of the road is at some angle (γ) to the intensity direction. In this case, the illuminance is given by the expression $E = \frac{I \cos \gamma}{d^2}$ lux.

This may be rewritten in terms of mounting height

$$E = \frac{I \cos^3 \gamma}{H^2} \text{ lux}$$

where H is the mounting height of the lantern.

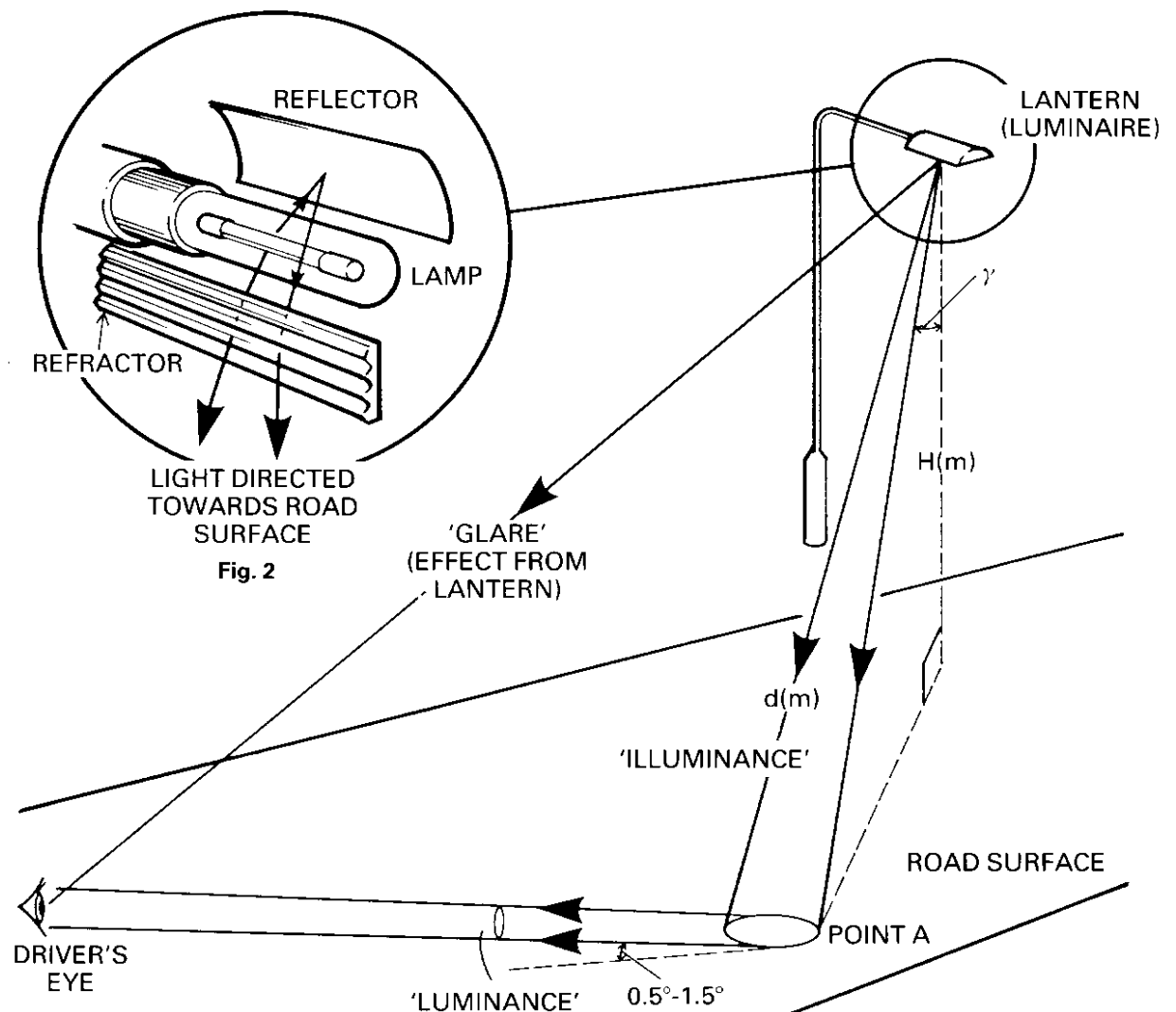


Fig. 3
The basics of road lighting.

2.2.9 Luminance

The light striking the road at point A has to be scattered and reflected towards the driver's eyes. Much of the roadway which the driver has to see is quite some distance away, so the angle of observation is fairly small—a few degrees. The measured intensity of reflected light per unit area is called the LUMINANCE, measured in candelas per square metre. The relationship between the amount of light striking the surface and the amount redirected in any given direction is quite complicated, and depends on the state and quality of the surface, and the various angles involved.

2.2.10 Calculations

Reflection factors for typical road surfaces have been measured, and using them it is possible to calculate the LUMINANCE of each part of the road as it receives light from many different lanterns, once their intensity distributions are known. This is a time-consuming process and is best done on a computer. Anyone wishing to use the full calculation method should consult BS5489 Parts 1-10⁽³⁾.

It is far simpler to use ILLUMINANCE and make some simplifying assumptions about reflection factors. Throughout this manual, recommendations of values relate directly to the equivalent luminance and illuminance levels given in as BS 5489⁽³⁾. Horizontal illuminance of an installation can be measured using a simple light meter.

It is the job of the lighting designer and lighting engineer to position lanterns to give the best spread and uniformity of illuminance, and a simplified code of practice to help with this task is presented in section 3.

2.2.11 Geometry of a Road Lighting System

The main terms used to define the geometry of a lighting system are illustrated in Fig. 4.

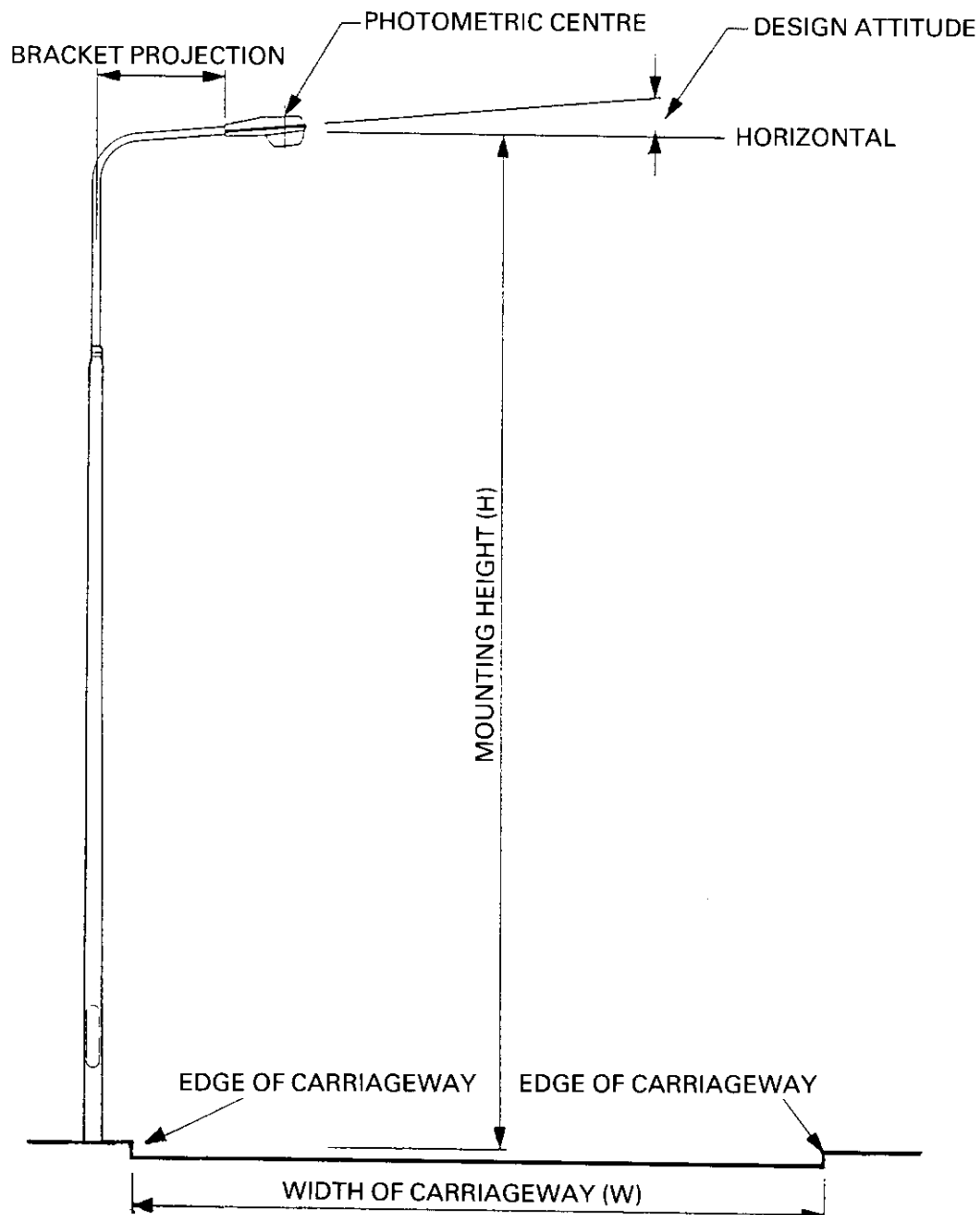


Fig. 4
Geometry in elevation of a road lighting system

2.3 ELECTRICAL

2.3.1 Supplies

Electricity generation produces two types of alternating current supply-single and multiphase. Transmission is generally by means of multiphase supplies where two or more live conductors are used. A neutral or earth may be used as a reference point and the voltage between the live conductors will be greater than that between a live and neutral.

Street lighting units generally require single phase supplies, i.e., one live and one neutral. Installations generally will be supplied from a multiphase supply arranged so that there are roughly equal loads on the different phases.

2.3.2 Protection

It is essential that any electrical equipment is protected so that it is safe for work to be carried out near it. Contact with live parts can cause a current to pass through the body and lead to violent muscle spasms and death, particularly where currents pass via the heart. Even voltages of 200-250V can be lethal. The fundamental means of protection against injury are:

- (i) **Direct Contact:** Conductors which are intended to be live in normal use require protection by insulation, enclosure, barriers or placing out of reach.
- (ii) **Indirect Contact:** Conductors which are intended not to be live in normal use, e.g., steel columns, require earthing to ensure automatic disconnection of the supply if such conductors become live.
- (iii) **Overcurrent:** Circuit conductors require protection by automatic disconnection of supply in the event of overload or short circuit.

Automatic disconnection of supply is normally achieved by a fuse or circuit breaker with thermal/magnetic trip. When the current exceeds the designed value the device operates to disconnect the supply. When used to disconnect faults to earth, its time/current characteristics must be suitable for the circuit impedance and operating voltage to ensure that a dangerous voltage on earthed metalworks is not prolonged.

2.3.3 Circuits

(i) Tungsten Lamps

Tungsten filament lamps can be operated directly from the supply, but they are very sensitive to voltage. Excess voltage can shorten lamp life drastically. Low voltage extends the life but reduces the light output.

(ii) Discharge Lamps

All lamps that contain a gas discharge need control gear to start the discharge and then to limit the current. The various components that perform those functions are described in the following section.

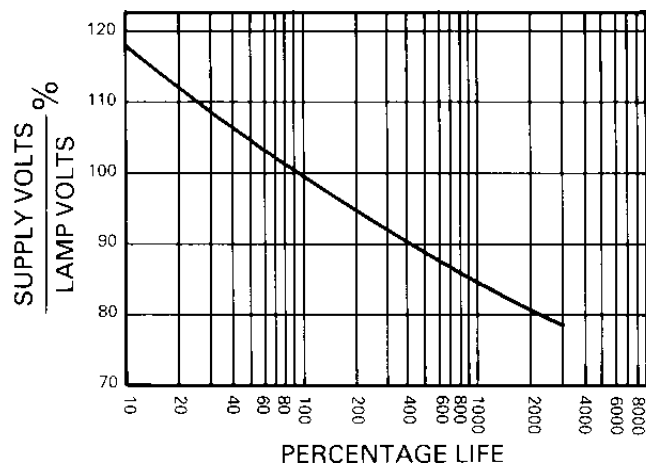


Fig. 5
Variation of life with applied voltage for Tungsten Lamps.

2.4 CONTROL GEAR (FOR DISCHARGE LAMPS) AND SWITCHES

2.4.1 Control Gear

- (i) **Ballast** Usually a copper winding around a steel core, this acts as an inductor and limits the current through the lamp. It is connected in series with the lamp.
- (ii) **Ignitor** This is usually some form of external electronic device that is used to start some discharge lamps.

- (iii) Capacitor This is used across the supply to control what is called the 'Power Factor' of the circuit. The Power Factor expresses the phase relationship between the voltage and current and should be as near unity as possible.

For a given lamp power and supply voltage, the higher the Power Factor the lower will be the supply current drawn. Some circuits use capacitors in series with the lamp. These are essential to the correct operation of the circuit.

2.4.2 Photo-Electric Controls (Photocells)

Photocells can be used for individually switching street lights. There are three basic types:

- a) Thermal photocells. These are not recommended where there are mains voltage fluctuations.
- b) Electronic photocells - preferred where there is a likelihood of mains voltage fluctuation.
- c) Hybrid photocells. A combination of the above.

All types can be supplied as a one-part unit which fits into a standard socket fixed into the lantern or as a two-part unit with the sensor in the lantern and the switch in the column base. All sensors, whether remote or integral with the switch, need good neoprene sealing to stop insects getting in and moisture building up. In extremely hot areas it is advisable to keep the sensors out of direct sunlight to avoid over-heating.

2.4.3 Time Switches

Time switches should be of the synchronous motor or quartz controlled type, fitted with a solar dial appropriate for the latitude. They should also be fitted with spring reserves or emergency battery back-up to operate the timing mechanism in the event of a power failure. It is important that time switches are fitted with dust-proof covers, and protected as far as possible from corrosion.

2.4.4 Group Switching

Where separate street lighting power cables are used, it is possible to switch groups of lights by means of contactors fitted in supply pillars or cabinets. The contactors can be activated either by means of photocells or time switches. Where multicore cables are in use, each phase should be controlled separately to avoid failures of large sections of lighting in the event of the controls not operating correctly.

2.4.5 Mains or Radio Teleswitching

These are very sophisticated switching systems which the reader should be aware of for possible future application.

2.5 MECHANICAL

IP Classification⁽⁴⁾

Lanterns are classified according to the level of protection against dust and moisture. This is indicated by the letters IP (which stand for Index of Protection) followed by two numerals, the first referring to dust and the second to moisture. (Note: the two numerals should be pronounced separately: e.g., "IP Five Four".)

The IP system supersedes the earlier classification of equipment as "rainproof", etc., accompanied by marking with symbols. The higher the number, the better the standard of protection. A summary of the IP coding appears on page 9. Normally, the only IP classifications relevant to lanterns are:

IP 23	IP 24	IP 25	—
—	IP 54	IP 55	—
—	IP 64	IP 65	IP 66

Index of Protection (IP) Code

FIRST NUMERAL		SECOND NUMERAL	
(a) PROTECTION OF PERSONS AGAINST CONTACT WITH LIVE OR MOVING PARTS INSIDE ENCLOSURE		PROTECTION OF EQUIPMENT AGAINST INGRESS OF LIQUID	
(b) PROTECTION OF EQUIPMENT AGAINST INGRESS OF SOLID BODIES			
No./SYMBOL	DEGREE OF PROTECTION	No./SYMBOL	DEGREE OF PROTECTION
0	(a) No Protection.	0	No Protection.
	(b) No Protection.		
1	(a) Protection against accidental or inadvertent contact by a large surface of the body, e.g. hand, but not against deliberate access.	1	Protection against drops of water. Drops of water falling on enclosure shall have no harmful effect.
	(b) Protection against ingress of large solid objects <50mm diameter.		
2	(a) Protection against contact by standard finger.	2 	Drip Proof:— Protection against drops of liquid. Drops of falling liquid shall have no harmful effect when the enclosure is tilted at any angle up to 15° from the vertical.
	(b) Protection against ingress of medium size bodies < 12mm diameter and <80mm length.		
3	(a) Protection against contact by tools, wires or suchlike more than 2.5mm thick.	3 	Rain Proof:— Water falling as rain at any angle up to 60° from vertical shall have no harmful effect.
	(b) Protection against ingress of small solid bodies.		
4	(a) As 3 above but against contact by tools, wires or the like, more than 1.0mm thick.	4 	Splash Proof:— Liquid splashed from any direction shall have no harmful effect.
	(b) Protection against ingress of small foreign bodies.		
5 	(a) Complete protection against contact.	5 	Jet Proof:— Water projected by a nozzle from any direction (under stated conditions) shall have no harmful effect.
	(b) DUSTPROOF:—Protection against harmful deposits of dust, dust may enter but not in amount sufficient to interfere with satisfactory operation.		
6 	(a) Complete protection against contact.	6	Watertight Equipment:— Protection against conditions on ship's decks, etc. Water from heavy seas or power jets shall not enter the enclosures under prescribed conditions.
	(b) DUST-TIGHT Protection against ingress of dust.		
IP CODE NOTES —Degree of protection is stated in form IPXX. —Protection against contact or ingress of water respectively is specified by replacing first or second X by digit number tabled, e.g. IP2X defines an enclosure giving protection against finger contact but without any specific protection against ingress of water or liquid.		7 	Protection Against Immersion in Water:— It shall not be possible for water to enter the enclosure under stated conditions of pressure and time.
		8	Protection Against Indefinite Immersion in Water Under Specified Pressure:— It shall not be possible for water to enter the enclosure.

N.B.—Use this table for General Guidance only—refer to BS 5490 for full information on degrees of protection offered by enclosures.

3.0 SIMPLIFIED DESIGN CODE OF PRACTICE

3.1 LIGHTING PARAMETERS

Parameters which the lighting designer has at his disposal are:

3.1.1 Mounting Height

The greater the height, the more light will be needed to achieve a given lighting level, but a more uniform result will be achieved.

3.1.2 Spacing

The wider the spacing of lanterns, the lower the level of light and the more patchy it becomes. However, small spacings result in greater cost and are not always practical. Very often a ratio of Spacing to Mounting Height is given in codes to ensure that minimum standards are achieved.

3.1.3 LampType

The type of lamp should be chosen according to the various criteria described in the Section on lamps (4.1). A lamp of correct power is then chosen to give the required lighting level.

3.1.4 Glare

Glare reduces visibility and can be uncomfortable. The light from the lamp should, therefore, be controlled, particularly at higher angles. A frequently used measure of glare control is to limit the intensities emitted from a lantern at any angle of azimuth above 80° to the downward vertical.

3.1.5 Surround Ratio

This is the ratio between the average illuminances on 5m strips on both sides of lines demarcating the edges of the carriageway width. A satisfactory value ensures that sufficient light is falling on the surrounds to the carriageway.

3.1.6 Overall Lighting Uniformity

This is measured as the ratio of minimum horizontal illuminance to the average.

3.2 LIGHTING REQUIREMENTS

The following design criteria are used.

- (i) Horizontal Illuminance
- (ii) Overall Uniformity (Measured as a ratio of Minimum to Average).

Table 1 sets out the lighting requirements as currently used in the UK for the various types of urban area.

	Range of Average Horizontal Illuminances (Lux)	Uniformity (Minimum)	Glare Control* Maximum Candelas	Surround Ratio** (Minimum)
Central Business Districts	20 – 30	0.3	160	0.5
Main Roads	10 – 20	0.2	130	0.5
Housing Estates	3.5 – 6	0.2	160	0.3
Industrial Estates	3.5 – 6	0.2	160	0.3
Minor Roads	3.5 – 6	0.2	160	0.3

* GLARE CONTROL – see 3.1.4. The maximum values shown here are intensities (in candelas/1000 lamp lumens) emitted from a lantern at any angle of azimuth above 80° to the downward vertical.

** SURROUND RATIO – see 3.1.5

Table 1: Lighting Requirements for Various Areas.

3.2.1 Central Business Districts

Lighting here should not only be sufficient for people to see at night, but also to enhance the general atmosphere. For example, throwing light onto adjacent building fronts.

3.2.2 Main Roads

The lighting requirements should be achieved over the whole surface of the road on which vehicles travel. If there is significant pedestrian movement then pedestrian areas should also be included in the design considerations.

3.2.3 Housing Estates

The lighting recommendations should be achieved over the whole of the area between property boundary lines.

3.2.4 Industrial Estates

The lighting in these areas is normally restricted to the road network, the lighting being for the benefit of those travelling to and from the estate. Individual premises would normally provide their own additional lighting for any outdoor loading/working areas.

3.2.5 Minor Roads

These will have less traffic usage than the roads described above. Vehicles will be using their own lights for guidance so the fixed lighting will be primarily for the use of pedestrians.

3.3 CALCULATIONS

Using the expressions defined in (2.2) it is possible to calculate the illuminance at a point from the intensity distribution of the lanterns. However, to cover a road length, many points will have to be taken and then added to the contributions from adjacent lanterns. The process is very tedious and best performed on a computer.

It is more useful for the practising engineer to benefit from others' calculations and experience and use simplified tables of spacings and heights as shown on page 12. These cover two general classes of lantern, namely,

Type A

Distribution which contains a broad beam which is symmetrical about the lantern.

Type B

Distribution with a light beam, directed predominantly onto the road.

Typical isocandela diagrams of Type A and Type B are shown on page 12.

The following pages give tables that can be used as a guide to the levels achieved from these distributions for different heights, road widths and lantern spacings.

NOTE

The spacings shown in the tables are typical for single-sided installations with the lanterns over the edge of the carriageway and inclined at 15° .

Where no data is given, it should not be presumed that the sequence of numbers will continue. What has happened is that the designed illuminance or uniformity can no longer be achieved. For more detailed information a specific calculation should be carried out with the particular lantern.

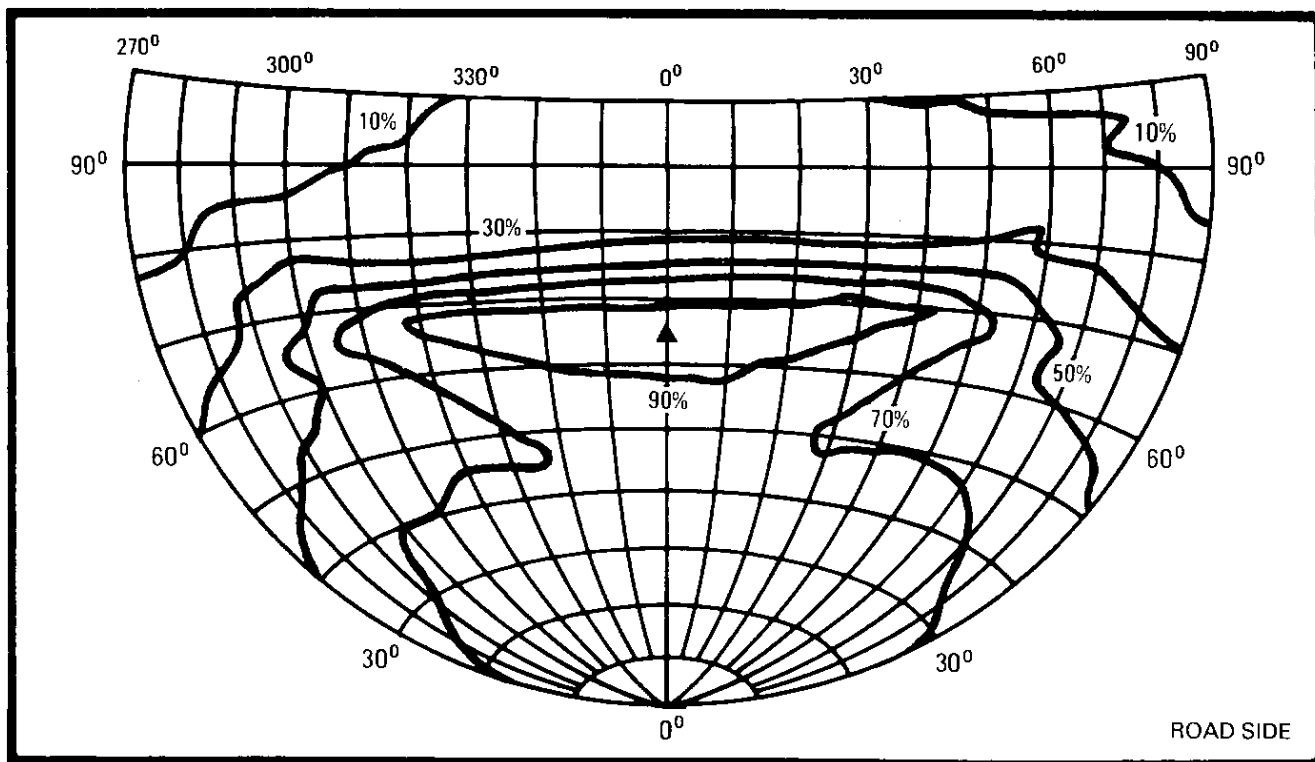


Fig. 6a
Type A.
L.P. Sodium Lantern.

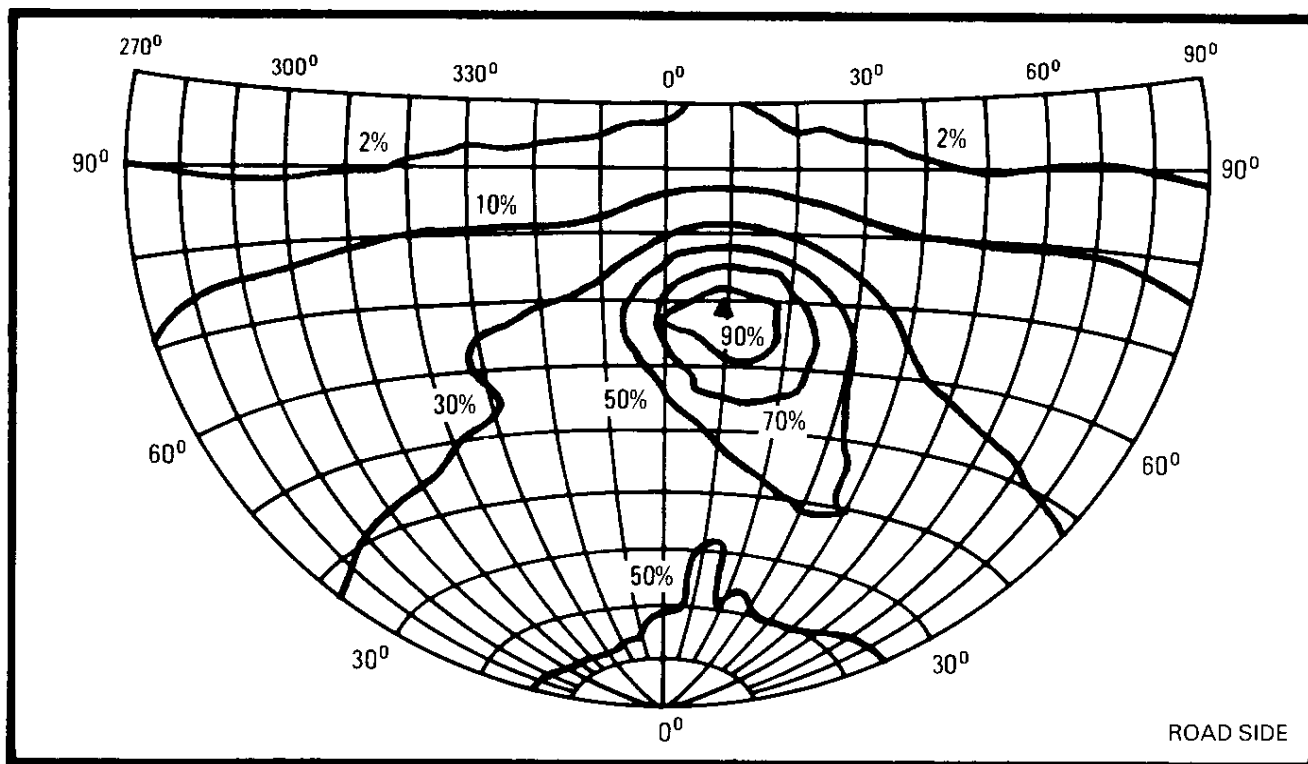


Fig. 6b
Type B
High Pressure Mercury or Sodium.

LANTERN TYPE A									SPACING (m)	
LAMP TYPE	HEIGHT (m)	ROAD WIDTH (m)								LIGHTING LEVEL
		4	5	6	7	8	9	10	11	
35W SOX	4	32	32	32	—	—	—	—	—	3.5 LUX
	5	35	35	35	35	35	34	32	—	
	6	42	40	38	36	33	31	30	29	
55W SOX	6	42	40	38	36	33	32	30	28	6.0 LUX
90W SOX	8	60	60	58	55	52	50	48	46	
90W SOX	8	36	35	35	33	31	30	29	28	10 LUX
135W SOX	10	46	45	45	44	43	41	40	39	
135W SOX	10	—	—	25	24	23	22	21	20	20 LUX
180W SOX	10	—	—	37	36	35	33	32	31	
180W SOX	10	—	—	—	—	22	21	20	20	30 LUX

SPACINGS ARE LIMITED BY EITHER LIGHTING LEVEL OR UNIFORMITY

Table 2a: Spacing for Typical Light Distribution/Lantern Classification.

LANTERN TYPE B		SPACING (m)								
LAMP TYPE	HEIGHT (m)	ROAD WIDTH (m)								LIGHTING LEVEL
		4	5	6	7	8	9	10	11	
50W SON or 80W MBF/U	4	31	30	29	28	26	—	—	—	3.5 LUX
	5	33	32	32	31	30	29	28	27	
70W SON or 125W MBF/U	6	48	47	46	44	43	41	39	37	
70W SON or 125W MBF/U	6	34	33	32	31	30	28	26	24	6.0 LUX
100W SON	6	48	47	45	42	40	38	36	34	
150W SON or 250W MBF/U	8	—	—	48	47	45	43	41	39	10 LUX
100W SON	6	—	—	28	26	23	—	—	—	
250W SON or 400W MBF/U	10	—	—	—	—	55	53	50	47	
250W SON or 400W MBF/U	10	—	—	36	35	33	32	30	28	20 LUX
400W SON	12	—	—	—	—	39	38	37	36	30 LUX

SPACINGS ARE LIMITED BY EITHER LIGHTING LEVEL OR UNIFORMITY

Table 2b: Spacing for Typical Light Distribution/Lantern Classification.

3.4 ARRANGEMENT OF LANTERNS

Special Note All layouts shown in the following examples are for right-hand driving.

3.4.1 Straight Roads

The layouts of lanterns will depend on local circumstances. The most common type of arrangement will be single sided, although staggered and opposite are also possible, particularly on wider roads.

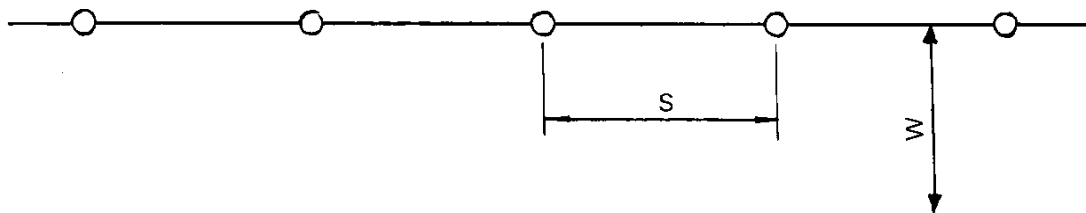


Fig.7
Single side arrangement of lanterns.

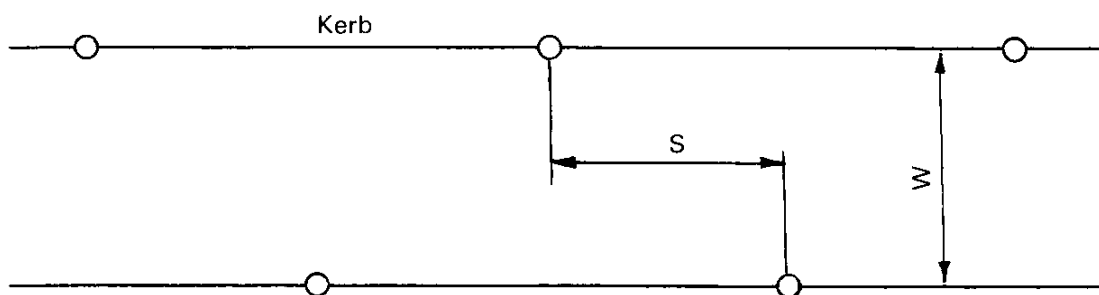


Fig. 8
Staggered arrangement of lanterns.

3.4.2 Bends

For roads with bends it is somewhat more complicated to calculate the required illuminance. A good approximation, however, will be achieved if the straight road spacing is applied, with lanterns moved to the outside edge of the road, but progressively reduced as the radius of the bend decreases.

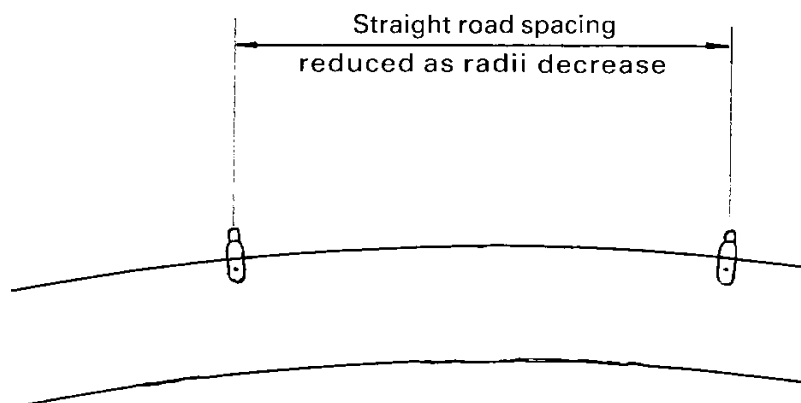
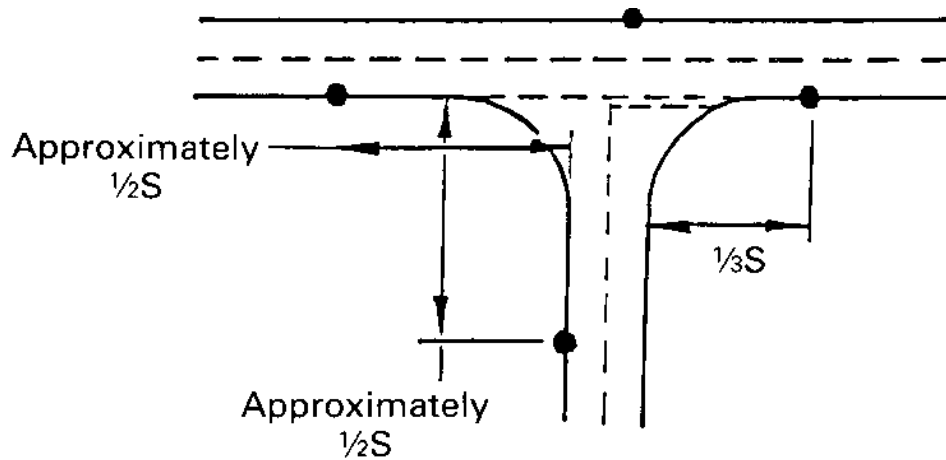


Fig.9
Bends.

3.4.3 'T' Junctions

At all types of junction it is important that the lighting along the main road is seen as continuous as well as providing sufficient illumination and visual guidance for traffic entering the main road. Typical layouts for a variety of junctions are shown below.

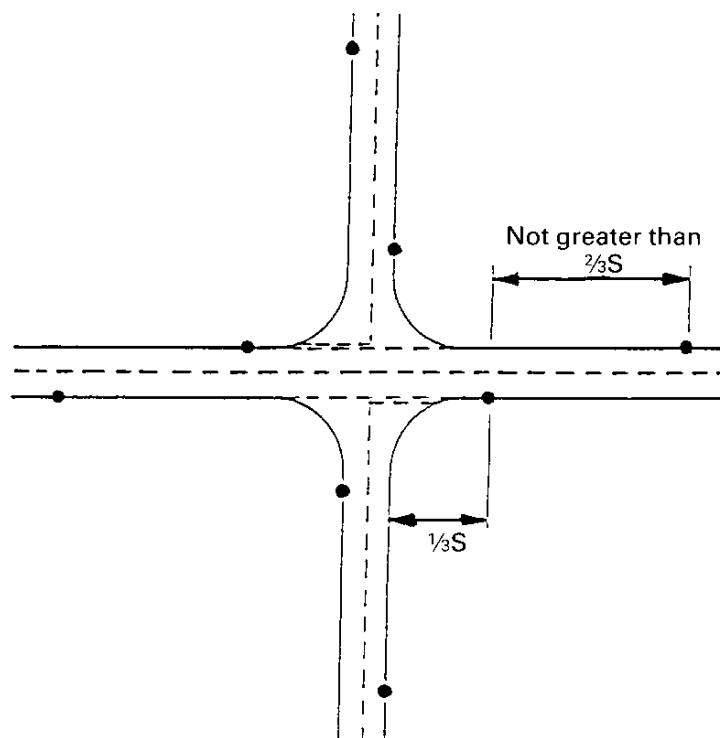


S is the design spacing for the major road

Fig. 10
T-junction.

3.4.4 Crossroads

Lanterns should be sited on the nearside beyond the junction to reveal crossing traffic.



S is the design spacing for the major road.

Fig. 11
Crossroads.

3.4.5 Roundabouts

A roundabout should be lit both for the benefit of vehicles using it and to make its presence clear to oncoming drivers. Placing the columns in the centre of the roundabout can give the impression that the road continues through it, unless a single column is used at its centre. The preferred method is to place lanterns around the outside of the roundabout at spacings not greater than that used for the straight road.

Note:

For further detailed information on lantern arrangement and for left-hand driving, the reader is referred to BS 5489 Part 2 (1987) ⁽³⁾ and for information on road junctions to BS 5489 Part 4 (1987).

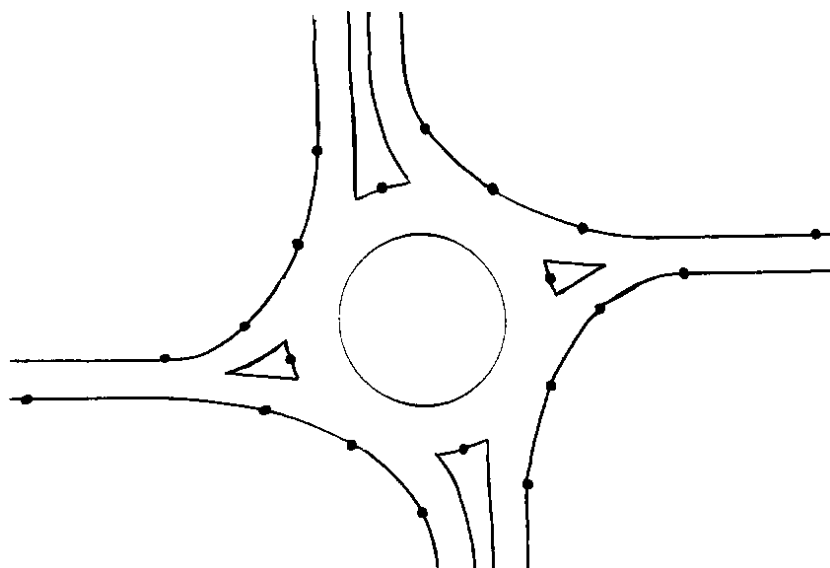


Fig. 12
Example of roundabout at four-way junction.

4.0 LAMPS AND LANTERNS

4.1 LAMPS

The main features of the basic lamp types are shown below (Table 3).

	Efficacy lm/watt	Life Hours	Sensitivity to Voltage	Purchase Cost	Colour Rendering
High Pressure Sodium	130	12000	AVERAGE	HIGH	AVERAGE
Low Pressure Sodium	200	8000	AVERAGE	HIGH	POOR
High Pressure Mercury	60	6000	LOW	MEDIUM	AVERAGE
Fluorescent	80	8000	LOW	MEDIUM	GOOD
Tungsten	14	1000	HIGH	LOW	VERY GOOD

Table 3: Lamp Characteristics.

Lamps should be chosen to meet as many of the following criteria as possible:

- (i) High efficacy and low energy consumption
- (ii) Long life
- (iii) Resistance to fluctuations in the electrical supply
- (iv) Low capital cost
- (v) Good colour rendition

High pressure mercury lamps, although not the most efficient discharge lamp, meet nearly all the above criteria. Their long and reliable life, tolerance to voltage fluctuation and low capital cost, make them ideal for developing countries. A 125W MBF lamp is substantially cheaper to buy than a 70W high pressure sodium lamp and gives a similar output in lumens.

The other cheap source of white light is the fluorescent tube. Lamps may be manufactured within the country and simple fixtures for 600mm (2ft), 1200mm (4ft) and 1500mm (5ft) tubes obtained locally.

Low pressure sodium lamps give the most efficient energy consumption, but their operation is less stable if the voltage is low, especially using low loss gear. Although they have poor colour rendering characteristics, they are still widely used in many industrialised countries, give excellent service and should not be overlooked.

High pressure sodium meets most of the criteria, but the capital and replacement costs, plus more expensive circuitry, make them less attractive, especially in the lower wattages.

A further consideration influencing the choice of lamp could be that of energy consumption. However, if energy costs are low, it may be that energy saving does not make up for the extra capital cost of more sophisticated lamps. Concentrating on a more reliable and stable power supply could be preferable.

4.2 LANTERNS

Lantern bodies should be corrosion resistant, made in aluminium or reinforced plastic material.

Totally enclosed lanterns should be particularly well sealed with an IP rating of at least IP 54. Special attention must be paid to gasket material, especially its resistance to tropical climates and insects.

Lamp compartments should preferably be a separate enclosure from the gear compartment, with sealing to prevent insects getting through the bracket arm into the lamp enclosure. It is particularly important to seal the lamp housing.

Enclosing bowls should be impact resistant acrylic or similar, to resist damage. Polycarbonate is not to be recommended as high levels of sunshine will accelerate discolouration even with UV stabilised polycarbonates.

For rural areas, an open lantern may well be a satisfactory and a relatively inexpensive alternative.

Where some form of switching is possible, lanterns with two lamps can be used, each lamp producing the same light distribution. This has the advantage that one lamp can be switched out later in the evening, and the chance of complete loss of light is reduced.

Where column base compartments are unavailable, lanterns with integral control gear can be used to avoid separate control boxes.

5.0 LIGHTING COLUMNS

5.1 INTRODUCTION

Lighting equipment is sometimes supported on available buildings or existing electricity supply poles. These simple supports can give rise to problems of replacement and maintenance, and the decision may be taken to use specially designed supports (which are readily available from many sources). The economics of local manufacture should be carefully considered. This section looks at the choices and decisions to be made in using lighting columns.

5.2 MATERIALS FOR COLUMN MANUFACTURE

Lighting columns are available, or can be made, in a variety of materials. Selection depends upon local availability and cost. Among the most common materials are:

5.2.1 Concrete

Concrete columns are virtually maintenance free, and will generally give a long and satisfactory life. However, they are heavy to transport and must be handled with reasonable care to prevent cracking until erected. (See also Section 6.2.3.)

This material may not, therefore, be satisfactory when transported long distances over poor roads but economic for a country which has concrete manufacturing facilities in advance of steel or other materials.

5.2.2 Steel

If the raw material is available, only relatively simple plant is required for the manufacture of tubular steel columns. Larger, more specialised, plant is needed for folded sheet steel columns.

Steel will corrode very quickly unless suitable protection is applied and maintained. Hot dip galvanising is the best treatment. This requires the column to be dipped into a sufficiently long galvanising bath to provide a zinc coating that is chemically bonded to the parent metal.

There is a great variety of applied protective coatings which can either be dipped, sprayed or applied by brush, but most will have a finite life before repair or further protective coating will be required. The actual life will depend upon the local humidity and temperature, and possible air pollution. In coastal regions, there is a need for increased protection against the salt-laden atmosphere.

5.2.3 Wooden Poles

In some circumstances, lighting equipment may be carried on wooden poles. Great care should be taken to protect the column roots with bitumen, plastic sheathing or other rot-resisting compounds. The remarks in 5.4.4 regarding possible attack by termites or other pests should also be noted.

5.2.4 Other Materials

Materials such as stainless steel, aluminium or glass fibre reinforced plastic can be used to make lighting columns but should only be considered if there is a local supply.

5.3 PHYSICAL DETAILS

The height of the column will be determined by the lighting requirements, but the need for maintenance access and the availability of suitable equipment to reach the lanterns must be borne in mind. (See Section 7 [Maintenance].)

If brackets are used, they must obviously be of sufficient height to allow all traffic to pass underneath without damage. Brackets are frequently supplied separately and the connection should be sufficiently robust to resist the design loads and prevent the entry of rain water.

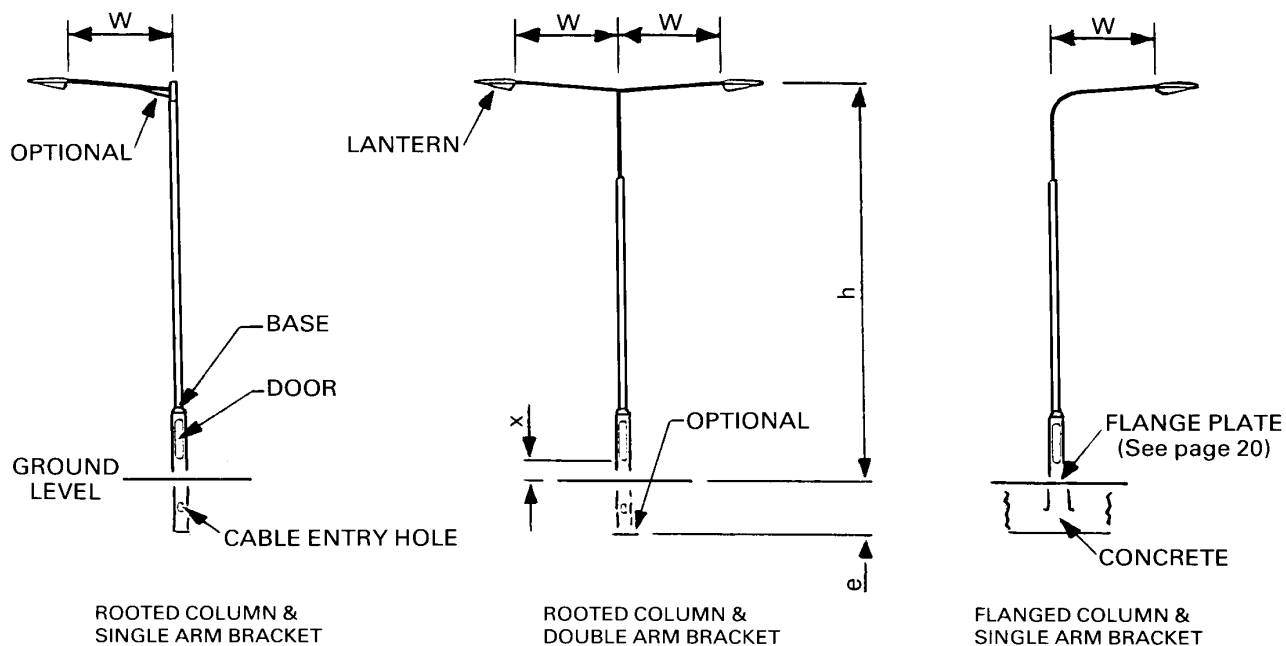
A great variety of designs are available and the sketches in Fig. 13 show some basic types with their principal dimensions and terms.

The method of securing the lantern should be considered and the dimensions of the spigot or other fixing detail specified for the selected lantern. (Fig. 14.)

If the electrical supply is by means of an underground cable and the control gear is to be housed in the base of the column, there will be a need for a cable slot in the column and a door large enough to give free access to the gear compartment.

If the control gear is in the lantern a much smaller compartment will be needed in the column.

Where the supply of power is from an overhead cable the control gear may either be housed in the lantern with possibly a small door in the column for a fuse compartment, or in a box attached to the column.



- COLUMN SHAPES: PARALLEL SIDED; STEPPED; TAPERED; OR COMBINATION OF ALL THREE; CIRCULAR OR POLYGONAL
- BRACKET SHAPES: POLYGONAL OR CIRCULAR; RIGHT-ANGLE OR SWEPT. A GREAT VARIETY OF ALTERNATIVES.
- KEY ELEMENTS: NOMINAL HEIGHT (h).
 BRACKET PROJECTION (w) NOT GREATER THAN $h/4$.
 BASE COMPARTMENT & DOOR
 COLUMN ROOT DEPTH (e).
 CABLE ENTRY HOLE.
 BASEPLATE WHEN REQUIRED AT BASE OF ROOT TO PREVENT SINKING.
 FLANGEPLATE AT GROUND LEVEL TO SECURE COLUMN WITH FOUNDATION BOLTS
 HEIGHT OF DOOR OPENING (x) GENERALLY GREATER THAN 300mm (1 ft).

Fig. 13
Column and bracket typical details.

5.4 DESIGN

5.4.1 The actual structural design process of the column itself is beyond the scope of this document but a column has to be designed for the imposed wind load it is expected to survive, and possibly the loading from overhead electrical supply cables if these are attached to, or supported by, the column.

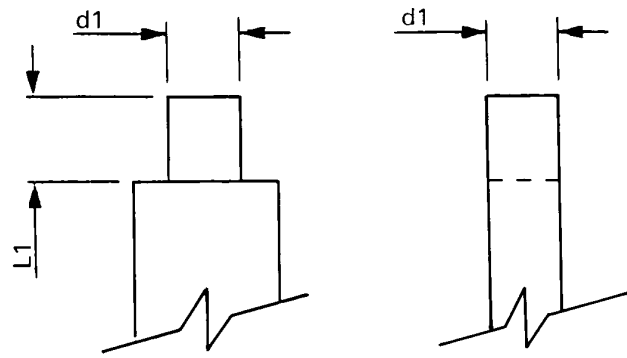
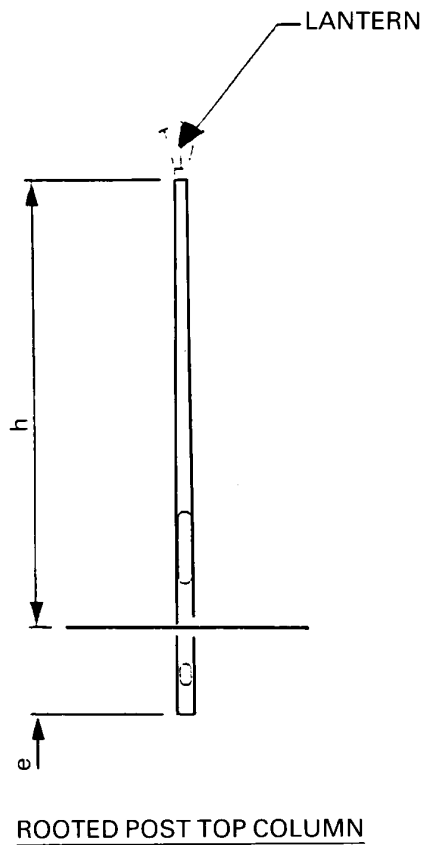
5.4.2 Wind Speeds

There are a number of design documents which are based on the expected wind speed or wind pressure, for example BS 5649-Lighting Columns: Part 6 – Loads⁽⁵⁾. Information on wind speed may not be available and a reasonable assumption will have to be made for the area. A pessimistic assumption of high wind loading will result in large, heavy and expensive columns.

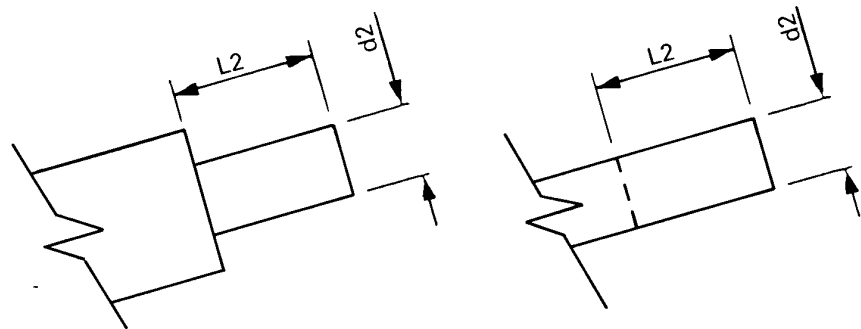
5.4.3 Foundations

In general, the most straightforward form of foundation for a lighting column is a simple root which is embedded in the ground with or without a surrounding concrete back-fill.

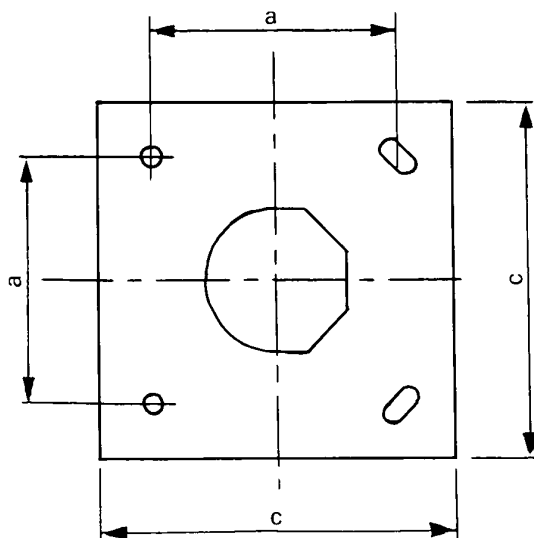
In certain aggressive soils the column material may be attacked below ground and a protective coating of bitumen or a plastic sleeve should be used.



TYPICAL POST TOP LANTERN SPIGOTS
 $d1$ LANTERN SPIGOT DIAMETER
 $L1$ LANTERN SPIGOT LENGTH



TYPICAL SIDE ENTRY LANTERN SPIGOTS
 $d2$ LANTERN SPIGOT DIAMETER
 $L2$ LANTERN SPIGOT LENGTH



TYPICAL FLANGE PLATE DETAIL FOR CIRCULAR
 OR POLYGONAL COLUMN USING CIRCULAR
 OR SLOTTED HOLES FOR FOUNDATION ANCHOR BOLT FIXING.
 a FIXING HOLE CENTRES
 c FLANGE PLATE DIMENSIONS

Fig. 14
 Post top column and lantern spigot type details.

The length of the root will depend on ground conditions but the following are generally adequate:

Height m	Root mm
5	600
6	800
8	1000
10	1200

Table 4: Length of Recommended Column Root.

A method of checking the strength of root foundations is given in the National Appendix B of BS 5649-Lighting Columns: Part 2-Dimensions and Tolerances⁽⁶⁾.

5.4.4 Special Considerations

Local conditions may affect decisions on selecting or designing a column. For example:

Termites and Vermin: Such pests may prevent the use of base compartments and wooden gear back boards due to the danger of nesting or destruction.

High Humidity: Ventilation may have to be provided to a column with a cable way by means of a breather hole at the base and top which permits air movement without allowing rain to enter. Such ventilation can be incorporated into the door rather than the column structural section.

Dust and Sand: In areas of dust or sand storms, special considerations of door openings or breather holes may be necessary.

Unauthorised Access: A column base compartment door cannot be made so strong that it can be guaranteed to prevent unauthorised access, but the design of the door and its attachment should be sufficiently robust to prevent easy access by vandals or those wishing to steal the equipment or power supply. If there is a threat of persistent vandalism, the door should be positioned above 2.5m from the ground or housed between the column and bracket.

6.0 INSTALLATION

6.1 SAFETY

The installation and subsequent maintenance of road lighting is, by virtue of its nature and location, potentially dangerous. Adequate precautions must be taken to protect the workmen and the general public.

6.1.1 Safety Considerations

These include:

- (i) Traffic management to suit local conditions and traffic speeds.
- (ii) Operator training in the safe use of cranes and slings used in the erection of columns.
- (iii) Operator training in the safe use of ladders, scaffolding and powered access equipment when working on lanterns.
- (iv) The employment of skilled electrical fitters for wiring and testing.

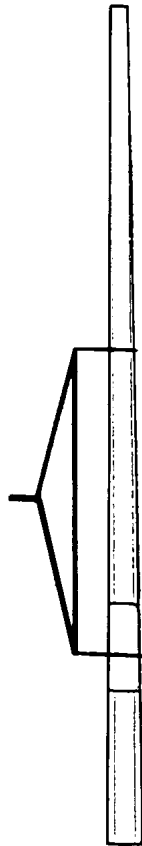
6.1.2 Safety Clothing and Apparatus

Work on live equipment requires great care and precautions must not be neglected. It may be necessary to use insulating gloves, insulated tools and non-metallic ladders, and their condition must be checked before using.

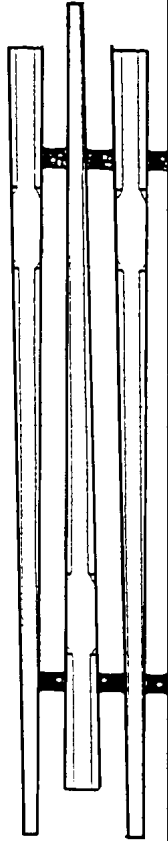
HANDLING AND STACKING OF COLUMNS

CONCRETE COLUMNS

Correct lifting procedure
Use only ropes or slings—not chains

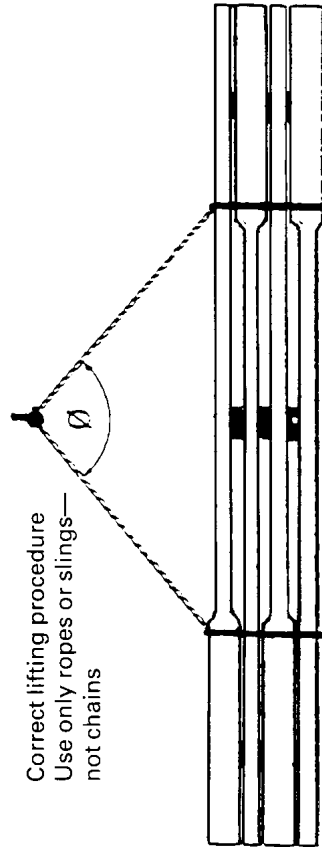


CLASS A COLUMNS One just below the door and one 5ft. from the top.
CLASS B COLUMNS One just below the door and one 4ft. from the top.



STEEL COLUMNS

Correct lifting procedure
Use only ropes or slings—not chains



Correct stacking procedure



Smaller gap on steel,
needs three sets of wooden bearers

Courtesy of CU LIGHTING LTD.
and British Steel Corporation.

Fig. 15

Remember that mains voltage electricity can kill.

All safety clothing and equipment should be kept in good, clean and undamaged order.

6.1.3 Avoiding Danger from Buried Services

Where underground obstructions are likely to be encountered, excavations should be carried out by hand to determine their depths and positions.

6.1.4 Adequate Working Clearances

During installation and maintenance it may be necessary to work near to overhead conductors. Where any equipment (including lifting equipment or access platforms) is used near overhead lines, these must always be regarded as 'live'. Locally agreed working clearances must be strictly observed (see Fig. 17).

6.1.5 Warning Notices

Where maintenance or installation work is being carried out on cable distribution systems, the circuits must first be isolated at all points and warning notices displayed. If practicable, the circuit should be locked off.

6.1.6 Use of Restraints and Harnesses

Harnesses and restraints should be used to prevent injury from falls, which may be accidental or result from reflex action from electric shock.

All equipment used for restraint purposes should be inspected regularly and replaced if damaged or unduly worn. A false sense of security can itself be a danger.

COLUMN AND LUMINAIRE ERECTION

6.2 PREPARATORY WORKS

6.2.1 Marking of Sites

The positions of the columns and/or brackets should be checked against the site plans. The positions should be marked in agreement with the engineer on the site, in such a way that the markings will not be obliterated before work begins.

IMPORTANT NOTE

Once again, the need for sufficient clearance between any equipment installed and existing overhead conductors is strongly emphasised.

6.2.2 Excavations

Holes should be excavated to the appropriate column planting depth. The width of the excavation should be kept to a minimum and the surrounding soil should be disturbed as little as possible. See also Section 5.4.4.

Immediately before erection the excavation should be examined to see that it is clear of obstructions, and the foot firm and free from water and loose soil.

6.2.3 Handling of Columns

Columns should be unloaded, stacked and erected strictly in accordance with the manufacturer's instructions. Particular care should be taken when handling concrete columns. (See Fig. 15.)

6.3 ERECTION

Before erecting a lighting column the site should be checked to ensure that the light from the lantern will not be obscured by existing or possible growth of foliage. Remember that the light has to strike the road surface a considerable distance from the column.

6.3.1 Alignment

Columns should be correctly aligned in the vertical position. If no instruments to do this are available, lining up by eye can be remarkably accurate. The door opening should face away from oncoming traffic or should face the road if erected at the back of the footpath and sufficient clearance exists from the road edge for safe working.

6.3.2 Back-Filling

When columns have been placed in position, the holes should be filled and firmly consolidated.

Excavations should be filled with enough concrete to hold columns firmly in their true positions. The concrete should be well mixed, i.e., there should be a uniform distribution of material and the mass be uniform in colour. The concrete should be thoroughly tamped and compacted by hand, at intervals of not more than 150mm, at the same time ensuring that the column does not move from its correct alignment. See also Section 5.4.3.

Provisions must be made for the entry of underground services to the columns. (Fig. 16.)

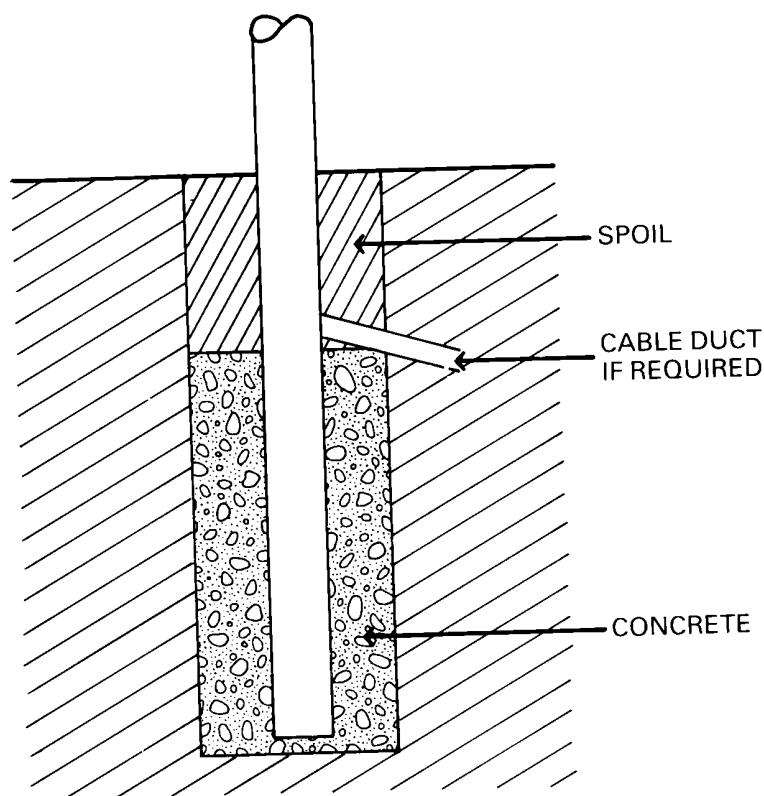
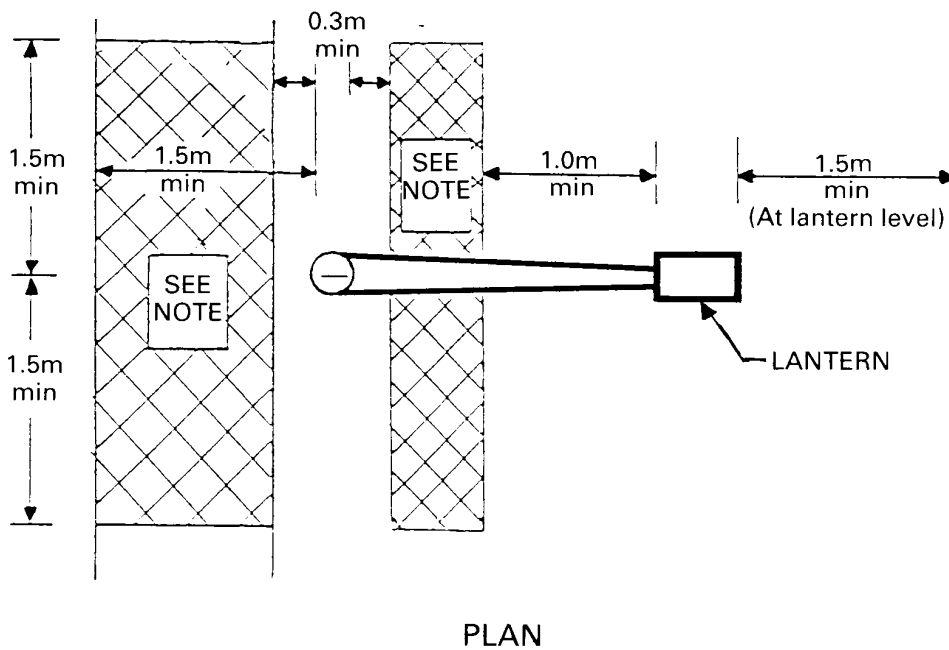
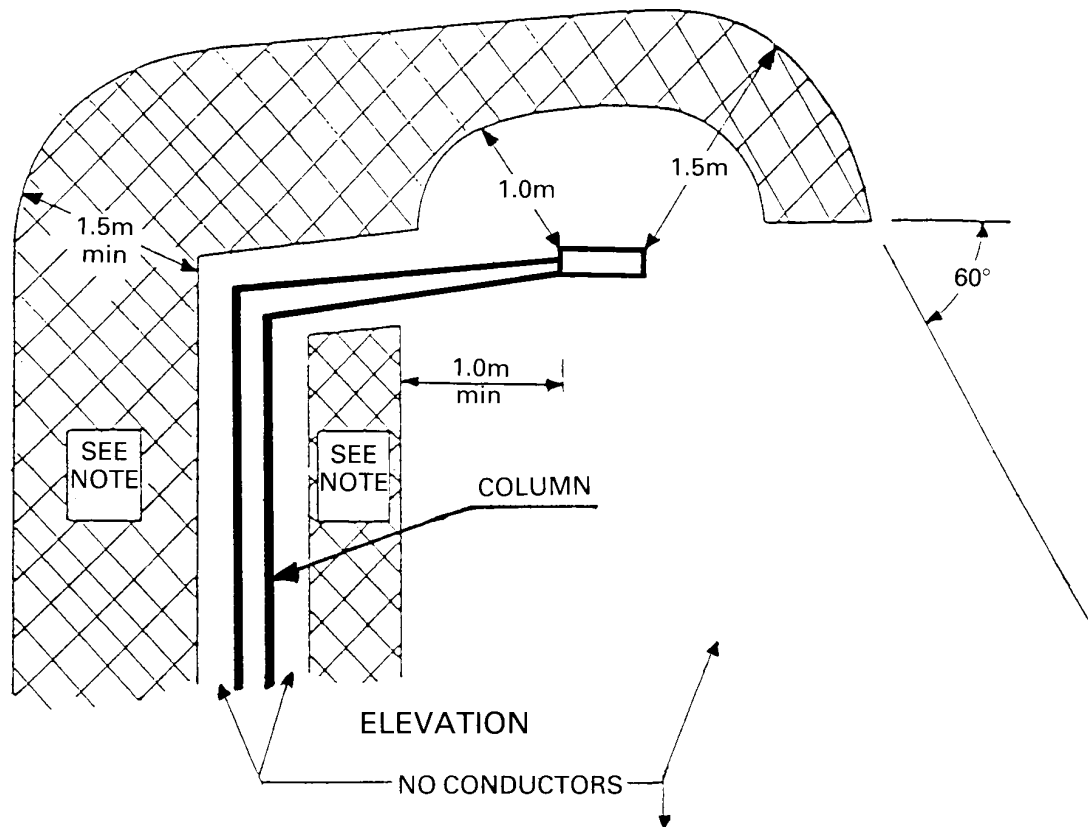


Fig. 16
Provision for entry of underground services to column.

6.3.3 Temporary Reinstatement

The remainder of the hole should be fitted with spoil which should be well rammed at regular intervals. The finished level should be substantially the same as that of the surrounding ground level. The earth around the column should not be disturbed for at least seven days after erection to ensure adequate curing of the concrete.



A All phase, neutral and switchwire conductors in this area shall be insulated for 1.5m minimum on each side of column

Fig. 17
Clearance from MV/LV Conductors.

6.4 TREATMENT OF COLUMNS AFTER ERECTION

6.4.1 Concrete Columns

The joints between parts of concrete columns should be sealed in accordance with the manufacturer's instructions.

6.4.2 Steel Columns

The exterior surface and external metal attachments of metal columns should be painted, if required, after erection.

6.4.3 Numbering

After erection, columns should be clearly marked with painted numerals, or with number plates or separate characters firmly fixed to the columns. This is to ensure that all columns can be individually identified for maintenance purposes.

6.5 ELECTRICAL EQUIPMENT

6.5.1 Lanterns and Lamps

Lamps should be fitted to the lanterns after the columns have been securely fixed in their vertical alignment. Together with any optical components, they should be correctly set up in relation to the road in accordance with the manufacturer's instructions. Lamps, reflectors, bowls, refractors and photocells should be clean and free from dust or obscuring films after assembly.

6.5.2 Wiring

Lanterns, switches, control gear and accessories should be fitted, wired and connected in accordance with the local Electricity Supply Authorities' requirements. The ILE Code of Practice for Electrical Safety gives useful general guidance⁽⁷⁾.

6.6 WALL AND BRACKET MOUNTING

Where lanterns are to be fixed to existing transmission poles the requirements of the supply authority should be complied with. Remember to make due allowance for operator safety by leaving sufficient clearance in accordance with Fig. 17.

When fixing to walls, care should be taken to make sure that the structure is strong enough to support the lantern and bracket. In some cases, backing plates may be required to spread the load.

Control gear which is not located inside the lantern should be housed in robust waterproof and tamperproof containers, securely fixed to the wall or pole.

Surface wiring between the lantern and control gear should be protected to a height of two metres above ground by means of galvanised steel conduit with screwed joints and should be securely fixed to the wall at not more than 1.0m centres.

7.0 MAINTENANCE

7.1 General

The importance of good maintenance cannot be stressed too highly.

Any well designed lighting installation will require regular and cost effective maintenance. If lights are left out of service, the design work is negated, the public dissatisfied, vandalism encouraged and traffic accidents increase.

The objective of lighting maintenance is to ensure efficient, safe and reliable working of the installation.

This will be achieved by:

- (i) Regular night inspection for failed lamps.
- (ii) The replacement or repair of defective equipment.
- (iii) Regular cleaning of the optical components.
- (iv) The programmed replacement of lamps at the end of their useful life.
- (v) The regular testing of the electrical equipment.

7.2 Night Inspection

During the course of a year, between 30% and 70% of the lanterns in an installation will fail. Experience has shown that members of the public cannot be relied upon to report which lights have failed and, therefore, a system of inspection must be instituted. This inspection is phased to enable the subsequent repairs to be carried out logically and economically.

Each lighting point should be inspected during the hours of darkness to establish which lights have failed.

The frequency of this inspection will depend on:

- (i) The level of service required. A maximum of three lamps out of 100 not working is often considered reasonable in industrialised countries.
- (ii) The annual burning hours of the lamps, and whether lit all night or part night.
- (iii) Whether lamps are bulk changed or burnt to destruction. (See 7.5.)
- (iv) The reliability of other components and their age.
- (v) The likely incidence of damage from vehicles, vandals or other causes.

If sufficient data is available, the ideal routine frequency of inspection can be calculated but such information often takes many years to compile. In British conditions, taking an average of many installations using discharge lamps burning all night, the optimum frequency is once every two weeks where lamps are burnt to destruction and once every three weeks where lamps are bulk changed. (See 7.5.)

Inspection should begin at lighting-up time on a route preplanned to cover all of the installation. The starting point of the route can then be varied on subsequent inspections to check the accuracy of the switching devices.

It is generally more economical to note the failed lighting and attend to it the following day rather than to attempt a repair during the course of the night inspection. This means that the patrol can be on bicycle or even on foot, since there is no need to provide immediate means of access to the light source.

After the night inspection the reported faults together with faults reported from other sources should be investigated. Lighting should be returned to service in the shortest economical time and in any case before the next inspection is due.

7.3 Repairs

This includes such work as:

- (i) Replacement of random type failure.
- (ii) Replacement or repair of faulty equipment-electrical or structural.
- (iii) Supply fault rectification.
- (iv) Replacement or repair of equipment damaged by accident or vandalism.

The repair team should carry sufficient replacement components for their day's work. A logical sequence for finding the cause of failure is given in the flow chart (Fig. 18). Substitution of any faulty components should be made according to this pattern. Note that testing of control gear is rarely practicable on site.

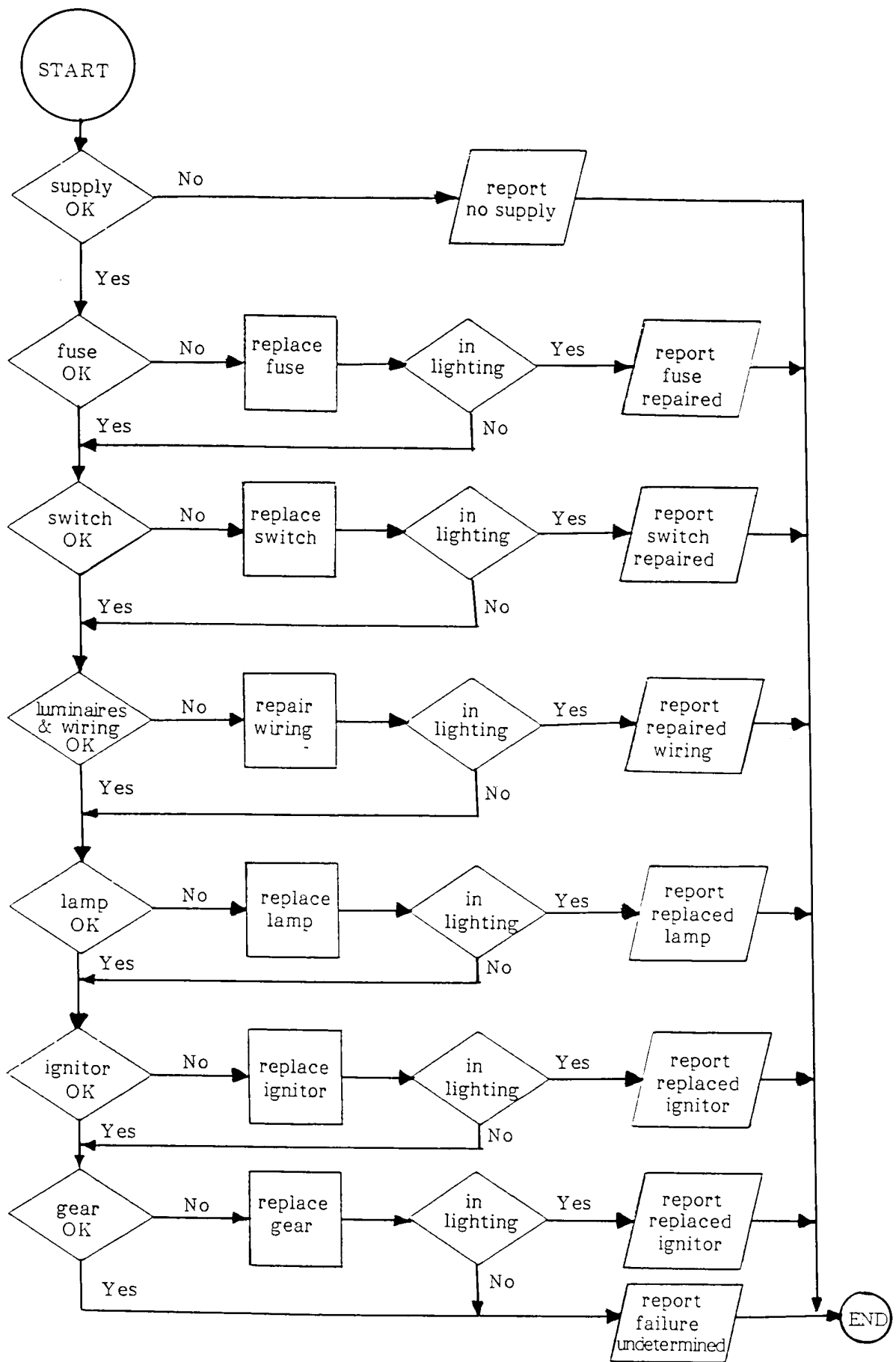


Fig. 18
Flow Chart.

Test procedure for fault analysis in a lighting system.

7.4 Cleaning

The cleaning cycle should take account of local levels of air pollution and the IP rating of the equipment.

Light from the lantern will reduce with time due to the build up of dust and dirt on both the inside and outside faces of the optical components. To minimise this it is essential to clean at regular intervals.

Plastic surfaces should *not* be polished. They should first be cleaned with water containing a small quantity of suitable detergent, then wiped over with a leather or cloth soaked in clean water (or a proprietary spray cleaner may be used).

7.5 REPLACEMENT OF LAMPS

Relamping is carried out in one of two ways. These are:

- (i) *Random Change*
Replacing lamps individually on failure.
- (ii) *Bulk Change*
Replacing groups of lamps at a predetermined life.

7.5.1 Lamp Survival

The pattern of lamp failure is not predictable. Some lamps fail early in life during the manufacturer's guarantee period, some fail during average life, whilst others will operate for a long time giving a reducing light output.

Most discharge lamps have a long period of life but their lumen output falls to uneconomically low values long before they fail.

Eventually, however, all lamps will fail.

Random replacement of lamps can be twice as expensive as planned cyclic replacement. Although the burning period of the lamps is extended, labour and transport costs are increased due to the random nature of the operations. There is a danger that when certain discharge lamps are burnt to destruction, damage to the control gear may result. A bulk change policy means that lamp replacements are planned. Travel between lights is minimised and since random failures between bulk changes are fewer, a better level of service is achieved. There are variations in the method of a planned replacement cycle:

- (i) All lamps are replaced at the bulk change. Selected randomly replaced lamps, having been in service for less than the manufacturer's guarantee period (or within one year) are recovered and used for random replacements in the next cycle.
- (ii) All lamps except those recently replaced as a result of random failure are changed.

These systems rely on the lamp having a date code applied at the time of replacement.

Although individual lamp failure is not predictable, studies of lamp life may show a pattern. For instance, the orientation of lanterns in relation to prevailing winds may produce vibrations that affect the performance of the lamp.

7.6 INSPECTION

A visual inspection of the electrical equipment and internal wiring of the column and lantern should be carried out at intervals not exceeding three years. The following actions should be taken:

- (i) Verify that the rating of the fuse or circuit breaker is correct.
- (ii) Ensure that the electrical equipment has been correctly installed with particular regard to Earthing Bonding.
- (iii) Ensure that there is no visible damage which might impair safety.
- (iv) Inspect the structure inspection of the bracket, column or pole together with the security of the fixing devices at intervals *not exceeding three years* for cracks, corrosion, defective welds, damage and insect infestation.

It is cost effective to carry out these visual inspections at the same time as cleaning.

7.7 TESTING

The electrical installation should be tested at intervals *not exceeding five years*. The tests carried out should include the following:

- (i) Earthing Electrode Resistance
- (ii) Insulation Resistance
- (iii) Polarity
- (iv) Earth Fault Loop Impedance
- (v) Operation of RCCB (Residual current circuit breaker)
- (vi) Voltage Drop

Advice and guidance on these matters is given in the ILE Code of Practice⁽⁷⁾.

7.8 RECORDS

Accurate records are vital to the successful running of a lighting system. They should enable managers:

- (i) To identify the equipment installed.
- (ii) To monitor its performance.
- (iii) To programme the routine maintenance.
- (iv) To verify the energy charges (if not metered).

Consequently, a system of recording the installation and its equipment should be initiated that details the following:

- (i) Identity No. (as recorded on the pole or column).
- (ii) Location.
- (iii) Mounting height and bracket outreach.
- (iv) Type of mounting (column, pole or wall bracket).
- (v) Electricity supply. (Statutory authority, own supply and source.)
- (vi) Lantern type.
- (vii) Light source (type) and wattage.
- (viii) Control gear.
- (ix) Switching apparatus. (Photocell, Timeswitch, group switching).
- (x) Routine maintenance dates.
- (xi) Bulk lamp change dates.

The above list should be considered the minimum requirements. A considerable amount of further information could be collated but care should be taken to ensure that data recorded will be used. It is expensive in clerical time to collect and store information that is unlikely to be consulted afterwards.

The method of keeping the records can be either a card system with a card for each luminaire position (Fig. 19) or preferably by storing the information on a microcomputer (Fig. 20). There are several street lighting software packages available commercially. However, most Database packages are now capable of handling the above requirements and are relatively simple to configure to the specific requirements.

The computer has the advantage of quickly providing totals of the installed load, various light sources and mounting heights (Fig. 21) together with the dates.

DESCRIPTION

SOUTHBANK. OPPOSITE N° 10

BULLEN'S GREEN
LAKE.

			COLUMN	LANTERN	LAMP	TYPE	GEAR	SWITCH	INSP.	CLEAN
14.3.82	NEW INSTALLATION		BS.5M	M150	35	SOX	LL	PC		
4.10.82	FUSE									
7.11.82								✓		
18.4.83									✓	✓
30.7.84	BOWL FITTED									
27.11.84	TX						✓			
5.2.85	FUSE									
10.3.85	BULK CHANGE				✓				✓	✓
14.4.85	KNOCK DOWN	✓	29530				✓	✓		
21.7.85	LAMP HOLDER									
8.8.86									✓	✓
11.11.86	CAPACITOR						✓			
6.3.87	B.C.				✓	SOXE				
30.3.88	IGNITOR						✓			
8.4.89									✓	✓
10.6.89					✓					

Fig. 19
Card Index Record.

Record 3 ANYTOWN INV on screen

ANYTOWN D C STREET LIGHTING INVENTORY	
BULLENS GREEN LANE	SOUTHBANK
UNIT TYPE (S=sign, B=bollard, L=light): <u>L</u>	LAST UPDATE: <u>/ /</u>
UNIT No.: <u>1</u>	LOCATION: <u>WEST SIDE ON GREEN</u>
COLUMN: <u>BRITISH STEEL</u>	hght (M): <u>5</u> brkt: <u>3</u> date erect: <u>21/07/78</u>
LANTERN: <u>PHILIPS M150</u>	
LAMP (watts): <u>35</u> (no.): <u>1</u> (type): <u>SOX</u>	date fitted: <u>06/06/87</u>
GEAR: <u>LL</u>	date fitted: <u>/ /</u>
SWITCH CONTROL: <u>EB</u>	PILLAR LOCATION: <u>BULLENS GREEN</u>

COUNT

Fig. 20
Fault Recording-Micro-Computer Recording System.

LISTING OF LAMPS INSTALLED BEFORE 01/04/87 REQUIRING CHANGE

AREA = SOUTHBANK

LAMP TYPE	ROAD NAME	QTY	
35W SOX	BOISSY CLOSE	2	
	CUTMORE DRIVE	7	
	FELLOWES LANE	15	
	FRANKLIN CLOSE	5	
	HALL GARDENS	14	
	HIGH STREET	7	
	HILL END LANE	9	
	HOBBS CLOSE	6	
	LYON WAY	4	
	MOONRAKERS	2	
	ROESTOCK LANE	3	
	SLEAPSHYDE LANE	11	
	SLEAPSHYDE, SLEAPCROSS GDN	10	
	SPRINGFIELD ROAD	6	
	WILKINS GREEN LANE	6	
		107	107
36W SOX-E	HILL END LANE	2	
		2	2
91W SOX-E	OAKLANDS LANE	1	
		1	
		1	1
			110

Fig. 21
Bulk Change Instruction.

8.0 COSTS

Cost Effective Lighting

All civic authorities have a responsibility to spend their scarce resources to maximum effect. To this end it is most important to remember that the cost of providing a lighting scheme is not limited to the initial expenditure on equipment and its installation. There are additional, continuing expenses which have to be taken into account, such as the cost of electrical energy, the repair and maintenance of equipment, the replacement of lamps and the costs of recording and managing the scheme.

This total funding is referred to as a 'Whole Life' cost and it is essential that this concept is understood before undertaking an initial capital investment in equipment.

The lowest equipment price may not prove the best value for money in the long run.

8.1 Assessing 'Whole Life' Cost

The following items should be thoroughly examined and, where possible, accurately costed. This may prove difficult initially but as detailed data builds up the original assessment can be up-dated and the information kept for costing future projects.

8.1.1 Capital Cost

The capital cost of the installation includes the materials, erection and connection to the electrical supply. If the capital is being financed from a loan then the effective cost can be considered spread over the life of the installation. Interest charges would then be included in completing a notional annual cost.

A bulk purchase, put out to competitive tender, is likely to result in lower costs and this should be done wherever possible. Local availability or ease of importing may affect the price, but if the result is a low quality product with a greatly reduced life, it will prove an expensive choice in the longer term.

Productivity of labour forces is likely to vary and this will affect the costs of installation and cabling. Care should be taken to obtain the best value for money; here again, a contractor with a proven record of good practice, even if not the cheapest, may prove less expensive eventually.

8.1.2 Electrical Energy

The annual cost will depend on the period each night that lamps are working and the cost per unit of electricity. Energy costs can be minimised by selecting energy efficient lamps. For example, it may be more economic to spend an extra £30 on a more energy effective light source if this results in a saving of £7.50 a year on energy, since this will give a 4-5 year pay-back for the investment.

Where quantities of power are being increased, it is sometimes possible to negotiate more favourable terms with the Power Supply Authority.

8.1.3 Lamp Replacement

Lamp replacement costs are affected by the number of hours that lamps are due to be burned each year. As explained earlier, all lamps fail and it is economically preferable to replace lamps on a bulk change cycle than to wait until they cease to work.

Burning lamps to failure requires fewer lamps but can cause damage to control gear. It also gives an inefficient lighting scheme, with many lamps out of commission at any one time and others which have lasted a long time giving out much less than their normal output. Bear in mind, also, that to identify additional random failures, more night inspection will be needed, with resulting expense.

8.1.4 Repairs and Replacements

Repairs and replacements resulting from damage or deterioration can account for at least half of all lighting failures. By incorporating this work into a routine to be carried out after regular night-time inspections, labour costs can be halved.

Purchasing small quantities of replacement components as they are needed can prove costly and incur delays. It is better to assess likely requirements over a period of several months, ensuring that spares are available and bought in economic quantities.

8.1.5 Routine Maintenance

Night-time inspection is cost effective because it reduces to a minimum the time for which lights are not working. Productivity levels vary, depending on factors such as the means of transportation, good route planning and motivation. It has already been stressed that an efficient, well planned service can be inexpensive and is much more reliable than responding to public complaints.

Neglect of routine maintenance may save expenditure in the short term but it can lead to an inefficient lighting scheme that deteriorates very quickly. The cost of total replacement usually exceeds the cost of routine maintenance.

If labour and plant costs are considered high it may pay to spend (for example) £15 more to have lanterns with a higher IP Rating and so save perhaps £3 a year on cleaning costs, giving a 5-6 year pay-back period.

Lighting columns that require no maintenance may be more expensive to purchase, but savings in repainting costs can often justify this expenditure.

8.2 Cost Effective Assessment

From the foregoing paragraphs it will be seen that the method of establishing an annual charge enables the engineer to assess the cost effectiveness of different options, even if the calculations are approximate and need refinement over time.

9.0 THE BENEFITS OF LIGHTING

The preceding section has discussed the various cost components of public lighting, and stressed that the aim must be maximum effectiveness of the lighting for the minimum whole life cost.

9.1 Benefits

The engineer may be challenged to show that the benefits attained by lighting outweigh its costs. Many of these benefits are impossible or difficult to quantify but they include:

- (i) A reduction in petty crime, personal robbery and burglary.
- (ii) An increased feeling of security for citizens.
- (iii) The opportunity for more night-time trading and commercial activity.
- (iv) Making city centres more attractive, especially for visitors and tourists.
- (v) The creation of better driving conditions, especially for two-wheelers (with their inadequate lighting systems).
- (vi) An increased use of the road network at night, helping to reduce day-time and peak-hour congestion.

The only benefit which *can* be quantified at present is the reduction in night-time traffic accidents. A common method of putting a cost on these is the 'gross output' or 'human capital' approach. This cost is the discounted present value of the victim's future output based on average current wage rates, to which is added an arbitrary sum for the 'pain, grief and suffering' of the deceased and his/her relatives.

In addition, amounts can be estimated for:

- (i) The cost of damage to property-vehicles, road-side furniture, etc.-remembering that vehicle repair costs can involve valuable foreign exchange.
- (ii) Administrative costs incurred in police investigations, legal procedures and insurance enquiries.
- (iii) Medical costs taken up in the use of rescue services, hospital care, etc. Again, valuable foreign exchange can be involved.

Global estimates have been made for several countries which show around 1% of Gross Domestic Product (GDP) wasted each year on road accidents. This is probably a conservative estimate; a recent study in Botswana estimated costs at some 2% of GDP.

9.2 The Effectiveness of Lighting in Reducing Accidents

Studies in industrialised countries have shown that lighting of even a modest standard can reduce night-time accidents on all-purpose main roads by about 30%. Increasing the quality of the lighting can bring further benefits-a comprehensive study in the UK on speed-limited all purpose roads demonstrated a further 35% reduction for an increase in average luminance of 1 cd/m². This shows that a top quality installation could halve the night-time accident rate (if there were no previous lighting), or reduce it by a third by upgrading an existing, low quality, installation.

To relate these potential benefits to his own city or district, the engineer needs information on the local accident situation. Unfortunately, many developing countries have no comprehensive accident reporting and recording systems, but what evidence there is shows rates typically in the range of 50 to 100 fatal accidents per 10,000 vehicles compared to 3 to 6 for the industrialised countries. Accident rates on urban roads carrying comparable levels of traffic have been found to be 5 to 10 times higher in developing countries compared with industrialised ones. The local police records of fatal and serious accidents may be detailed enough to estimate the annual accident toll for a particular length of major highway, and these should be used whenever possible. If they do not distinguish between day and night-time, it can reasonably be assumed that a third of accidents take place in the dark.

An interesting comment on lighting budgets can be made using overall national data. For example, in a city of one million inhabitants, with an average GDP per capita of £500, road accidents could be costing 2% of 'local' GDP or £10 million per annum. Thus, night-time accidents could be costing the community £3m per annum.

We could, therefore, be looking for a further saving of £1m per annum by upgrading the lighting. This is a measure of a reasonable overall budget for capital and running costs.

Such estimates are only very approximate, and are economic rather than financial since the city engineer's department does not receive the benefits of the investment itself. However, all the non-quantifiable benefits listed earlier must be considered and a local administration may decide that these are sufficient justification in themselves for the implementation of a lighting programme.

IN CONCLUSION

This manual attempts to set out the basic elements of good road lighting for the local engineer. It explains the fundamental facts which determine lighting design, and gives guidance on practical installations, maintenance and good working practices. It has had to be general, but its authors hope it will help correct decisions to be made in facing local situations and problems.

Further advice or information can be found in the documents and standards listed overleaf and by contacting the following:

Overseas Unit, Transport and Road Research Laboratory,
Crowthorne, Berkshire RG45 6AU, United Kingdom.

Institution of Lighting Engineers, Lennox House, 9 Lawford Road, Rugby CV21 2DZ, United Kingdom.

Association of Street Lighting Contractors, 34 Pishiobury Drive, Sawbridgeworth, Herts CM21 OAE, United Kingdom.

Between them, these organisations have considerable experience in helping local authorities make best use of their manpower, equipment and their limited budgets.

APPENDIX - DOCUMENTS REFERRED TO IN THE TEXT

- (1) Department of Transport (UK) Current Manual of Highways and Traffic Advice Note TA 49/86.
- (2) TRRL Laboratory Report LR 929 "The Relationship Between Road Lighting Quality and Road Accident Figures". P. P. Scott (1980).

Institution of Lighting Engineers Lighting Journal Volume 44 pp.213-221. "Measurements of Road Lighting and Accidents-The Results". R. A. Hargroves and P. P. Scott (1979).
- (2a) Van Bommel/de Boer-"Road Lighting" published 1980.
- (3) BS 5489 (Road Lighting).
 - Part 1 Guide to General Principles
 - Part 2 Code of Practice for Lighting for Traffic Routes
 - Part 3 Lighting for Subsidiary Roads (Group B)
 - Part 4 Code of Practice for Lighting for Single-Level Road Junctions including Roundabouts
 - Part 5 Lighting for Grade-Separated Junctions
 - Part 6 Lighting for Bridges and Elevated Roads (Group D)
 - Part 7 Lighting for Underpasses and Bridged Roads (Group E)
 - Part 8 Code of Practice for Lighting for Roads near Aerodromes, Railways, Docks and Navigable Waterways
 - Part 9 Lighting for Town and City Centres and Areas of Civic Importance (Group G)
 - Part 10 Lighting for Motorways
- (4) BS 5490 "Specification for Classification of Degrees of Protection Provided by Enclosures".
- (5) BS 5649 (Part 6)1982 "Specification for Design Loads".
- (6) BS 5649 (Part 2)1978 "Dimensions and Tolerances".
- (7) The Institution of Lighting Engineers "Code of Practice for Electrical Safety in Public Lighting Operations (Second Edition 1987)".

The Code of Practice of the Association of Street Lighting Contractors (ASLC), although not specifically referred to in the text, may be found to be a useful reference.

