EASTERN MEDITERRANEAN UNIVERSITY

DEPARTMENT OF
ELECTRICAL AND ELECTRONIC
ENGINEERING

GRADUATION PROJECT

ILLUMINATION OF ST. BARNABAS MONASTERY

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ACKNOWLEDGEMENTS

I would like to have a special thanks to my supervisor Prof. Haldun Gürmen for providing me all the required documents and directing me through my project and also I would like to thank Mr. Yilmaz Öztürk (B.Eng) for helping me with the electrical distribution plan and cost of the project.

CONTENTS

INTRODUCTION

Floodlighting is a term which has never had a precise definition, but with the passage of time is now accepted as meaning the lighting of an object or an area out of doors so that it becomes brighter than its surroundings. The objectives are many and varied: to provide security, to allow work to carry on after dark, to model a feature such as a statue, to enable sporting events to be seen by spectators or to be televised, to advertise, or to enhance the appearance of a scene or a building for pleasure.

The range of applications open to floodlighting has increased considerably during recent years. This is mainly because of the much wider use of high-mast (20m) lighting, which uses floodlights for lighting the scene below. Thus, the most important areas where floodligting is in now used are

* Large open spaces
* Airport aprons
* Sports and grounds
* Buildings and monuments
* Parks and gardens

Of all exterior of floodlighting applications, the decorative floodlighting of buildings is unique in three ways. Firstly, it is possible to use too much light: buildings which have been beaten into luminous pulp are at the very least visually unsatisfying and frequently downright uncomfortable. Secondly, the characteristics of the surface of the building are as important as those of the illuminant. Thirdly, areas of shadow make as useful a contribution to the final effect as do illuminated areas.

It is not only the lightness of the building surface which is important, but also the degree of specularity. Highly specular surfaces, such as glass, gold leaf, aluminium, stainless steel, mosaic, glazed bricks, and tiles, may present particular difficulties when floodlighting buildings.

Whatever the reflection characteristics of a building surface, the absence of a large diffuse sky and the general reversal of the direction of the incident light mean that floodlighting cannot duplicate the daytime appearence of a building. Although the daytime view of a building with the sun at a low altitude may suggest a floodlighting pattern, the best installations are those which exploit the differences between day and night rather than attempt to minimize them, not least in making effective use of shadow and possibly colour.

A coherent flow of light across a facade is desirable, implying one general aiming orientation for the main floodlights. This direction should not coincide with the most common viewing direction for the building, since no shadows will then be visible and the scene will appear flat. The main floodlighting should be done from a substantially different angle, and it is well worth examining the different shadow patterns cast by the architectural features of the facade when alternative angles are used.

Completness of floodlighting is important in that the whole building should be revealed, including the return walls to the main facade, the roof, and the full height of any chimney stacks. The main floodlighting units usually need suplementing, not only to guarantee completeness, but sometimes to avoid the 'floating' appearence which can arise from the base of the building being shadowed or underlit. It is important that floodlighting equipment is shielded from view by being installed behind existing or purposely-introduced features. The overall effect of a scheme is spoiled if the lighting units are silhoueted against the floodlit scene.

Coloured light can be used in other ways to produce a deliberately garish effect or festival atmosphere. A colour contrast between, for example, the facade and a side wall of a building emphasizes the depth of the structure. Artists use blue colours to simulate shadow and a similar technique has proved successful in floodlighting, using tungsten and sodium light to suggest a sunlit area with mercury light suggesting shadowed areas.

The calculation techniques explained in this project are very relevant to building floodlighting, and the photometric characteristics of floodlights are still important, but no better advice can be offered to someone undertaking building floodlighting for the first time than this: take a floodlight outside, point it at something, walk around, look at the varying pattern of light and shade, and never let that visual experince be overruled by illuminating engineering theory.

PART 1

BUILDING FLOODLIGHTING

1. BUILDING FLOODLIGHTING

During the hours of daylight, a building is lit by direct sunlight, by diffused light radiated from the sky, or by both. The result, is that the architectural features of the buildings are emphasized by a continuously changing interplay of light and shadow. The design of a good floodlighting installation calls for a close study of these lighting effects. It is not usually possible to achieve the same effect using artificial light as was created by daylight; the effects may, indeed, be totally different. The task of floodlighting expert is to decide which features of the building are most attractive, and then to carry out his design accordingly. The technique of floodlighting a building is not based solely on the principles of lighting engineering - feeling and insight as regards the aesthetic values of the architecture are just as important.

1.1 General Considerations

Direction of view

There will generallly be several directions from which a building can be viewed, but often a particular one can be decided upon as the main direction of view.

Distance

Viewing distance is important, as this will decide the amount of detail visible on the facade.

Surroundings and the background

If the surroundings and background of the building are dark, a relatively small amount of light is needed to make the building lighter than the background (Fig 1-1a).

If there are other buildings in the close vicinity, their lighted windows will give a strong impression of brightness. More light will than be needed for the floodlighting if it is to have any impact. The same is true if, in addition, the background is also bright (Fig 1-1b). Another solution can be found in the creation of a colour contrast instead of a brightness contrast.

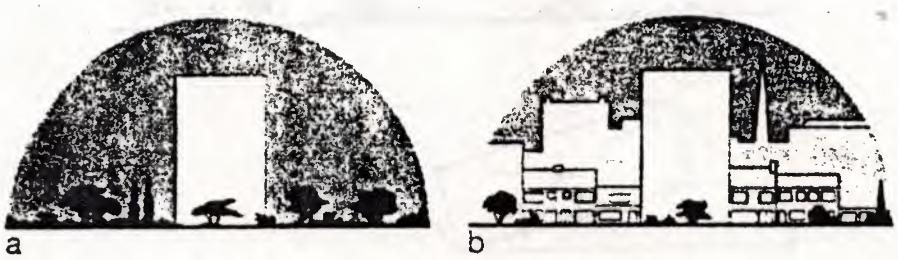


Fig 1.1 A floodlight building with a) DARK b) BRIGHT background

Obstacles

Trees and fences around a building can form a decorative part of an installation. An attractive way of dealing with these is to place the sources of light behind them. Two advantages are gained: firstly, the light sources are not seen by the viewer and secondly, the trees and fences are silhoutted against the light background of the facade. The impression of depth is thereby increased.

Water

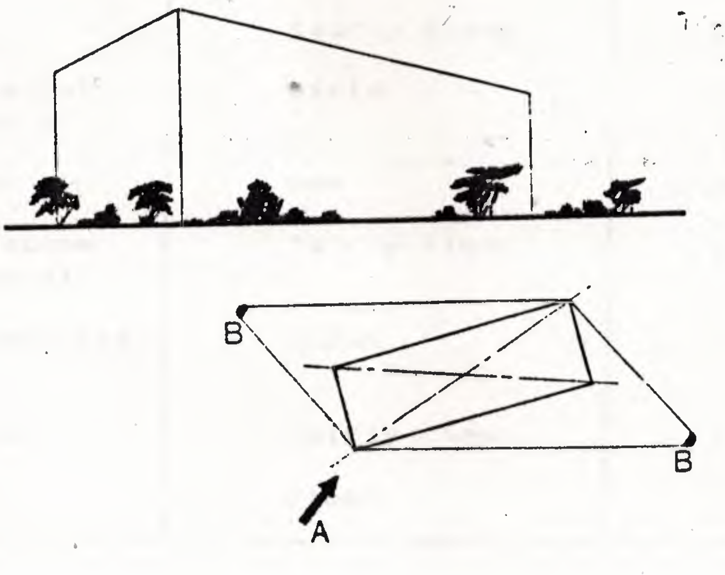
The design can also take advantage of any expanse of water in the foreground, such as a lake, moat, river or canal. The lighted building will be reflected in the surface of the water, which serves as a 'black mirror'.

The form of the building

Once the main direction of view has been chosen, the choice of the direction of the light will depend on the shape of the building, or rather on the form of its ground plan or horizontal section. The position of the light sources may then be more or less fixed.

It has been found that the best arrangement of the light sources for a rectangular-plan building is that shown in Fig 1-2 in which the main direction of view is indicated by arrow A and the position of the light sources by the points marked B. If the light sources are placed to either side of the diagonal, the effect achieved is a good contrast in brightness between the two adjacent sides of the building, which results in good prespective. The oblique beams of the floodlights also make the most of the texture of the building'ssurface material. The arrangement described for a rectangular building is also applicable to a building with a square ground plan.

<u>Fig 1-2</u> The position of the light sources (B) in realation to the main direction of view (arrow A).



1.2 Facade Surface Materials

In determining the illuminance level necessary to give a facade the required degree of brightness, the reflectance of the surface material and the way in which it reflects the light are important factors to be borne in mind. Fig 1-3 indicates the reflectance of a number of different building materials.

The total reflection from a facade depends on the following:

- The type of surface material
- The angle at which the light is incident
- The position of the observer in relation to the reflecting surface (specular reflections).

Whether a particular surface will reflect diffusely, specularly, or in some manner which lies between thes two extremes, will depend on the texture of that surface. Four classes of surface may be distinquished: very dull, dull, smooth and very smooth. For a normal installation, in which the light is directed upwards at a vertical surface, the amount of reflected light reaching an observer at a ground level will decrease with an increase in the smoothness of the surface illuminated.

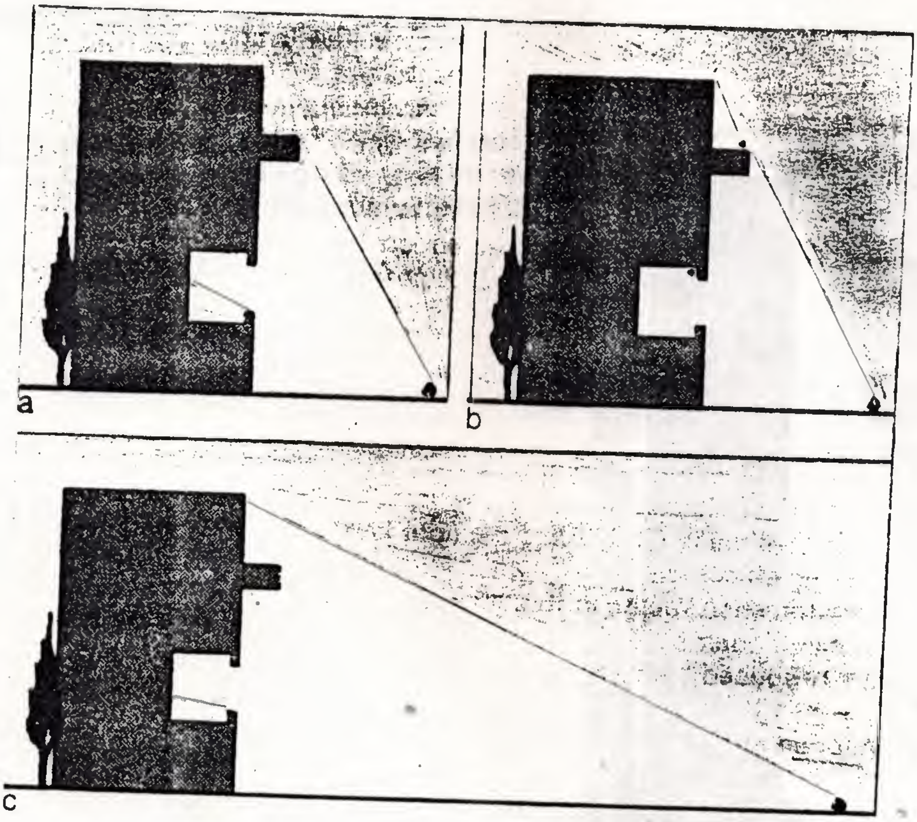
Fig 1-3. Reflectance of building materials

Material	Condition	Reflectance
Red brick	dirty	0.05
Concrete & stone (light colours)	very dirty	0.05-0.10
Granite	fairly clean	0.10-0.15
Concrete & stone (light colours)	dirty	0.25
Yellow brick	new	0.35
Concrete & stone (light colours)	fairly clean	0.40-0.50
Imitation Concrete (paint)	clean	0.50
White marble	fairly clean	0.60-0.65
White brick	clean	0.80

1.3 Positioning and Choice of the Light Sources

All possible positions of the light sources should be investigated. For example, projecting features such as balconies, parapets or balustrades can add to the appearance of the facade if included in the lighting scheme. But the floodlights must then be placed at some distance from the facade so as to avoid producing excessive shadow. If the site does not allow this, it may be possible to use supplementary lighting with small light sources mounted on the projection itself (Fig 1-4).

Fig 1-4 Excessive shadow a) avoided by the use of supplementary lighting b) & floodlighting from a greater distance c).



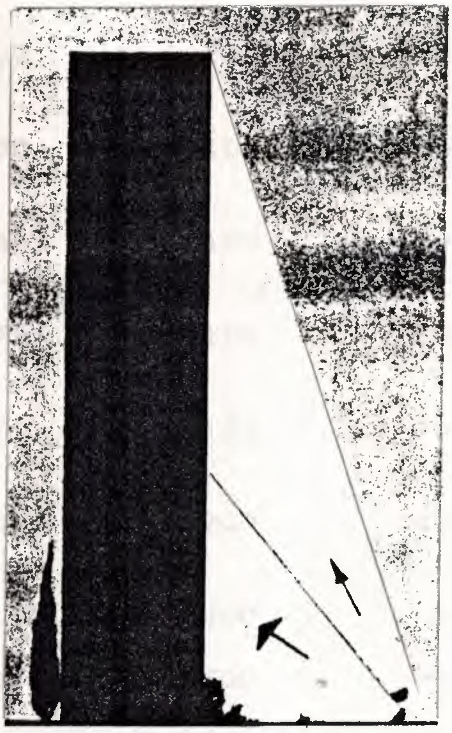
Features that are recessed, such as galleries, balconies or roofs, will be in shadow if the floodlights are placed only a short distance from the facade. In such cases, supplementary lighting located in the recess can be used; lighting of another colour being suitable for this purpose. Floodlighting from a greater distance, however, produces less shadow and does away with the need for additional lighting.

Some of the many alternative methods of mounting the light sources are: on street lamps or on posts specially erected for the purpose; on a neighbouring roof; on brackets attached to the facade; or on the ground behind low walls, flower-beds or bushes.

Just as the positioning of the floodlight batteries depends principally on the shape of the ground plan of the building and on the features to be highlighted, so the type of the floodlight to be used in particular, width of its beam- is dependent mainly on the building's height.

Wide-beam floodlights are the most suitable light sources for low buildings of one or two storeys. In the case of high buildings of eight or more storeys, the best results are obtained using a number of narrow-beam and medium-beam floodlights (Fig 1-5). Uniform brightness is achieved by careful distribution of the beamsover the facade and by proper adjustments of the sources themselves.

Fig 1-5 A narrow-beam and medium-beam floodlights used in lighting a high building.



1.4 Recommended Illuminances

Fig 1-6 gives some recommended illuminance levels for a number of building surface- materials with surroundings that are either poorly lit, well lit or brightly lit.

Fig 1-6 Recommended illuminances for building materials

Surface		Illuminance (lux)		
		Surroundings		
Type	Condition	Poorly-lit	Well-lit	Brightly-lit
White brick	fairly clean	20	40	80
White marble	fairly clean	25	50	100
Light-coloured concrete or stone	fairly clean	50	100	200
Yellow brick	fairly clean	50	100	200
Dark-coloured concrete or stone	fairly clean	75	150	300
Red brick	fairly clean	75	150	300
Granite	fairly clean	100	200	400
Red brick	dirty	150	300	---
Concrete	very dirty	150	300	---

1.5 Uniformity Over The Illuminated Plane

In many area lighting installations there should be limits on the diversity of illumination provided: Fig 1-7 suggests, for various applications, limiting values for two alternative measures of overall uniformity - the ratio of maximum to minimum illuminance over the critical plane and the average to minimum ratio - and also the 'gradient ' or maximum rate of change of illuminance with distance.

Fig 1-7 Uniformity recommendations for exterior light

Application	Uniformity of illuminance in critical plane of measurement		Min distance over which 20% change in lux occurs (metres)
	max:min	av:min	
Most building facades	20:1	10:1	2
Even lighting of plain light-coloured surfaces	10:1	5:1	3

1.6 Calculation of Illuminance

There are two methods of calculating the type and number of floodlights needed to achieve the desired illuminance: the lumen method and the luminous intensity method. The lumen method should be used when dealing with large facades and the luminous intensity method for high towers, steeples, chimneys etc.

Lumen method.

This method necessitates calculating the total number of lumens (i.e. luminous flux) directed on the facade by all the lamps. This total luminous flux can be calculated using the formula:

$$0_{total} = \frac{F E}{\eta}$$

where F = the surface area of the surface illuminated in m2

E = the desired illuminance, in lux

η = the utilization factor, which takes into account the efficiency of the floodlight and the light losses (luminous efficiency).

The presence of a utilization factor in this formula indicates that not all the lamp lumens contribute to the illuminance level on the facade: the lumens produced by the lamps are focussed by means of reflectors; some loss is thus inevitable. After the floodlight has been in operation for some time, a further loss takes place because of the decrease in luminous flux due to the ageing of the lamp and the accumulation of dirt on both it and its floodlight. Finally, a percentage of the losses is accounted for by wasted light, that is, light not incident upon the building's facade.

In practice, an average utilization factor between 0,25 and 0,35 may be reckoned with. Using this figure in the formula given above, the total luminous flux can be calculated. Dividing the total luminous flux by the number of lumens installed per floodlight gives the number of floodlights required i.e.

$$\text{Number of floodlights} = \frac{0_{total}}{0_{floodlight}}$$

Luminous Intensity Method.

With this method, the starting point is the calculation of the luminous intensity, in candela, that must be radiated by the light source in a given direction to produce the desired vertical illuminance. This luminous intensity, I, is calculated using either:

$$I = E\, d^2 \qquad \text{Fig 1-8a}$$

$$I = \frac{E\, h^2}{\sin^2 a \cos a} \qquad \text{Fig 1-8b}$$

where E = the vertical illuminance on the facade, in lux

h = the height in metres, above the level on which the floodlights are mounted, at which the centre of the light beam is incident on the facade

d = the horizontal distance, in metres, from floodlight to facade

a = the angle at which the light beam is incident on the facade

(Note: a = arctan h/d)

Knowing the value of I, luminous intensity diagrams or tables may then be used to determine a suitable type of light source.

Fig 1-8a

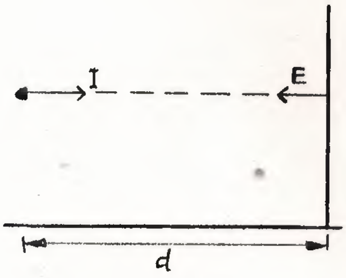
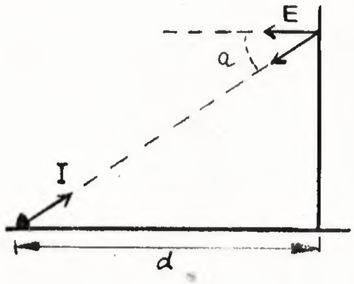


Fig 1-8b



NOTE:

Here, the lumen method is explained as a method of determining the number of floodlights needed to achieve the desired illuminance on a facade. It can also be used for determining the illumination within enclosures and is a procedure accepted in the designing of interior illumination.

The point-by-point method is used to determine the illumination at a point from a specific lighting equipment for which the distribution curve is known and this method is accurate for outdoor lighting, which will be explained.

PART 2

LAMPS AND LIGHTING TERMINOLOGY

2. LAMPS AND LIGHTING TERMINOLOGY

2.1 Photometric and Optical Units and Definitions

Luminous intensity. In SI, the luminous intensity is the candela. This unit replaces the International candle which was defined in terms of the light emitted per second in all directions by a specified electric lamp.

SI base unit, the candle (cd). The candela is the luminous intensity, in the perpendicular direction, of a surface of 1/600 000 square metre of full radiator at the temperature of freezing platinum under a pressure of 101325 newtons per square metre.

1 candela = 0.982 international candles

Luminous flux: The unit of luminous flux, the lumen (lm) is defined as the light energy emitted per second within unit solid angle by a uniform point source of unit luminous intensity. Thus 1 cd = 1 lm / sr.

Illuminance of a surface is defined as the luminous flux reaching it perpendicularly per unit area. The British unit is the lumen / ft^2, formerly called the foot candle (f.c.)The SI unit is the lumen / m^2 or lux (lx).

Lambert's Cosine law: For a surface receiving light obliquely, the illumination is proportional to the cosine of the angle which the light makes with the normal to the surface.

Brightness of a surface is that property by which the surface appears to emit more or less light in the direction of view. This is a subjective quantity. The corresponding physical measurement of the light actually emitted is called the luminance.

Luminance of a surface is the measure of light actually emitted (i.e. the luminous intensity) per unit projected area surface, the plane of projection being perpendicular to the direction of view. Unit, cd / m^2 (or cd / ft^2 in British). In engineering, the luminance of an ideally diffusing surface emitting or reflecting one lumen / ft^2 is called one foot-lambert (ft-L).

2.2 General Information About Lamps

It is not quite as old as the incandescent lamp, which has meanwhile celebrated its first centenary, but the gas-discharge lamps, and more particularly HID (high-intensity discharge) lamps have by now also achieved a venerable age. Advancing technological developments and labaratory research have brought a wide diversity of HID lamps, which makes it easier to select the appropriate lamp for each situation. However, at the same time it increases the risk of obscuring the individual identity of the various lamps and lamp types.

The light from a gas discharge lamp is not produced by heating a filament (as conventional incandescent lamp), but by the excitation of a gas (a metal vapour or a mixture of several gases and vapours) contained in either a tubular or elliptical outer bulb.

For a proper understanding of the special aspects of the light properties of the various types of high-intensity discharge lamps, the relevant characteristics of lamps must be known in general. These are:

* the light output of the lamp, termed luminous flux, in lumen, lm

* the efficiency of the lamp, termed luminous efficacy, in lumen per watt, lm / W

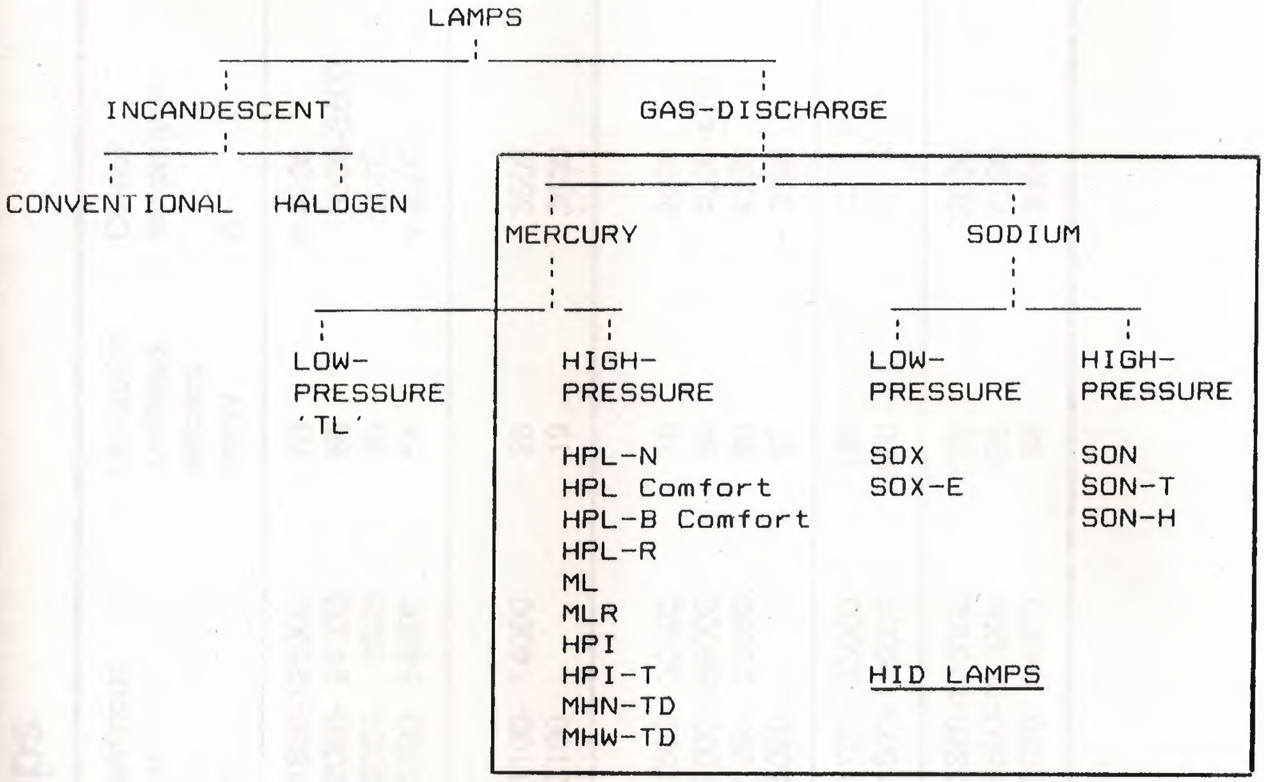
* the colour aspect of the light, expressed in the colour temperature, degrees Kelvin, K

* the colour rendering qualities of the light, expressed in the colour rendering index, Ra

* the shape and size of the lamp

* the lamp life

Following their main principle of operation, the family of electric light sources can be subdivided as follows:



Apparently, two basic directions can be distinguished within the group of gas-discharge lamps, depending on the metal used: mercury or sodium. The most striking contrast between the two is the immediately recognisable difference in the colour of the light. Sodium lamps produce a yellow light, mercury lamps on the other hand emit a crisp white light.

Both groups can be further sub-divided into low-pressure and high-pressure lamps. Low-pressure mercury lamps, invariably coated with the fluorescent powder on the inside of the tube wall and generally known as 'TL' fluorescent lamps, are only available in relatively low power ratings, and are therefore not considered as high intensity lamps.

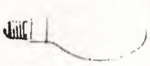
The remaining three groups, the HID lamps, each contain a number of variants, mainly based on gas filling, on shape and finish of the bulb, and on method of current control.

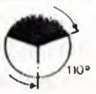
The most important lighting characteristics of each of these categories are given in the following tables:

Lighting characteristics of HID lamps

Category	Lamp type	Wattage range W	Luminous flux lm	Maximum luminous efficacy lm/W	Colour temperature K	Colour rendering index Ra
High-pressure mercury	HPL-N	50-2000	1800-125000	63	≈ 4000	50
	HPL Comfort	50- 400	2000- 24000	60	3300-3500	55-60
	HPL-B Comfort	50- 80	2050- 3900	49	3300	55-60
	HPL-R	125-1000	5700- 54000	54	≈ 3500	50
Blended light, self-ballasted						
	ML	100- 500	1100- 14000	28	3500	60
	MLR	160	3100	19	3600	60
Metal halide						
	HPI	250- 400	17500- 30600	76	4000	68
	HPI-T	250-2000	17000-189000	94	4000-4700	65
	MHN-TD	150- 250	11250- 20000	80	4300	85
	MHW-TD	70	5000	67	3000	75
Low-pressure sodium	SOX	35- 180	4700- 33000	180	—	—
	SOX-E	18- 131	1800- 26000	200	—	—
High-pressure sodium	SON	50-1000	3300-120000	120	2000	20
	SON-T	70-1000	6500-125000	125	2000	20
	SON-H	210- 350	18000- 34500	98	2000	20

Survey of HID lamps

Type	Wattage W	Type of base			Luminous flux lm	Average lamp voltage V[1]	Average lamp current A[1]	Run-up time min.[2]	Burning position	Bulb shape
		E27	B22	E40/45						
HPL-N	50	•	•		1800	95	0,6	5	 Any	
	80	•	•		3700	115	0,8	4		
	125	•	•	•	6300	125	1,15	4		
	175			•	8400	130	1,5	4		
	250			•	13000	135	2,13	4		
	400			•	22000	140	3,25	4		
	700			•	40000	145	5,4	4		
	1000			•	58000	145	7,5	4		
	2000			•[3]	125000	270	8,0	4		
HPL Comfort	50	•	•		2000	95	0,6	5	 Any	
	80	•	•		4000	115	0,8	4		
	125	•	•	•	6500	125	1,15	4		
	250			•	14000	135	2,1	4		
	400			•	24000	140	3,25	4		
HPL-B Comfort	50	•			2050	95	0,6	12	 Any	
	80	•			3900	115	0,8	12		
HPL-R	125	•		•	5700	125	1,15	4	 Any	
	250			•	12000	135	2,13	4		
	400			•	20000	140	3,25	4		
	700			•	36000	145	5,40	4		
	1000			•	54000	145	7,50	4		
ML	100	•	•		1100	[4]	0,46	5		
	160	•	•		3150	[4]	0,75	5		
									 [5]	
MLR	160	•			3100	[4]	0,75	5		
HPI	400			•	27600	125	3,4	3		
BU(S)	400			•	30600	125	3,4	3		
HPI-T	250			•	17000	125	2,1	3		
	400			•	31500	125	3,4	3		
	1000			•	81000	130	8,25	3		
380V	2000			•	183000	240	8,6	3		
220V	2000			•	189000	135	16,5	3		

Type	Wattage W	Type of base			Luminous flux lm	Average lamp voltage V[1]	Average lamp current A[1]	Run-up time min.[2]	Burning position	Bulb shape
		E27	B22	E40/45						
MHN-TD	150	2x R7s			11250	90	1,8	4		
	250	2x FC2			20000	100	3,0	4		
MHW-TD	70	2x R7s			5000	95	1,0	4		
SOX	35		•[6]		4500	68	0,62	7		
	55		•[6]		7400	107	0,59	7		
	90		•[6]		13000	117	0,83	9		
	135		•[6]		21500	176	0,82	10		
	180		•[6]		33000	250	0,83	12		
SOX-E	18		•[6]		1800	57	0,35	11		
	26		•[6]		3500	83	0,35	15		
	36		•[6]		5700	114	0,35	15		
	66		•[6]		10700	115	0,62	15		
	91		•[6]		17500	165	0,62	15		
	131		•[6]		26000	245	0,62	15		
SON	50	•			3300	85	0,76	5	 Any	
	70	•			5600	90	1,0	5		
	100			•	9500	100	1,2	5		
	150			•	13500	100	1,8	5		
S	150			•	15500	100	1,8	4		
	250			•	25000	100	3,0	5		
	400			•	47000	105	4,4	5		
	1000			•[3]	120000	110	10,3	6		
SON-T	50	•			4000	86	0,75	5	 Any	
	70	•			6500	86	1,0	5		
	100			•	10000	100	1,2	5		
	150			•	14000	100	1,8	5		
S	150			•	16000	100	1,8	4		
	250			•	27000	100	3,0	5		
	400			•	47000	100	4,6	5		
	1000			•[3]	125000	100	10,6	6		
SON-H	210			•	18000	104	2,5	3	 Any	
	350			•	34500	117	3,6	3		

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[1] After 100 burning hours.

[2] The number of minutes after which the lamp has reached 80 per cent of its final luminous flux.

[3] E40/80 x 50.

[4] These lamps are connected directly to the mains. The data given in this table refer to the 220-230V version.

[5] Recommended burning position, especially when undervoltage is expected.

[6] BY 22.

2.3 HID Lamp Types

2.3.1 Low-pressure sodium lamps.

The glass discharge tube in a low-pressure (SOX) lamp contains sodium which vaporizes at 98°C (at a pressure of a few N/m^2) and a mixture of inert gases (neon and argon) at a pressure of several hundred N/m^2 to obtain a low ignition voltage. The discharge is contained in an evacuated tubular glass envelope coated on its inner surface with indium oxide. This coating acts as infrared reflector and so maintains the wall of the discharge tube at the proper operating temperature (270°C).

The low-pressure sodium lamp is characterized by its nearly monochromatic radiation (Fig 2-1a), high luminous efficacy (which may be as high as 200 lm/watt), and long life. It therefore finds application where colour rendering is of minor importance and mainly contrast recognition counts e.g. highways, harbours, and marshalling yards. The SOX lamp is available in wattages ranging from 35 W to 180 W.

2.3.2 High-pressure sodium lamps.

The discharge tube in a high-pressure sodium lamp contains an excess of sodium to give saturated vapour conditions when the lamp is running at a pressure of between 13 and 26 kN/m^2, and to allow for internal surface absorption. An excess of mercury is also used to provide a buffer gas and xenon is included, at low pressure, to facilitate ignition and limit heat conduction from discharge arc to tube wall. The discharge tube, which is made of sintered aluminium oxide to withstand the intense chemical activity of the sodium vapour at the operating temperature of 700°C , is housed in evacuated protective hard-glass envelope.

High-pressure sodium lamps radiate energy across a good part of the visible spectrum (Fig 2-1b). In comparison with the low-pressure sodium lamp, therefore, they give quite good colour rendering. However, as is nearly always the case, a certain amount of efficacy must be sacrificed for this. High-pressure sodium lamps are available with luminous efficacies up to 130 lm/watt at a colour temperature of about 2100 K.

High-pressure sodium lamps, with their high efficiency and agreeable colour properties, are being used to an increasing extend for all types of floodlighting and for high-bay factory lighting. The SON and SON/H types have an elliptical bulb coated on the inside with a diffusing powder. The envelope of the SON/T lamp is clear, and tubular in shape.

Fig 2-1 a) Relative spectral energy distribution of a low pressure sodium lamp

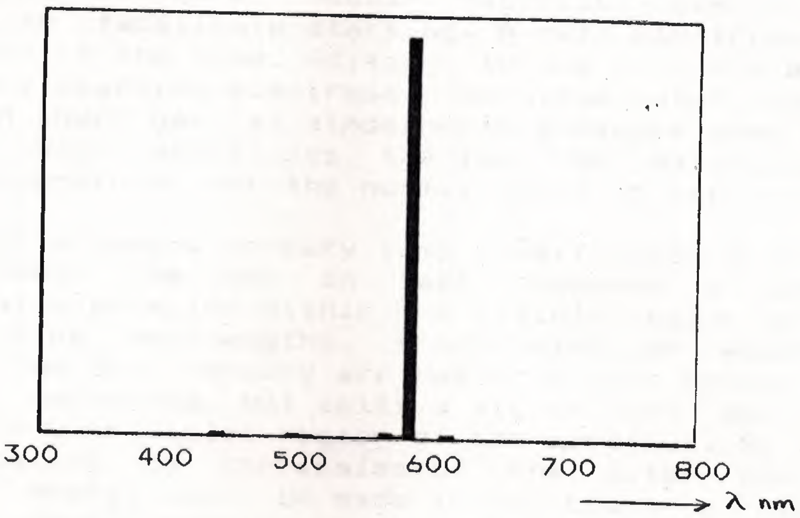
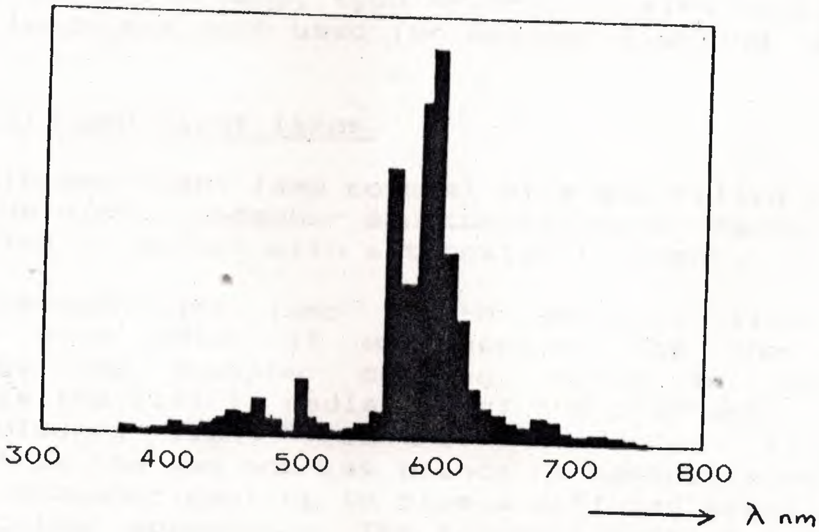


Fig 2-2 b) Relative spectral energy distribution of a high pressure sodium lamp



2.3.3 Mercury lamps.

In operation, the fused silica discharge tube in a mercury lamp contains vaporized mercury at a pressure of from 200 kN/m^2 to 1000 kN/m^2. But at room temperature mercury is a liquid. A small amount of more readily vaporized gas is therefore introduced to facilitate starting. A main electrode is sealed into each end of the tube. Adjacent to one of these electrodes is an auxiliary starting electrode. The glass outer bulb normally contains an inert gas (at atmospheric pressure when the lamp is operating) which stabilizes the lamp by maintaining a near constant temperature over the normal range of ambient conditions.

The high-pressure mercury lamp itself appears to be bluish-white, although the arc in fact produces a line spectrum (Fig 2-1c) with emission within the visible region at the yellow, green and blue wavelengths, there being an absence of red radiation. the pure mercury arc has both poor colour appearence and colour rendering, but emits a significant portion of its energy in the ultraviolet region of the spectrum. By the use of a phosphor coating on the inside of the outer envelope, this ultraviolet energy can be made to introduce a red component (Fig 2.1d) thus improving both colour rendering and colour appearence.

High-pressure mercury vapour lamps intended for floodlighting applications have a clear glass tubular envelope - types HP and HP/T. Those with a phosphor to improve colour rendering are denoted by the type letters HPL-N. A reflector lamp version of the HPL-N lamp, type HPLR-N, is also available. Both these HPL lamps are much used for outdoor lighting and factory lighting.

2.3.4 Blended-light lamps.

The blended-light lamp consist of a gas filled bulb coated on its inside with a phosphor and containing a mercury-discharge tube connected in series with a tungsten filament,

The blended-light lamp (MLL-N series), like the HPL-N mercurylamp from which it was derived has the ultraviolet radiation by the phosphor coating. Added to this visible radiation is the visible radiation of the discharge itself and the warm-coloured light from the incandescent filament. The radiation from the two sources blends harmoniously as it passes through the phosphor coating to give a diffused white light with a pleasant colour appearence. The filament acts as a ballast for the discharge so stabilizing the lamp current. No other ballast is needed. Blended-light lamps can , therefore, be connected direct to the mains. This means that existing lighting installations employing incandescent lamps can easily be modernized using blended-light lamps, which have twice the efficacy and almost six times the operating life, at no extra cost in terms of special gear, wiring. or luminaries.

Fig 2-1 c) Relative spectral energy distribution of a clear mercury lamp

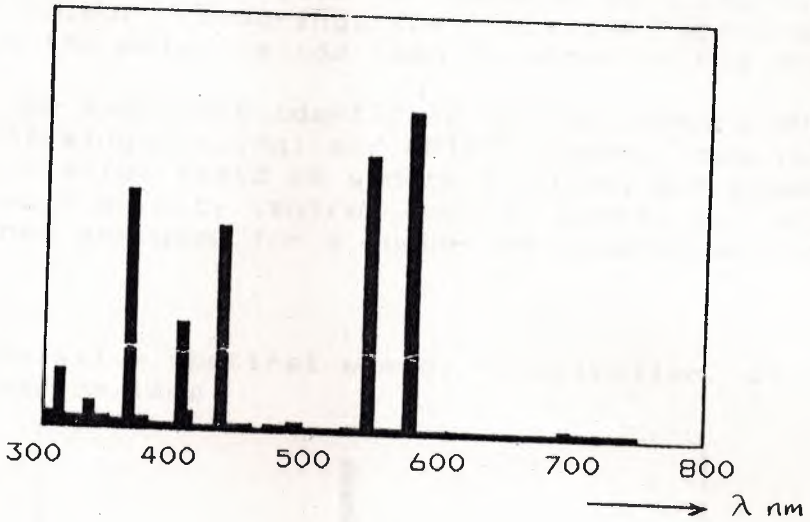
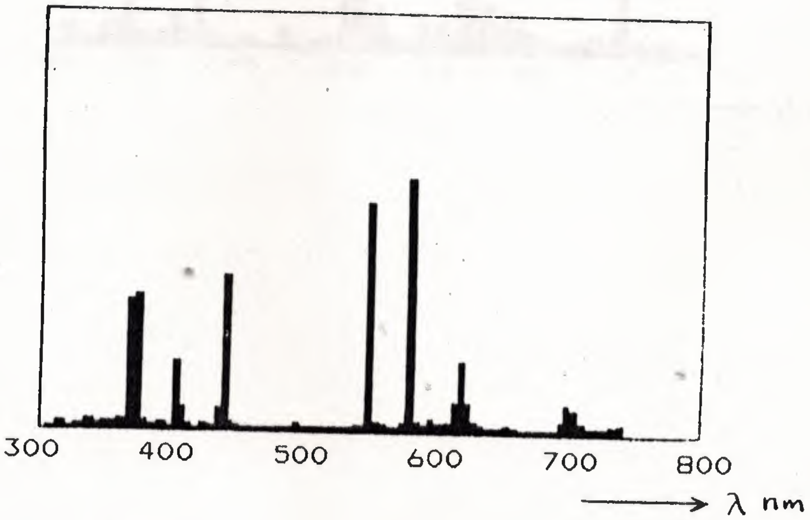


Fig 2-1 d) Relative spectral energy distribution of a phosphor coated mercury lamp

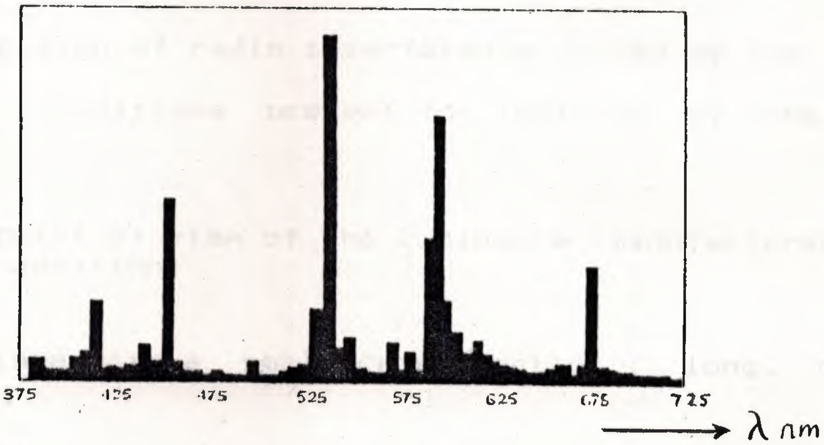


2.3.5 Metal halide lamps.

The metal halide lamp, which is very similar in construction to the mercury lamp, contains iodide additives such as indium, thallium, and sodium to give a substantial improvement in efficacy and colour rendering. The relative spectral energy distribution to the metal halide lamp is shown in Fig 2-1e.

Metal halide lamps are identified by the letters HPI (avoid bulb with diffusing coating) and HPI/T (clear, tubular bulb). Their main application field is sports lighting and other similar large areas such as city centres and car parks. In other more compact form they are used for a number of diverse applications.

Fig 2-1 e) Relative spectral energy distribution of a metal halide lamp



2.4 Control Gear

Ballast

All discharge lamps require a means of controlling, or stabilising, the current passing through them. The device used, which is called a ballast, is designed to satisfy certain rigid requirements. Apart from providing good stabilization of the lamp current the ballast must have:

* A high power factor, which ensures economic use of the supply system

* A low percentage of harmonics in the current drawn from the mains

* A high impedance to audio-frequencies

* Adequate suppression of radio interference caused by the lamp

* The necessary conditions present for ignition of the lamp concerned

From the point of view of the luminaire manufacturer the ballast must, in addition:

* Be of small volume with a small cross-section (long, narrow units)

* Be low in weight

* Have a low self-heating ability

The user is interested in:

* Low power losses

* Low price

* Freedom from acoustic noise

* Long life

* Absence of TV or radio interference

* Safety

The simplest ballast is the reactor, or choke, placed in series with the lamp. Inherently, the power factor of this circuit is low i.e. about 0.5 lagging. The power factor can be increased to 0.85 or greater in a number of ways. One circuit, which consists of a choke in series with the lamp and a capacitor connected across the supply is illustrated in Fig. 2-2. Whatever the system of compensation chosen, the ballast characteristic must conform the specific requirements of the lamp type in use.

Ignitors

Lamps that will start at mains voltage are usually operated in series with simple choke ballasts. Metal halide (HPI) high-pressure sodium (SON) lamps, on the other hand, need a voltage higher than that of the mains supply to initiate the discharge and must be used with some form of auxiliary, starting device.

The HPI lamp is started with a thyristor ignitor which is connected across the lamp, Fig. 2-3a. The ignitor generates a series of high voltage pulses (600-700 V peak), which cease whenthe lamp starts.

SON lamps need a peak voltage of from 1500 to 3000 volts, depending on lamp type, in order to ensure ignition. The necessary voltage is obtained by means of a tapping on the choke winding, which acts as a step-up transformer for the starting pulses from the ignitor, Fig 2-3b.

Fig 2-2
Choke ballast with
capacitive compensation

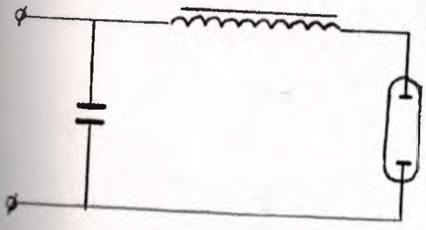
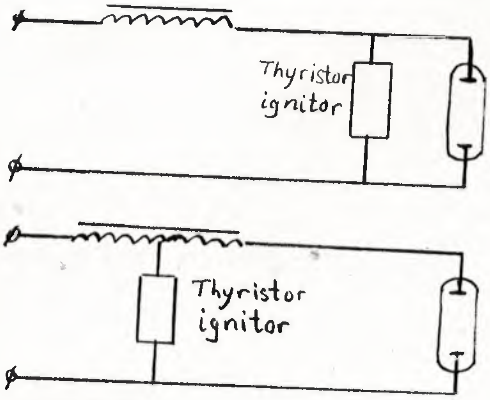


Fig 2-3 Thyristor ignitor
circuits for
(a) an HPI lamp
(b) a SON lamp



PART 3

ILLUMINATION CALCULATIONS

3. ILLUMINATION CALCULATIONS

3.1 Luminous Intensity and Illuminance

Luminous intensity of a point source.

A frequent requirement in lighting engineering is the calculation of the illuminance produced on a surface by a given arrangement of a light sources. The simplest example is the illumination of a plane surface by a single 'point source', which in practice means any source whose dimensions are small compared with its distance from the surface. Refering to Fig 3.1, a point source S emitting luminous flux in various directions, illuminates a plane surface P. The flux d0 intercepted by an element of area dA on P is the flux emitted within the solid angle dw subtended at the surface by the element dA; it is assumed that no absorbtion of light occurs in the space between the source and the surface. The quotient d0/dw is called the luminous intensity I of the source in the particular direction considered; thus

$$I = \frac{d0}{dW} \quad (\text{ lm/sr or cd }) \qquad (\text{Eq } 3.1)$$

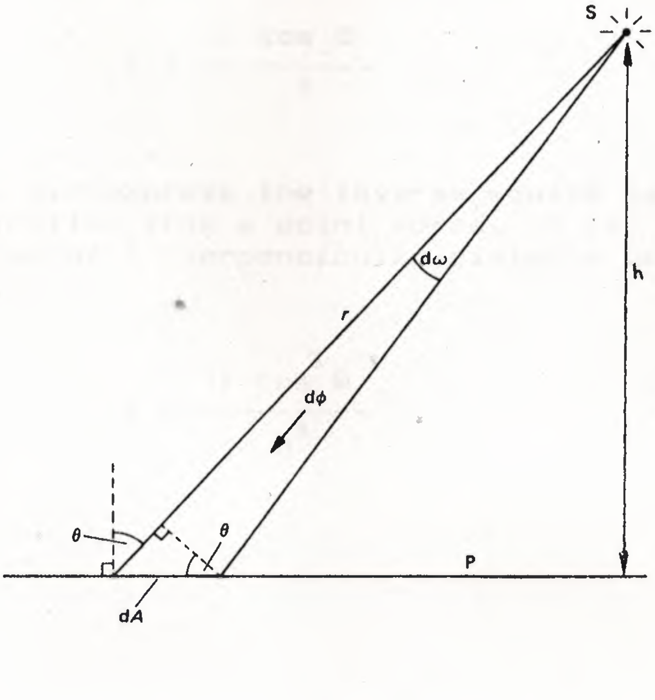


Fig 3-1 Illumination of a plane surface by a point source

Inverse square and cosine laws of illumination

Illuminance, E, whose unit is the lumen per square metre (or lux) is defined as

$$E = \frac{d\emptyset}{dA} \qquad \text{(Eq 3.2)}$$

The illuminance produced by a point source at a distance r from a plane (Fig 3-1) is obtained by first eliminating d0 between Eqs 3.1 and 3.2 to give

$$E = I\frac{dw}{dA} \qquad \text{(Eq 3.3)}$$

then in (Fig 3-1)

$$dw = \frac{dA \cos \theta}{r^2}$$

and substitution for dw in Eq 3.3 gives

$$E = \frac{I \cos \theta}{r^2} \qquad \text{(Eq 3.4)}$$

Equation 3.4 express the inverse square law and the cosine law of illumination from a point sorce. It can be rearranged to give E interms of h (perpendicular distance between source and surface).

Then $$E = \frac{I \cos^3 \theta}{h^2}$$

3.2 Design and Calculation Technique

The design of many decorative floodlighting schemes rely for success on a combination of aesthetic appreciation, experience, intuition, and flair. However, the majority of exterior lighting installations, areas, succeed by satisfying the various lighting criteria outlined in Part 1, following a design process normally consisting of three stages:

a) A practical assessment is made of where to locate the floodlights, the type of light distribution required, and the light source characteristics which suit the particular application.

b) A 'lumen calculation' is carried out to establish the number and loading of the lamps to achieve the required average illuminance.

c) When necessary, 'point-by-point calculations' are performed to determine the aiming pattern of the floodlights for the required uniformity.

The third stage may necessitate modifications to the preliminary calculations, and is the stage when the use of a computer becomes invaluable for large and complex installations.

3.3 Lumen calculations

For their lumen calculations exterior lighting designers use a formula very similar to that used by interior lighting designers. This formula is

$$E = \frac{N * L * MF * AL * UF}{A}$$

where E is the average illuminance (lux),

N is the number of lamps used in the installation,

L is the lighting design lamp lumens (the product of initial lumens and lamp lumen depriciation factor),

MF is the maintenance factor,

AL is the factor to represent atmospheric absorption losses,

UF is the utilization factor of the floodlights used,

A is the area (m^2) to be lit.

Utilization factor. The utilization factor of a floodlight, a measure of the proportion of the bare lamp flux which reaches the area to be lit, is considered to be made up of two factors. One of these is the beam factor BF, a characteristic of the floodlight itself. The other is the waste light factor WL, a measure of how much of the beam reaches the area to be lit, and which is therefore a characteristic of the installation design. Taking these two factors together, UF = BF * WL.

If the average utilization factor of the floodlights were known, as well as the lamp type, the number of floodlight locations, and the average illuminance required over the area, then the lumen formula above would enable the number of lighting design lumens needed at each location to be evaluated. This would then determine the lamp loading and the number of floodlights.

In a first rough assessment of a scheme it is common practice to take UF = 0.3: this value will inevitably be low for assymetric projectors and high for very wide angle projectors. A better estimate is obtained by multiplying the beam factor of the type of floodlight to be used by an estimate of the waste light factor. This is likely to be somewhere in the range of 0.5 to 0.9: the lower value for a long narrow site or one with an irregular shape and the upper value for a large site or one where the beam angles of the chosen floodlight relate well to the angles substended by the site at the chosen floodlight locations. The estimate is made by sketching the general shape of the various beams on the plan of the area to be lit and evaluating what fraction of the beams are actually intercepted by the area.

3.4 Point-By-Point Calculation

To examine the uniformity of the proposed floodlighting scheme requires illuminances to be calculated at specific points. The inverse square and cosine laws of illumination (Section 3.1) lead to the expressions $E = (I \cos \theta) / r^2$ for the illuminance on a surface due to a source of intensity I cd at a distance r metre away when the light falls at an angle of θ to the normal to the surface or $E = (I \cos^3\theta) / h^2$ where h is the perpendicular distance between surface and source.

In floodlighting the effective source intensity is the photometric value multiplied by the maintenance factor and by the atmospheric light loss factor.

Illumination diagram.

For some exterior luminaires, primarily those with a fixed mounting attitude, illumination diagrams may be available. These are series of equi-illuminance contours which is given the title of an isolux diagram. Such diagrams could be produced for floodlights, but since a different diagram would be needed for every aiming angle, this is not very practical.

Isocandela diagram.

For floodlighting it is usual to resort to the inverse square and cosine law formula. The most useful form of intensity data (I-table) is one using the C - GAMMA coordinate system.

It is usual in these cases to define X-Y grid covering the area. The steps in X and Y can be selected to give either coarse or fine grid, depending on the requirements. The positions of the floodlights are then defined in terms of X,Y and Z (distance h).

Next, the procedure to find illuminance at a given point (X,Y), on the plane to be illuminated, can be summarized as follows.

$$E = \frac{I.\cos^3 \theta}{h^2}$$

I and $\cos^3\theta$ is to be determined .

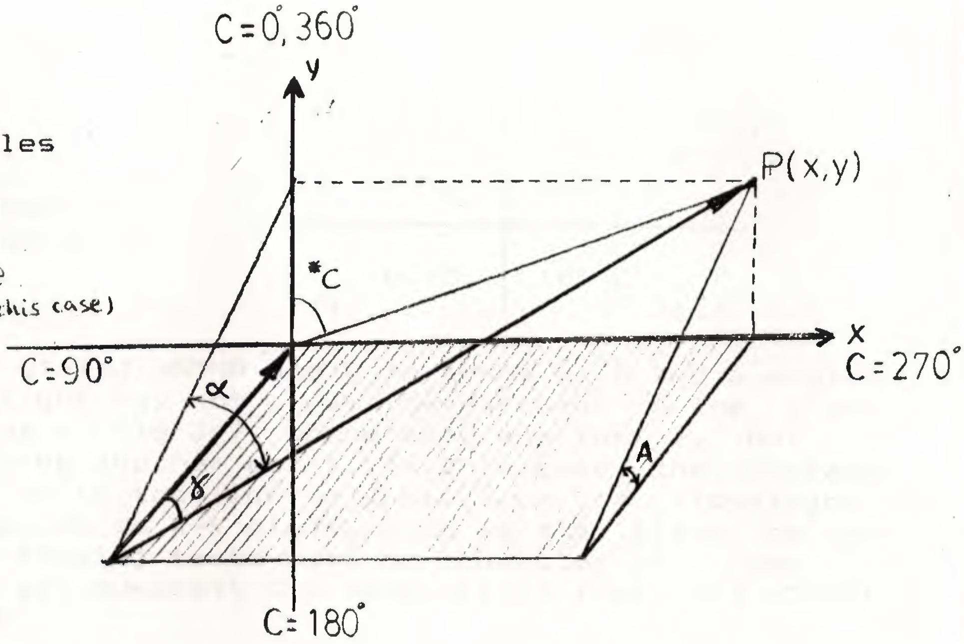
I is read from an isocandela matrix of chosen floodlight and it is given in terms of C and GAMMA angles.

C and GAMMA angles can best be explained by the following diagram (Fig 3-2).

Let (X,Y) be the point at which illuminance is to be determined.

Let (Xo,Yo) be the point where the projector is directed. (For simplicity Xo=0 and Yo=0 for the figure given).

Fig 3-2 C & GAMMA angles



$$A = \tan^{-1} \frac{y'\sqrt{1+x_0'^2}}{1+x'x_0'} - \tan^{-1} \frac{y_0'}{\sqrt{1+x_0'}}$$

$$\alpha = \cos^{-1}\left[\frac{1 + x'x_0' + y_0'\left(\frac{1+x_0'^2}{1+x'x_0'}\right)}{\sqrt{\left(1+x'^2+y'^2\right)\left(1+x_0'^2+y_0'^2\cdot\left(\frac{1+x_0'^2}{1+x_0'x'}\right)^2\right)}} \right]$$

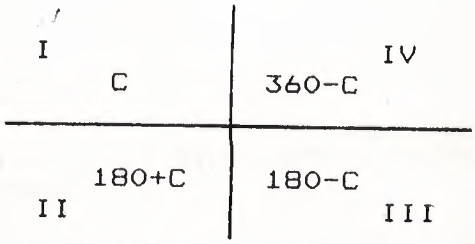
$$\cos^3\Theta = \frac{1}{\left(1+x'^2+y'^2\right)^{3/2}} \qquad \text{where } x'=\frac{x}{h},\ y'=\frac{y}{h},\ x_0'=\frac{x_0}{h},\ y_0'=\frac{y_0}{h}$$

$$C = \tan^{-1} \frac{\tan\alpha\sqrt{1+\tan^2 A}}{\tan A}$$

$$\gamma = \tan^{-1}\sqrt{\tan^2\alpha\left(1+\tan^2 A\right)+\tan^2 A}$$

*C angle shown on the figure, is the C found according to the formula. The actual C, which will give the value of I from I-table, is 360-C (for quadrant IV). For others it is given as folbws;

quadrant I : C
quadrant II :180+C
quadrant III:180-C



The reason for giving GAMMA and C in terms of A and a angles is that; the floodlight may not always be directed to the plane perpendicularly (as in Fig 3-2, where Xo=0 and Yo=0), but it may be directed towards another point. In this case, the C-plane which is perpendicular to the line of projection (of floodlight) is altered in relation to X-Y plane which is the plane to be illuminated. So following tests must be conducted in order to decide about on which quadrant the point (X,Y) lies and about the value of C. Then;

If A is positive and X < Xo : C=C (Quad I)
If A is negative and X < Xo : C=180+C (Quad II)
If A is negative and X > Xo : C=180-C (Quad III)
If A is positive and X > Xo : C=360-C (Quad IV)

At this stage the use of computer can be valuable since many repetitive calculations must be carried out. However, the computer can only act as design aid in the limited sense that the final printout of the results can tell the planner quickly and accurately whether the design works or not.

In the following page, the program written in FORTRAN gives the C, GAMMA and cos$^3\theta$ values at specified steps in X and Y. For this the limits of the plane (wall) to be illuminated are also entered before running the program.'Factor' output obtained on the printout is the value ((cos$^3\theta$)*lampflux / h^2) which is to be multiplied with I value of the corresponding point in order to give the value of illuminance, E at that point. For this reason lampflux of the lamp used is also included in the program.

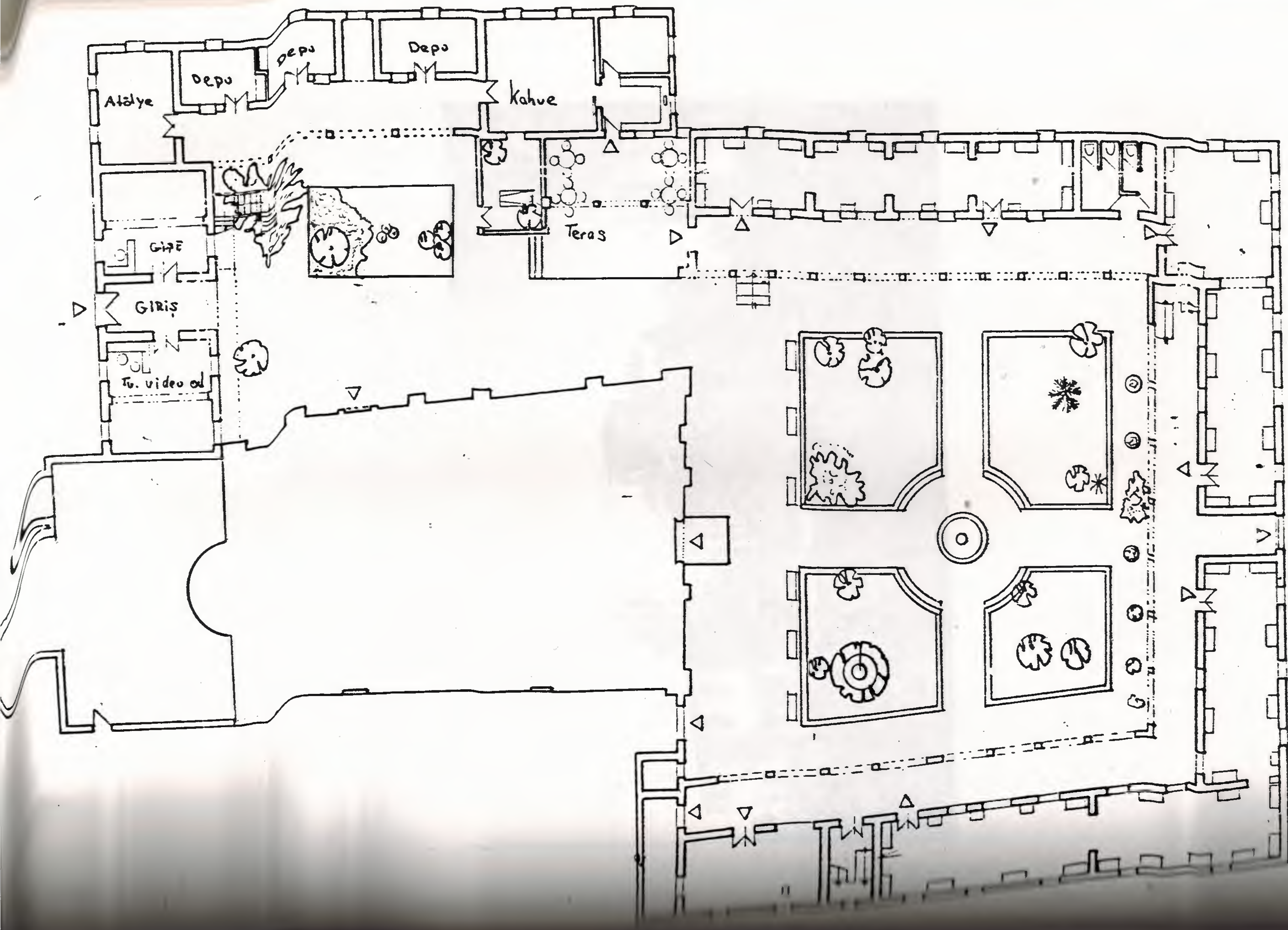
```
      INTEGER X,Y
      REAL XMIN,XMAX,YMIN,YMAX,INCX,INCY,H
      REAL XO,YO,X1,Y1
      REAL CUBE,B,D1,D2,ALFA1,ALFA,F,A,A1,C,C1,GAMA,GAMA1,FACTOR
      OPEN(3,FILE='ILLUM.DAT',STATUS='NEW')
      WRITE(*,*)'ENTER XMIN AND XMAX'
      READ(*,*)XMIN,XMAX
      WRITE(*,*)'ENTER YMIN AND YMAX'
      READ(*,*)YMIN,YMAX
      WRITE(*,*)'INCREMENT FOR X AND Y'
      READ(*,*)INCX,INCY
      WRITE(*,*)'ENTER XO AND YO'
      READ(*,*)XO,YO
      WRITE(*,*)'ENTER H'
      READ(*,*)H

      X10=XO/H
      Y10=YO/H
      WRITE(3,13)XO,YO,H
      FORMAT(21X,'Xo=',F4.1,8X,'Yo=',F4.1,8X,'h=',F4.1//
   $16X,'X',6X,'Y',9X,'C',9X,'GAMA',8X,'COS CUBE',5X,'FACTOR'/
   $14X,65('-'))
      DO 7 Y=YMAX,YMIN,-INCY
      DO 7 X=XMIN,XMAX,INCX

      X1=X/H
      Y1=Y/H
      CUBE=1/(((1+X1*X1+Y1*Y1))**(1.5))
      B=1+X1*X10+Y1*Y1*((1+X10*X10)/(1+X1*X10))
      D1=(1+X1*X1+Y1*Y1)*(1+X10**2+(Y1**2)*((1+X10**2)/(1+X10*X1))**2)
      D2=SQRT(D1)
      ALFA1=ACOS(B/D2)
      ALFA=((ALFA1*180)/3.141592654)
      F=SQRT(1+X10**2)
      A1=ATAN((Y1*SQRT(1+X10**2))/(1+X10*X1))-ATAN(Y10/F)
      A=((A1*180)/3.141592654)
      C1=ATAN (  (TAN(ALFA1)*SQRT(1+TAN(A1)*TAN(A1)  )  )/TAN(A1+.00001))
      C=((C1*180)/3.141592654)
      GAMA1=ATAN(SQRT((TAN(ALFA1))**2*(1+(TAN(A1))**2)+(TAN(A1))**2))
      GAMA=((GAMA1*180)/3.141592654)
      IF ((A.LT.0).AND.(X.GT.XO)) C=180-C
      IF ((A.LT.0).AND.(X.LT.XO)) C=180+C
      IF ((A.GT.0).AND.(X.GT.XO)) C=360-C
      IF ((A.GT.0).AND.(X.LT.XO)) C=C
      FACTOR=CUBE*27/H**2
      WRITE(3,11)X,Y,C,GAMA,CUBE,FACTOR
      FORMAT(14X,I3,4X,I3,7X,F5.1,6X,F5.1,8X,F7.5,5X,F7.4)
      CONTINUE
      ENDFILE(3)
      CLOSE(3)
      STOP
      END
```

PART 4

ILLUMINATION CALCULATIONS
FOR
ST. BARNABAS MONASTERY


Atölye
Depo
Depo
Depo
Kahve
GİŞE
Teras
GİRİŞ
Tv. video od

Wall 1

Wall 2

Wall1 ($27 \times 12 \, m^2$)

Xo= 0.0 Yo= 5.0 h=13.0

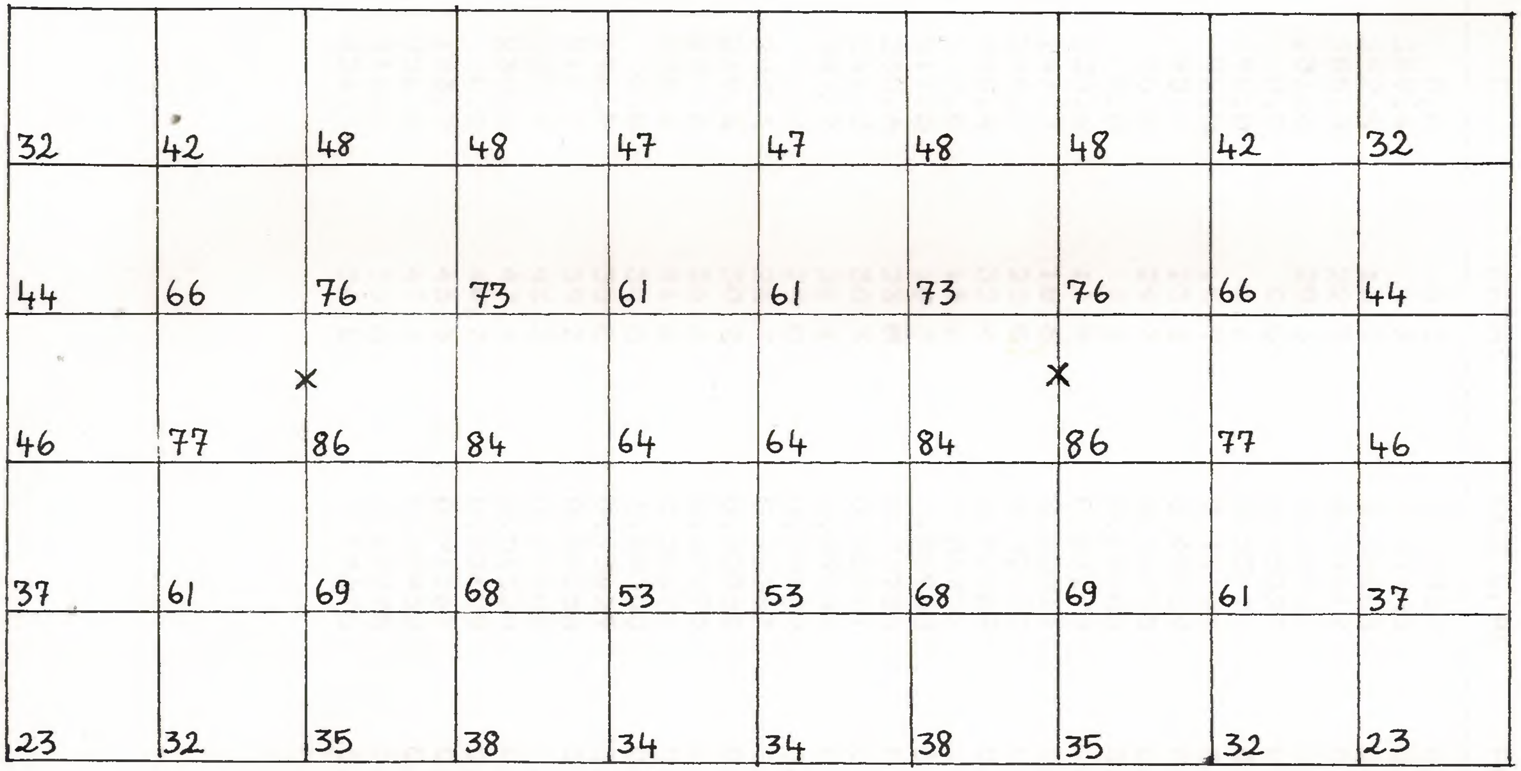
X	Y	C	GAMA	COS CUBE	FACTOR
0	9	0.0	13.7	0.55580	0.0888
3	9	321.2	17.3	0.52708	0.0842
6	9	301.9	24.7	0.45424	0.0726
9	9	292.5	32.4	0.36483	0.0583
12	9	287.3	39.3	0.28092	0.0449
15	9	284.0	45.2	0.21222	0.0339
18	9	281.7	50.1	0.15976	0.0255
21	9	280.1	54.2	0.12095	0.0193
0	6	0.0	3.7	0.74851	0.1196
3	6	287.3	12.4	0.70179	0.1121
6	6	278.8	23.0	0.58723	0.0938
9	6	275.9	32.3	0.45424	0.0726
12	6	274.4	40.1	0.33697	0.0538
15	6	273.6	46.4	0.24639	0.0394
18	6	273.0	51.6	0.18057	0.0288
21	6	272.5	55.8	0.13381	0.0214
0	3	0.0	8.0	0.92512	0.1478
3	3	238.1	15.0	0.85915	0.1373
6	3	252.7	25.4	0.70179	0.1121
9	3	258.3	34.8	0.52708	0.0842
12	3	261.2	42.6	0.38023	0.0607
15	3	262.9	48.8	0.27156	0.0434
18	3	264.1	53.9	0.19533	0.0312
21	3	264.9	57.9	0.14266	0.0228
0	0	0.0	21.0	1.00000	0.1598
3	0	212.7	24.6	0.92512	0.1478
6	0	232.1	32.1	0.74851	0.1196
9	0	242.6	39.9	0.55580	0.0888
12	0	248.7	46.7	0.39675	0.0634
15	0	252.7	52.3	0.28092	0.0449
18	0	255.5	56.9	0.20071	0.0321
21	0	257.5	60.6	0.14583	0.0233
0	-3	0.0	34.0	0.92512	0.1478
3	-3	201.9	36.0	0.85915	0.1373
6	-3	218.8	40.9	0.70179	0.1121
9	-3	230.3	46.6	0.52708	0.0842
12	-3	238.1	52.0	0.38023	0.0607
15	-3	243.5	56.6	0.27156	0.0434
18	-3	247.5	60.4	0.19533	0.0312
21	-3	250.4	63.6	0.14266	0.0228

Wall1

2 × SONT 250W

$x_o = 0$ $y_o = 5$ h = 13 m

$E_{av} = 54$ lux
$E_{max} = 86$ lux
$E_{min} = 23$ lux



32	42	48	48	47	47	48	48	42	32
44	66	76	73	61	61	73	76	66	44
46	77	86	84	64	64	84	86	77	46
37	61	69	68	53	53	68	69	61	37
23	32	35	38	34	34	38	35	32	23

Wall 2 ($16 \times 12 m^2$)

```
         Xo= 0.0            Yo= 8.0           h=11.5

X        Y          C           GAMA          COS CUBE        FACTOR
--------------------------------------------------------------------
0        10         0.0          6.2          0.42969         0.0877
2        10       309.4          9.7          0.41883         0.0855
4        10       292.3         15.9          0.38883         0.0794
6        10       285.3         22.3          0.34617         0.0707
8        10       281.6         28.3          0.29827         0.0609
0         8         0.0          0.0          0.55320         0.1129
2         8        90.0          8.1          0.53670         0.1096
4         8        90.0         15.9          0.49184         0.1004
6         8        90.0         23.2          0.42969         0.0877
8         8        90.0         29.7          0.36225         0.0740
0         6         0.0          7.3          0.69688         0.1423
2         6       230.6         11.4          0.67275         0.1373
4         6       247.7         18.6          0.60811         0.1242
6         6       254.7         25.8          0.52102         0.1064
8         6       258.4         32.4          0.42969         0.0877
0         4         0.0         15.6          0.84256         0.1720
2         4       211.3         18.2          0.80958         0.1653
4         4       230.6         23.8          0.72250         0.1475
6         4       241.3         30.3          0.60811         0.1242
8         4       247.7         36.4          0.49184         0.1004
0         2         0.0         25.0          0.95629         0.1952
2         2       202.1         26.7          0.91567         0.1869
4         2       219.1         30.9          0.80958         0.1653
6         2       230.6         36.3          0.67275         0.1373
8         2       238.4         41.6          0.53670         0.1096
0         0         0.0         34.8          1.00000         0.2042
2         0       196.9         36.0          0.95629         0.1952
4         0       211.3         39.2          0.84256         0.1720
6         0       222.4         43.3          0.69688         0.1423
8         0       230.6         47.6          0.55320         0.1129
0        -2         0.0         44.7          0.95629         0.1952
2        -2       193.7         45.5          0.91567         0.1869
4        -2       206.0         47.7          0.80958         0.1653
6        -2       216.2         50.8          0.67275         0.1373
8        -2       224.3         54.1          0.53670         0.1096
```

Wall 2

1 × SONT250W

x = 0 y = 8 h = 11.5m

E_{av} = 46 lux

E_{max} = 81 lux

E_{min} = 14 lux

	19	32	45	47	50	47	45	32	19
	21	36	58	64	69	64	58	36	21
	22	44	65	74	81	74	65	44	22
	21	43	64	73	81	73	64	43	21
	19	35	58	69	74	69	58	35	19
	14	22	38	44	45	44	38	22	14
Behind Fence {	7	11	11	12	12	12	11	11	7

Wall 3

Wall 3

Wall 3 (27×12m^2)

Xo=12.0 Yo= 4 h=11.0

X	Y	[illegible]	GAMA	COS CUBE	FACTOR
0	[illegible]	49.3	48.8	0.46361	0.1034
3	9	43.4	37.6	0.43426	0.0969
[illegible]	9	34.4	27.7	0.36250	0.0809
9	9	20.6	20.0	0.27958	0.0624
12	9	0.0	15.1	0.20681	0.0461
15	9	334.9	13.4	0.15085	0.0337
18	9	313.1	14.0	0.11033	0.0246
21	9	298.3	15.8	0.08163	0.0182
24	9	288.7	17.9	0.06134	0.0137
27	9	282.3	19.9	0.04685	0.0105
0	6	63.4	46.3	0.67659	0.1510
3	6	59.9	33.1	0.62232	0.1389
6	6	53.5	21.3	0.49641	0.1108
9	6	39.4	12.0	0.36250	0.0809
12	6	0.0	6.4	0.25488	0.0569
15	6	304.9	7.3	0.17827	0.0398
18	6	282.3	10.9	0.12617	0.0282
21	6	273.4	14.4	0.09102	0.0203
24	6	268.8	17.4	0.06707	0.0150
[illegible]	6	266.1	20.0	0.05047	0.0113
0	3	82.0	45.9	0.89797	0.2004
3	[illegible]	84.3	31.2	0.81219	0.1812
6	3	88.8	18.3	0.62232	0.1389
9	3	92.3	8.2	0.43426	0.0969
12	3	[illegible]	7.4	0.29346	0.0655
15	3	233.5	[illegible]	0.19899	0.0444
18	3	243.4	12.3	0.13759	0.0307
21	3	247.2	16.0	0.09755	0.0218
24	3	249.2	19.1	0.07095	0.0158
27	3	250.4	21.5	0.05287	0.0118
0	0	102.3	49.0	1.00000	0.2231
3	0	110.7	34.8	0.89797	0.2004
6	0	124.9	23.2	0.67659	0.1510
9	0	148.9	16.0	0.46361	0.1034
12	0	0.0	13.8	0.30854	0.0688
15	0	204.7	15.1	0.20681	0.0461
18	0	219.4	17.6	0.14179	0.0316
21	0	228.0	20.2	0.09990	0.0223
24	0	233.5	22.5	0.07233	0.0161
27	0	237.2	24.4	0.05371	0.0120
0	-3	120.0	55.2	0.89797	0.2004
3	-3	130.6	42.8	0.81219	0.1812
6	-3	144.8	33.1	0.62232	0.1389
9	-3	162.1	27.0	0.43426	0.0969
12	-3	0.0	24.2	0.29346	0.0655
15	-3	195.5	23.8	0.19899	0.0444
18	-3	207.3	24.5	0.13759	0.0307
21	-3	216.0	25.7	0.09755	0.0218
24	-3	222.3	27.0	0.07095	0.0158
27	-3	227.0	28.2	0.05287	0.0118

Wall 3

2 × SONT 250W

$x_0=12$ $y_0=4$ $h=11m$

E_{av} = 48 lux

E_{max} = 84 lux

E_{min} = 17 lux

17	32	42	40	39	39	40	42	32	17
25	47	65	59	56	56	59	65	47	25
26	58	84	73	64	64	73	84	58	26
26	56	75	63	56	56	63	75	56	26
18	35	56	48	43	43	48	56	35	18

Wall4

Entry

Wall 4 (18 × 12 m^2)

Xo=14.0 Yo= 5.0 h= 9.0

X	Y	C	GAMA	COS CUBE	FACTOR
5	9	39.0	34.4	0.28508	0.0950
8	9	31.6	24.4	0.21457	0.0715
11	9	19.6	16.7	0.15313	0.0510
14	9	0.0	11.7	0.10762	0.0359
17	9	332.4	9.5	0.07611	0.0254
20	9	306.2	9.8	0.05472	0.0182
23	9	288.8	11.3	0.04013	0.0134
5	6	57.2	29.1	0.43082	0.1436
8	6	53.4	17.5	0.29937	0.0998
11	6	43.9	8.7	0.19855	0.0662
14	6	0.0	3.1	0.13165	0.0439
17	6	278.1	4.7	0.08911	0.0297
20	6	261.3	8.3	0.06201	0.0207
23	6	255.9	11.4	0.04440	0.0148
5	3	86.9	27.0	0.59113	0.1970
8	3	98.1	15.3	0.38146	0.1272
11	3	126.2	8.0	0.23785	0.0793
14	3	0.0	6.5	0.15072	0.0502
17	3	211.6	9.2	0.09880	0.0329
20	3	223.9	12.2	0.06721	0.0224
23	3	229.9	14.8	0.04734	0.0158
5	0	118.2	32.4	0.66799	0.2227
8	0	135.8	22.7	0.41752	0.1392
11	0	158.2	17.9	0.25392	0.0846
14	0	0.0	16.7	0.15813	0.0527
17	0	196.4	17.4	0.10243	0.0341
20	0	207.5	18.7	0.06911	0.0230
23	0	214.9	20.1	0.04839	0.0161
5	-3	138.4	43.1	0.59113	0.1970
8	-3	152.4	34.4	0.38146	0.1272
11	-3	166.8	29.4	0.23785	0.0793
14	-3	0.0	26.9	0.15072	0.0502
17	-3	190.9	26.0	0.09880	0.0329
20	-3	199.6	25.9	0.06721	0.0224
23	-3	206.3	26.2	0.04734	0.0158

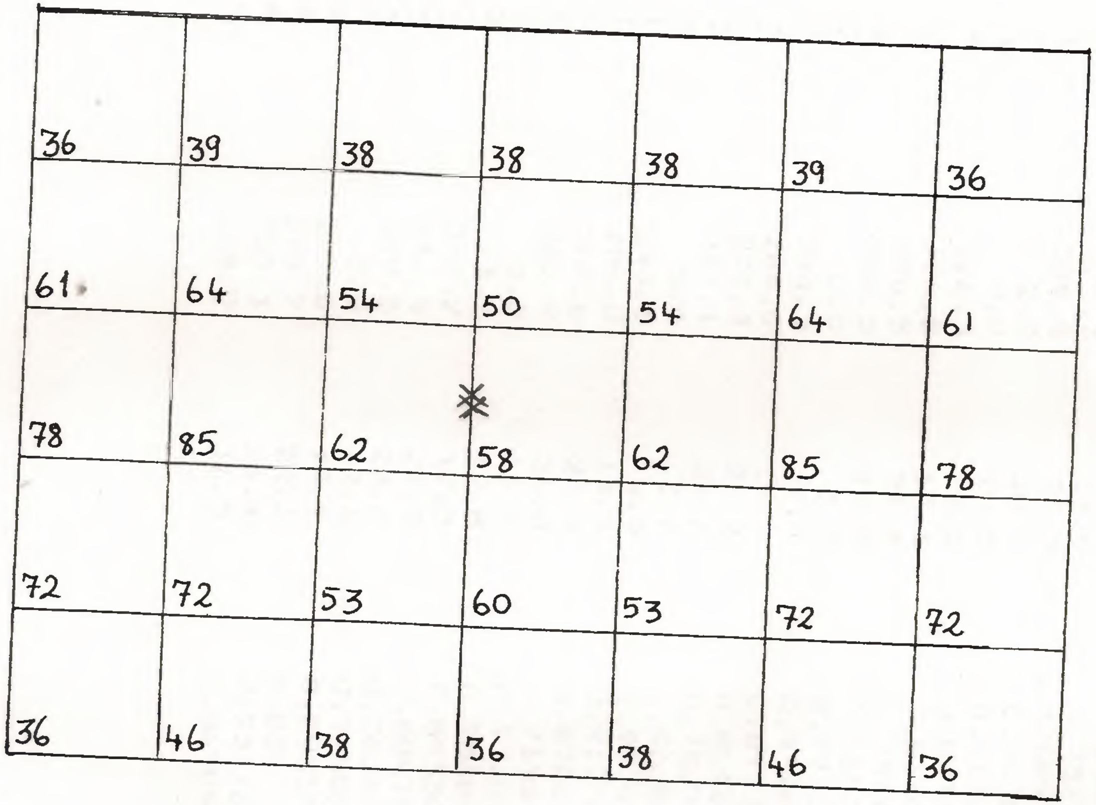
<u>Wall4</u>

2 × SONT 250W
x_o=14 y_o= 5   h=9 m

E_{av} = 55 lux

E_{max} = 85 lux

E_{min} = 36 lux



36	39	38	38	38	39	36
61	64	54	50	54	64	61
78	85	62	58	62	85	78
72	72	53	60	53	72	72
36	46	38	36	38	46	36

Entry (16 ×10m²)

Xo= 0.0 Yo= 1.0 h=16.0

X	Y	C	GAMA	COS CUBE	FACTOR
0	6	0.0	17.0	0.82089	0.0545
2	6	338.2	18.2	0.80431	0.0534
4	6	321.3	21.4	0.75776	0.0503
6	6	309.8	25.5	0.68952	0.0458
8	6	302.0	30.0	0.60980	0.0405
0	4	0.0	10.5	0.91308	0.0606
2	4	326.3	12.5	0.89330	0.0593
4	4	306.8	17.1	0.83805	0.0557
6	4	296.5	22.5	0.75776	0.0503
8	4	290.5	27.8	0.66504	0.0442
0	2	0.0	3.5	0.97701	0.0649
2	2	296.5	7.9	0.95489	0.0634
4	2	284.0	14.4	0.89330	0.0593
6	2	279.4	20.7	0.80431	0.0534
8	2	277.1	26.6	0.70233	0.0466
0	0	0.0	3.6	1.00000	0.0664
2	0	243.5	8.0	0.97701	0.0649
4	0	256.0	14.5	0.91308	0.0606
6	0	260.6	20.9	0.82089	0.0545
8	0	262.9	26.8	0.71554	0.0475
0	-2	0.0	10.7	0.97701	0.0649
2	-2	213.7	12.8	0.95489	0.0634
4	-2	233.2	17.5	0.89330	0.0593
6	-2	243.5	22.9	0.80431	0.0534
8	-2	249.5	28.3	0.70233	0.0466
0	-4	0.0	17.6	0.91308	0.0606
2	-4	201.8	18.9	0.89330	0.0593
4	-4	218.7	22.1	0.83805	0.0557
6	-4	230.3	26.4	0.75776	0.0503
8	-4	238.0	31.0	0.66504	0.0442

Entry

1×HPI 250W
$x_0=0$ $y_0=1$ h=16m

E_{av} = 35 lux

E_{max} = 83 lux

E_{min} = 16 lux

10	16	22	30	34	30	22	16	10
13	21	35	51	58	51	35	21	13
15	25	45	68	82	68	45	25	15
15	25	46	70	83	70	46	25	15
13	22	36	54	62	54	36	22	13
10	16	24	32	36	32	24	16	10

Eastern Walls

Western Wall

Southern Wall

Eastern walls (two) - (3.5m*35m each)

Southern wall - (3.5m*42m)

Western wall - (3.5m*39m)

Consider 4*35m wall

Using lumen method, we determine the no of lamps needed:

$$\phi_{total} = \frac{A \times E_{av}}{\eta} = \frac{(4\times35)(50)}{0.3} = 23333 \text{ lm}$$

$$\phi_{sox55} = 7400 \text{ lm} \quad \therefore \text{ no of lamps} = \frac{23333}{7400} \simeq 3$$

Then, using relative-isolux diagram of luminaire SNF026-N with 0 aiming angle we determine the positions of luminaires.

h = 10m (we can not increase h since the site does not allow this, this is also one reason chosing 55W SOX lamp and not less floodlights with higher wattage or luminous flux)

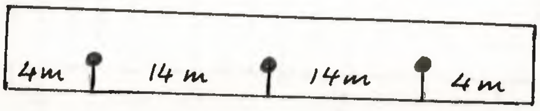
Then, height of the walls in terms of h is 0.4h,

i.e. between - 0.2h and + 0.2h since luminaires are on 2m poles.

E_{min} / E_{max} > 0.2 must be satisfied

Chosing E_{min} / E_{max} = 0.4 following arrangement of lamps are obtained.

OR



Calculations made on relative isolux diagram are on next page.

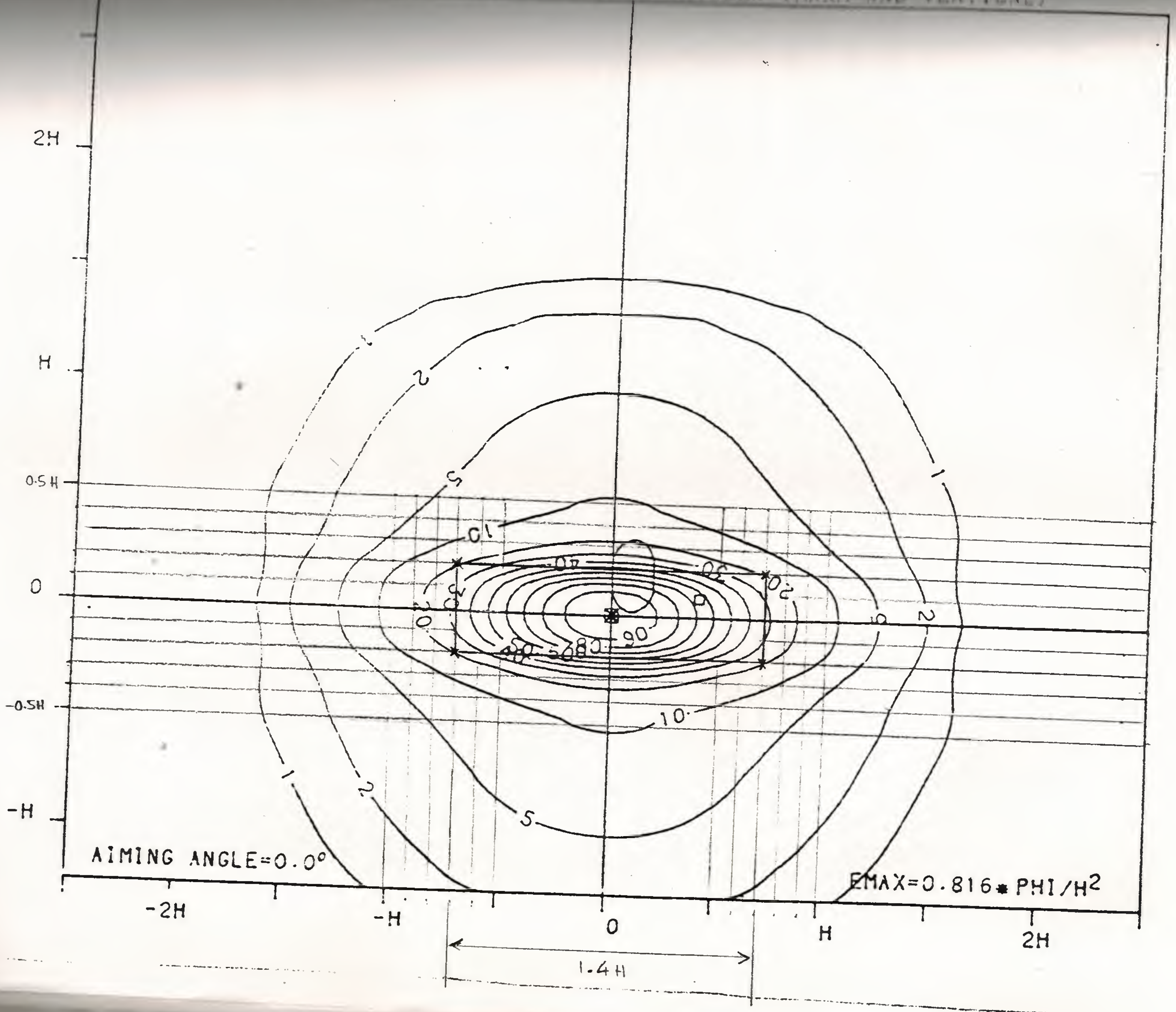
So, E = 0.816 * PHI / h = 60 lux

E = 0.4 * E = 24 lux

Although other walls are longer in length (>35m) we could still use above arrangement since our chosen coefficient of regularity is better than desired

[illegible]

[illegible] ANGLE BETWEEN IMAXM AND VERTICAL)



CONCLUSION

The buildings of historic and architectural interest are floodlighted in order to *enhance their appearence and aesthetic beauty. For this purpose special types of* lamps have been developed and certain design techniques are available.

In my project, I had chosen illumination of St. Barnabas monastery as an object and followed the following steps.

Firstly, I had examined the building and took the photographs of the place, then I had decided the level of illumination required on the facade as 50 lux. When deciding the level of illumination I took account of the general brightness of the surroundings, the type and condition of the building materials and, the reflection factor of the surface.

Secondly, I had chosen the floodlights to be used according to the nature of the walls (such as height, surface material...) and decided to use three types of floodlights. The height of the walls helped me to make selection between wide-beam and narrow-beam floodlights. So, the floodlights I used are;

* HNF003-W luminaire with SONT250W lamp for the church walls which are 12m high and made of yellow stone.

* NNF010-W luminaire with HPI250W lamp for the wall at the enterance of the building which is white in colour and has dimensions of 16m*10m.

* SNF026-N luminaire with SOX55W lamp for the outside walls of the monastery which are 3.5m high and made of yellow stone.

Thirdly, I had made the floodlighting calculations such that I get the recommended uniformity on the facade ($E_{min}/ E_{av} > 0.4$ and $E_{min}/ E_{max} > 0.2$). At this stage, first I calculated the number of floodlights needed for the facade by lumen method and then I used isolux diagrams (for SOX55W) and isocandela matrix (I-tables for SONT250W and HPI250W) in order to determine illuminance levels. For the latter case, I made a computer program to make the calculations easily.

As a result, I can say that, this project thought me the steps I should follow when floodlighting a building and showed me how to proceed when illuminating a place. However, the technique of floodlighting a building is not based solely on the principles of lighting engineering- experience, feeling and insight as regards the aesthetic values of the architecture are just as important.

APPENDIX A

SONT LAMPS / HNF003-W FLOODLIGHT AND I-TABLE

SON-T lamps

SON-T 50 W
SON-T 70 W
SON-T 100 W
SON-T 150 W

SON-ST 150 W
SON-T 250 W
SON-T 400 W
SON-T 1000 W

Definition

High-pressure sodium vapour lamps, for outdoor and indoor use, with sintered aluminium oxide discharge tube enclosed in a clear, tubular hard-glass outer bulb.

Description

- Because of the high sodium pressure the lamp has a high luminous efficacy and a good colour appearance.
- The clear, tubular outer bulb makes this light source highly suitable for use with specially designed optical systems.
- Additional assets:
  - Long economical life
  - Excellent lumen maintenance
  - Reliable, stable operation.

Applications

- Public lighting
- Parking lots
- Airports
- Floodlighting
- Industrial lighting
- Plant irradiation
- Sports lighting

Ballasts and ignitors

High-pressure sodium lamps require high quality ballasts for optimum operation, as well as ignitors to ensure reliable ignition. For ballasts and ignitors see relevant leaflets.

Temperatures

Max. permissible base temperature: 250 °C
Max. permissible bulb temperature: 450 °C

Dimensions

Lamp designation	A max.	B nom.	C max.	D nom.
SON-T 50 W-E	159	105	38	35
SON-T 70 W-E	159	105	38	35
SON-T 100 W	211	132	48	41
SON-T 150 W	211	132	48	58
SON-ST 150 W	211	132	48	58
SON-T 250 W	257	158	48	65
SON-T 400 W	283	175	48	85
SON-T 1000 W	390	240	67	148

ing positions

ersal

nical data

ation	Base	Min. supply voltage for ignition[1]) V +20° C	Min. supply voltage for ignition[1]) V −18° C[4])	Average lamp voltage[2]) V	Average lamp current[4]) A	Min. supply voltage for stable operation V	Max starting current (mains current) A	Average luminous flux[2]) lm	Average luminance cd/cm²	Run-up time minutes[3])
50 W-E	E27/30	190	200	86	0,76	200	1,08	4000	300	5
70 W-E	E27/30	190	200	86	1,00	200	1,35	6500	300	5
100 W	E40/45	190	200	100	1,20	200	2,70	10000	300	5
150 W	E40/45	170	200	100	1,80	200	2,40	14000	300	5
150 W	E40/45	170	200	100	1,80	200	2,40	16000	340	4
250 W	E40/45	170	200	100	3,00	200	4,50	27000	360	5
400 W	E40/45	170	200	100[5])	4,30	200	6,50	47000[6])	550	5
000 W	E40/80x50	170	200	100[5])	10,30	200	14,00	125000[6])	650	6

hours. [2]) After 100 burning hours.

number of minutes after which the lamp has reached 90% of its final luminous flux.

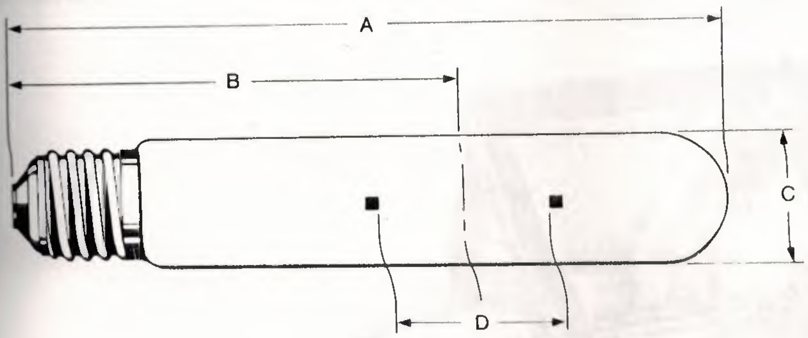
will ignite even on nominal voltage at temperatures of −30° C.

this arc voltage and a bare lamp, a power consumption of 392 W is obtained for the 400 W (IEC) and 960 W for the 1000 W type.

luminous flux is obtained under conditions according to note 5).

ering and packing data

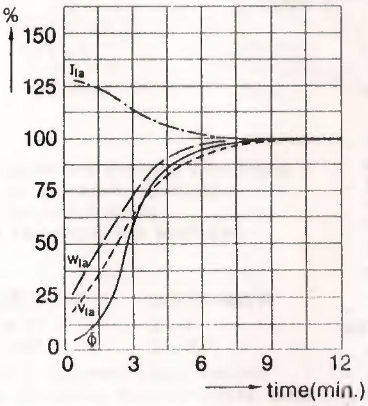
ation	Ordering number	Nett weight kg	Packing unit Qty	Packing unit Weight kg	Packing unit Dimensions cm	Packing unit Volume m³
50 W-E	9281 519 088 . .	0,05	12	1,2	23 x 17 x 20	0,008
70 W-E	8222 341 145 . .	0,05	12	1,2	23 x 17 x 20	0,008
100 W	9281 517 092 . .	0,16	12	3,09	34 x 27 x 32	0,029
150 W	9281 504 092 . .	0,17	12	3,09	34 x 27 x 32	0,029
150 W	9281 509 092 . .	0,17	12	3,09	34 x 27 x 32	0,029
250 W	9281 515 092 . .	0,20	12	3,60	34 x 27 x 37	0,034
400 W	9281 445 092 . .	0,20	12	3,90	34 x 27 x 37	0,034
000 W	9281 545 092 . .	0,45	4	2,99	28 x 28 x 48	0,038



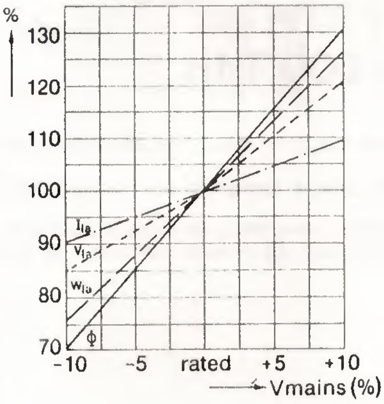
Typical curves

W_{la} = lamp wattage
V_{la} = lamp voltage
I_{la} = lamp current
Φ = luminous flux

Lamp performance during starting period

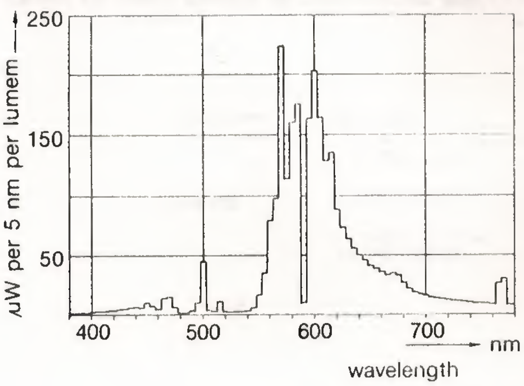


Effects of mains voltage variations

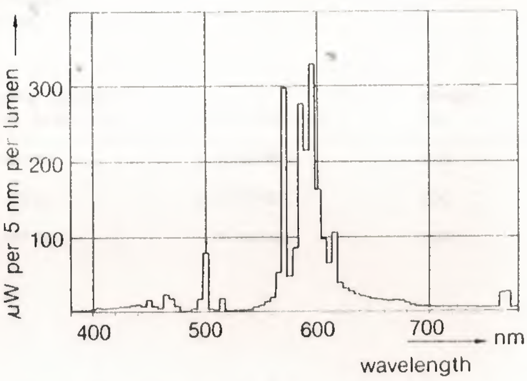


Normalised spectral power distributions

100 W



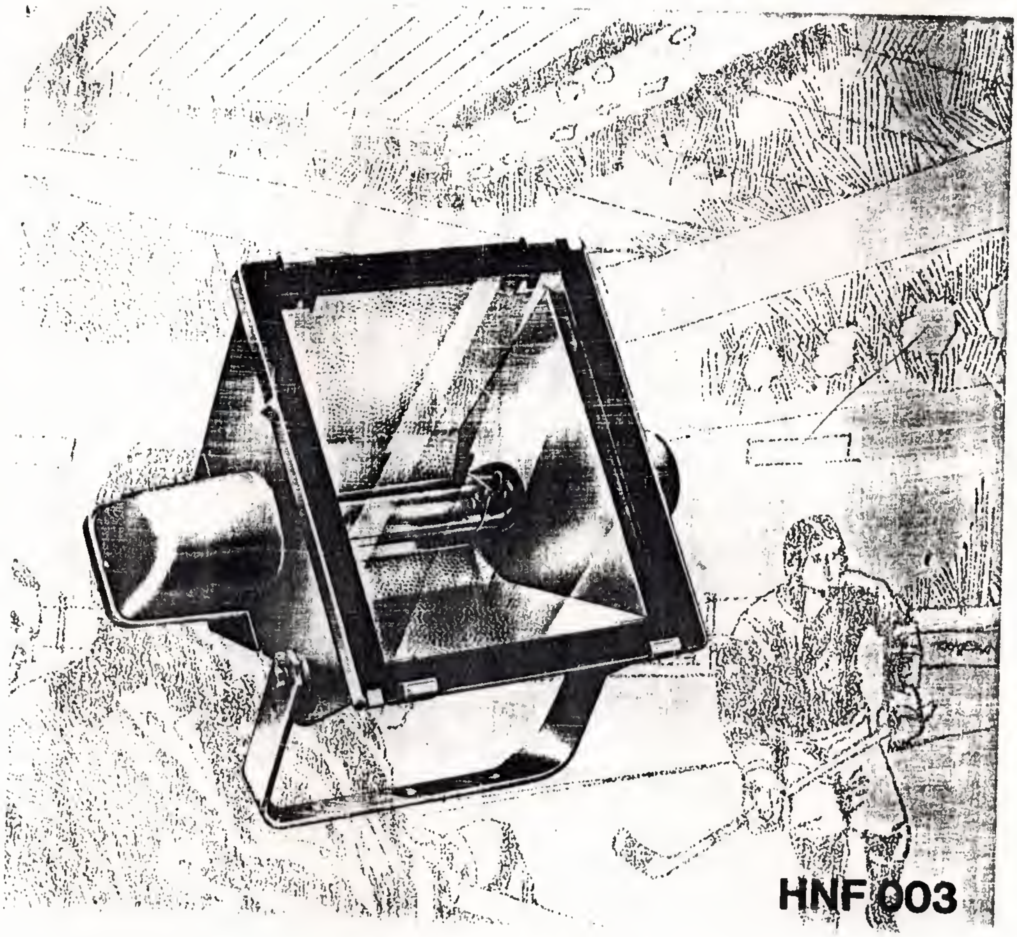
400 W



ITION

ight for one of the fol-
g lamps:
T 400 W metal halide lamp
T 400 W mercury vapour

T 250 W or 400 W high-
ure sodium lamp.



HNF 003

PTION

ng and rear cover of high-pressure die-cast aluminium gs of low copper-content for excellent corrosion-nce, even in coastal and industrial areas.

beam-versions, as different reflectors are available:

	HPI/T 400 W and HP/T 400 W	SON/T 250 W	SON/T 400 W
beam:	2 x 7°	2 x 7°	2 x 7°
am:	2 x 27°	2 x 27°	2 x 27°

rade aluminium reflectors for accurate beam control

replacement is effected by removing the rear-cover, thus ing servicing

o-operate stainless steel clips on rear-cover; to be closed and opened by using a simple tool.

odlight cannot be easily opened by unauthorized per-

- Cast-on beam-aiming sight and protractor scale for quick day-light adjustment.
- Silicone rubber gasket for jetproof and dustproof sealing of front glass.
- The front glass is a 5,5 mm-thick toughened glass plate, which is attached to the housing by 4 stainless steel clips; two extra safety brackets.

APPLICATIONS

- Sports grounds
- Floodlight of buildings
- Marshalling yards
- Car parks
- Skating rinks
- High-mast lighting
- Sports halls
- Shipyards

NG DATA

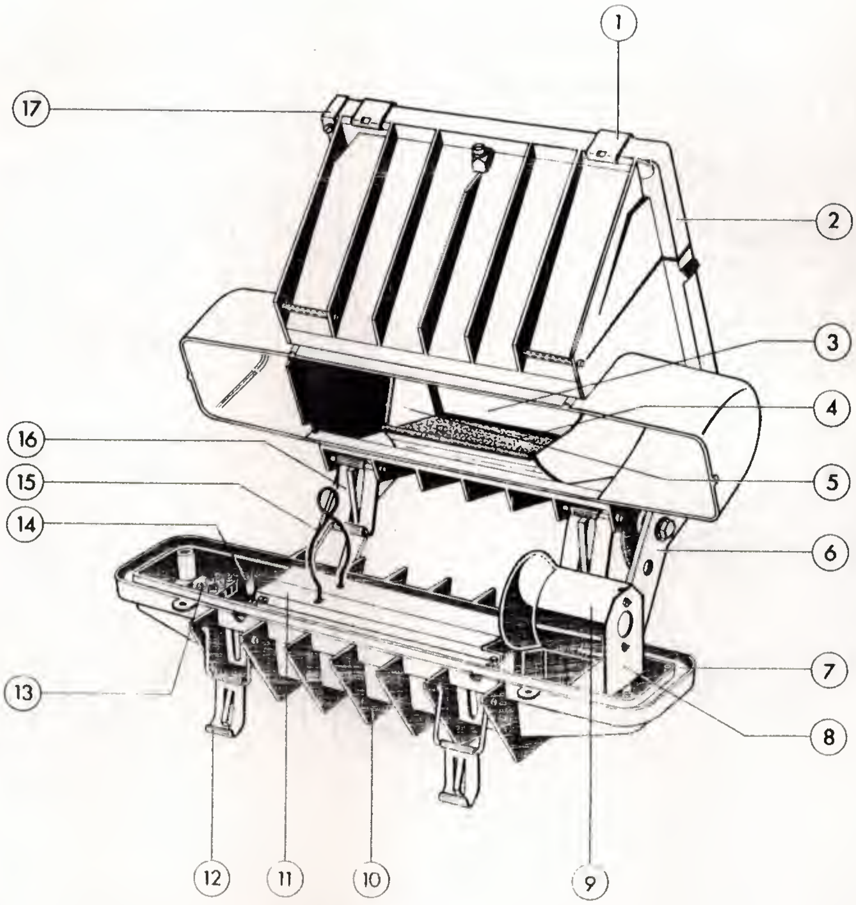
Designation	For lamps	Ordering number * Narrow-beam type	Wide-beam type	Weight kg
	1 x SON/T 250 W	9112 702 302..	9112 702 303..	7,30
HNF 003	1 x HP/T 400 W	9112 702 426..	9112 702 427..	7,30
	1 x SON/T 400 W or 1 x HPI/T 400 W	9112 702 448..	9112 702 449..	7,30

* Complete floodlight

FLOODLIGHT FOR METAL HALIDE LAMP, MERCURY VAPOUR LAMP OR HIGH-PRESSURE SODIUM LAMPS

ILED DRAWING

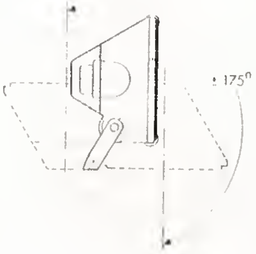
- Front-glass clips (4x)
- Housing
- Front glass
- Parabolic reflector
- Side reflector
- Bracket
- Gasket rear cover
- Lampholder bracket
- Lampholder
- Rear cover
- Rear reflector
- Closing clip top (2 x)
- Terminal block
- Cable entry
- Lamp support
- Closing clip bottom (2 x)
- Safety bracket (2 x)



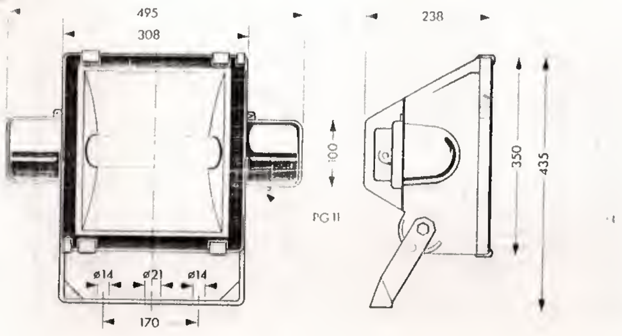
REPLACEMENT OF FRONT GLASS

- Remove the two safety brackets
- Open the four clips by placing a screwdriver in the appropriate holes

ADJUSTMENT POSSIBILITIES



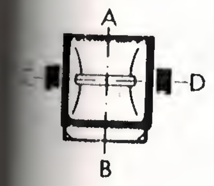
DIMENSIONS



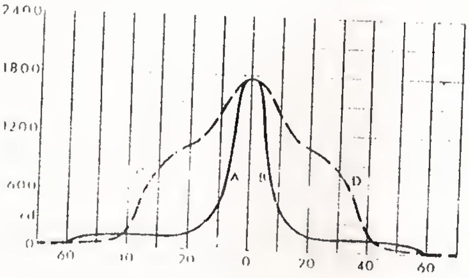
HTING DATA
= 1000 lm

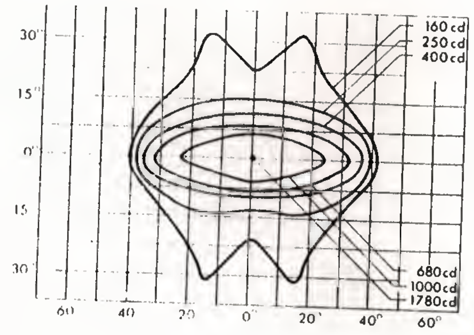
Light distribution diagrams

Isocandela diagrams

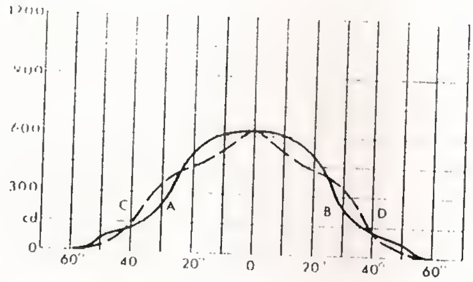


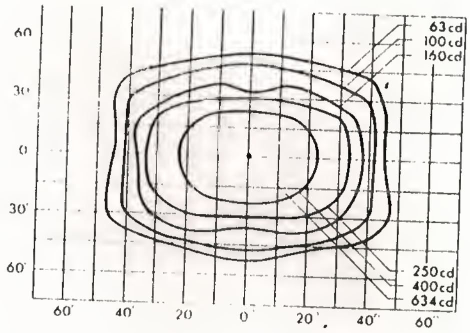
SON/T 250 W narrow beam



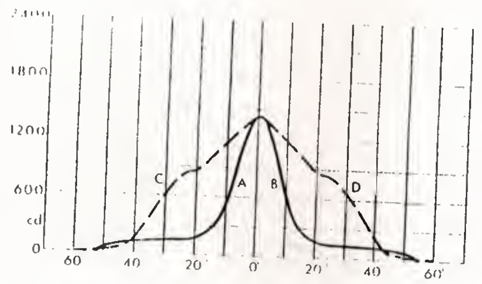


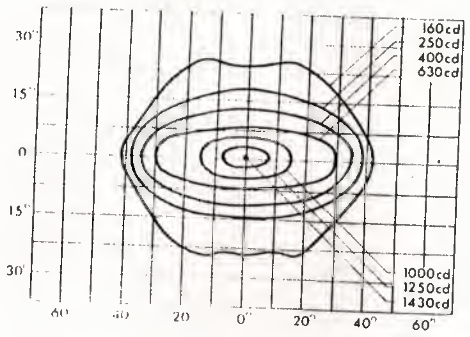
SON/T 250 W wide beam



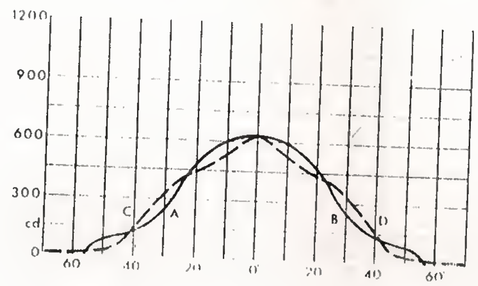


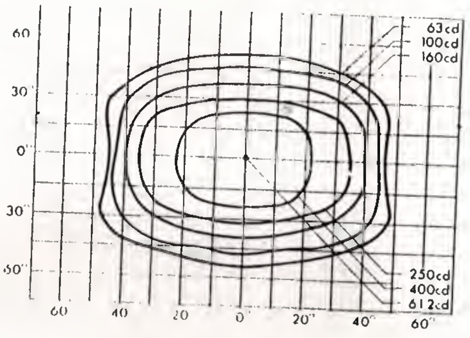
SON/T 400 W narrow beam





SON/T 400 W wide beam

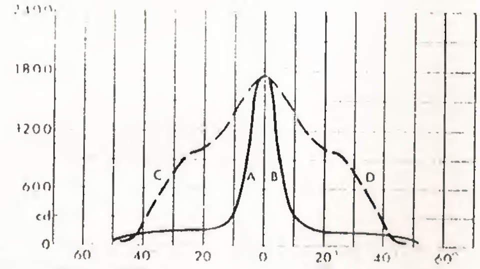


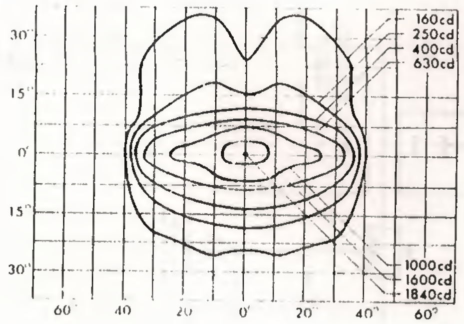


Light distribution diagrams

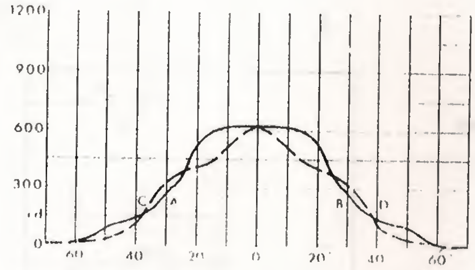
Isocandela diagrams

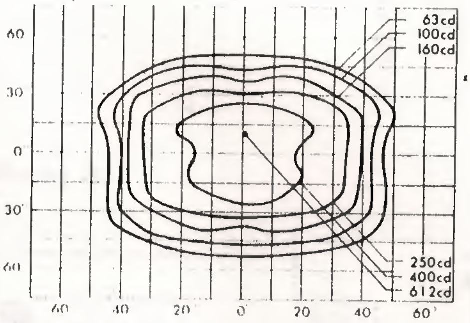
400 W narrow beam



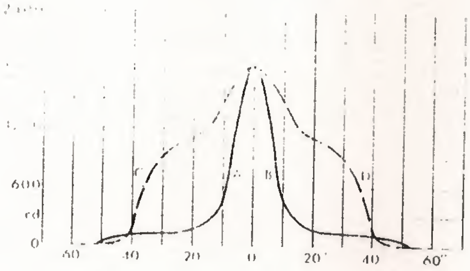


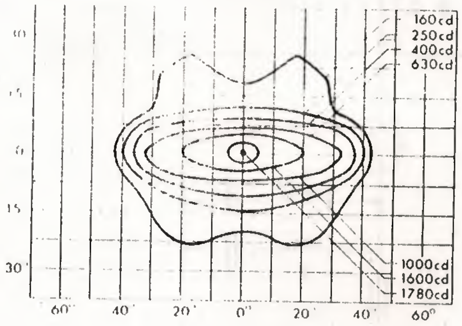
400 W wide beam



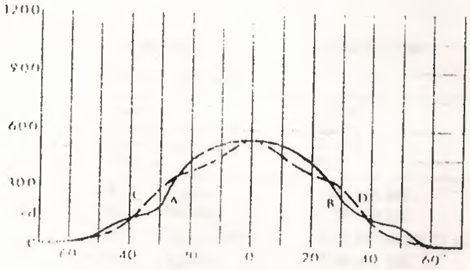


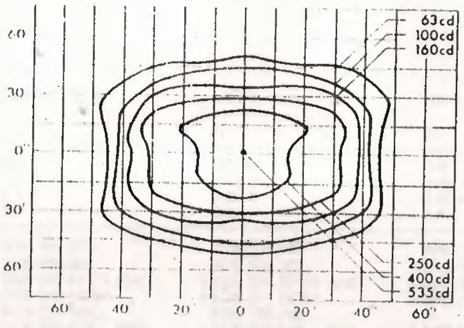
W narrow beam





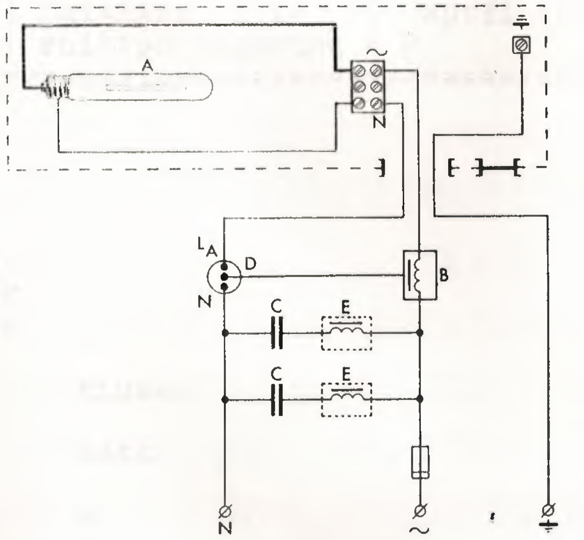
W wide beam



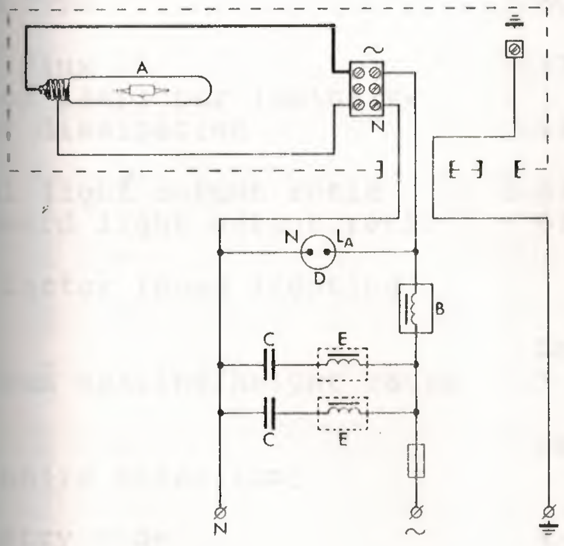


WIRING DIAGRAMS

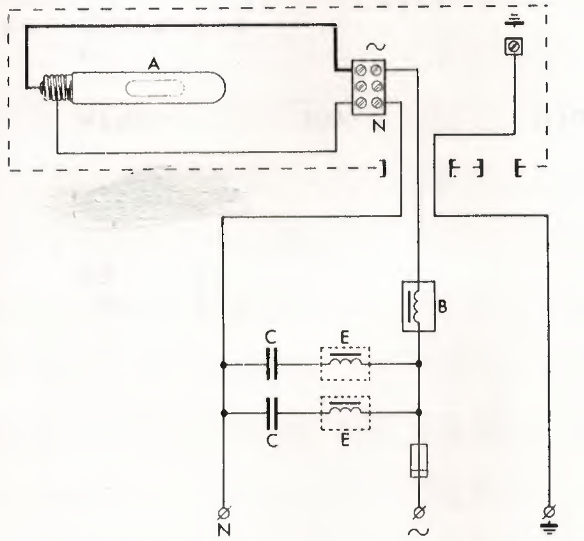
Wiring diagram I



Wiring diagram II



Wiring diagram III



TECHNICAL DATA

For lamps:		SON/T 250 W	SON/T 400 W	HPI/T 400 W	HP/T 400 W
Wiring diagrams:		I	I	II	III
Mains		220 V	220 V	220 V	220 V
Starting current		2,4 A	3,5 A	3.05 A	3,05 A
Operating current		1,45 A	2,2 A	2,05 A	2,05 A
Cos φ		0,9	0,9	0,9	0,9
A	Lamp	9281 515 092..	9281 445 092..	9280 734 092..	9280 595 092..
B	Ballast	9136 250 203..	9136 230 203..	9136 040 303..	9136 040 303..
C	Capacitor	2222 242 02123 (2 x)	2222 242 02123 and 2222 242 02134	2222 242 02123 and 2222 241 54101	2222 242 02123 and 2222 241 54101
D	Ignitor	9136 250 103..	9136 250 103..	9136 190 599..	—
E	Filter coil	9136 800 010.. (2 x)	9136 800 010.. and 9136 800 011..	9136 800 010.. and 9136 800 008..	9136 800 010.. and 9136 800 008..

```
=====================================================================
LIPS LIGHTING B.V.                                  Date     : 89-08-14
ghting Design and Engineering Centre  | Computer Aided Lighting Design
puter Aided Lighting Design           | DATABASE  1.20       April 1989
                                      | Philips Lighting B.V.
=====================================================================

minaire (INR) number          : 73

easuring code                 : LVO 4147
minaire type                  : HNF 003-W
mp type                       : SONT 400W

mp flux                       : 47.00        kLumen
. of lamps per luminaire      : 1
wer dissipation               : 431.00       Watt

tal light output ratio        : 67           %
wnward light output ratio     : 67           %

LI-factor (Road lighting)     :

                                 Lengthwise   Crosswise
aximum spacing/height ratio   : *            *

                                Length       Width       H0        H90
minaire sizes [mm]            :

mmetry code                   : 4

                                N1     N2     N3     N4
 Fluxcode [%]                 : 82     99     100    100
```

Date : 89-08-14

LIPS LIGHTING B.V.
hting Design and Engineering Centre
puter Aided Lighting Design

Computer Aided Lighting Design
DATABASE 1.20 April 1989
Philips Lighting B.V.

inaire (INR) number : 73

asuring code : LVO 4147
inaire type : HNF 003-W
p type : SONT 400W

-Table *

	0.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0
.0	612	612	612	612	612	612	612	612	612	612	612
.5	602	599	600	601	602	603	604	606	608	610	608
.0	586	586	588	589	590	587	589	589	592	597	592
.5	564	565	565	565	564	566	569	574	577	583	577
.0	538	533	533	536	539	546	556	567	574	583	574
.5	509	507	508	510	515	526	549	573	585	597	585
.0	480	485	480	477	489	520	548	572	587	597	586
.5	453	457	450	450	471	511	537	552	560	556	560
.0	426	426	423	427	462	496	507	503	507	510	507
.5	407	401	399	410	444	466	456	456	457	455	457
.0	379	383	381	402	416	417	414	408	399	400	399
.5	343	350	355	387	388	381	376	363	346	341	346
.0	303	306	324	359	362	344	336	316	293	287	293
.5	257	264	292	325	328	308	290	274	248	234	248
.0	211	221	254	285	287	273	252	233	206	196	206
.5	164	178	214	237	246	233	217	201	181	179	181
.0	123	133	168	194	206	196	182	175	171	163	171
.5	86	99	127	153	170	166	154	153	151	147	151
.0	58	69	89	119	139	141	134	130	129	130	129
.5	45	49	63	90	113	118	113	116	108	110	108
.0	32	37	49	70	91	99	98	92	87	90	87
.5	20	25	35	56	70	82	100	45	66	69	66
.0	12	16	20	41	49	68	72	10	45	37	45
.5	9	10	10	21	33	44	21	9	22	19	22
.0	6	8	7	10	13	12	7	7	11	5	11
.5	4	5	4	5	3	3	5	7	4	5	4
.0	2	3	4	2	3	3	5	7	2	6	2
.5	2	2	3	3	2	2	4	6	7	6	7
.0	1	2	2	2	2	2	4	6	6	5	6
.5	1	1	2	2	1	2	3	5	6	5	6
.0	1	1	1	1	1	2	3	4	5	3	5
.5	1	1	1	1	1	1	2	3	4	2	4
.0	0	0	0	0	1	1	1	2	2	1	2
.5	0	0	0	0	0	0	1	1	1	0	1
.0	0	0	0	0	0	0	0	0	0	0	0
.5	0	0	0	0	0	0	0	0	0	0	0
.0	0	0	0	0	0	0	0	0	0	0	0

--> C-plane

V
ma-angle

```
=====================================================================
PHILIPS LIGHTING B.V.                      | Computer Aided Lighting Design
Lighting Design and Engineering Centre     | DATABASE   1.20        April 1989
Computer Aided Lighting Design             | Philips Lighting B.V.
=====================================================================

Luminaire (INR) number         : 73

Measuring code                 : LVO 4147
Luminaire type                 : HNF 003-W
Lamp type                      : SONT 400W


* I-Table *
-----------

       110.0 120.0 130.0 140.0 150.0 160.0 170.0 180.0 190.0 200.0 210.0
      +-----------------------------------------------------------> C-plane
      |
  0.0 |  612   612   612   612   612   612   612   612   612   612   612
  2.5 |  606   604   603   602   601   600   599   602   599   600   600
  5.0 |  589   589   587   590   589   588   586   586   586   588   589
  7.5 |  574   569   566   564   565   565   565   564   565   565   565
 10.0 |  567   556   546   539   536   533   533   538   533   533   536
 12.5 |  573   549   526   515   510   508   507   509   507   508   510
 15.0 |  572   548   520   489   477   480   485   480   485   480   477
 17.5 |  552   537   511   471   450   450   457   453   457   450   450
 20.0 |  503   507   496   462   427   423   426   426   426   423   427
 22.5 |  456   456   466   444   410   399   401   407   401   399   410
 25.0 |  408   414   417   416   402   381   383   379   383   381   402
 27.5 |  363   376   381   388   387   355   350   343   350   355   387
 30.0 |  316   336   344   362   359   324   306   303   306   324   359
 32.5 |  274   290   308   328   325   292   264   257   264   292   325
 35.0 |  233   252   273   287   285   254   221   211   221   254   285
 37.5 |  201   217   233   246   237   214   178   164   178   214   237
 40.0 |  175   182   196   206   194   168   133   123   133   168   194
 42.5 |  153   154   166   170   153   127    99    86    99   127   153
 45.0 |  130   134   141   139   119    89    69    58    69    89   119
 47.5 |  116   113   118   113    90    63    49    45    49    63    90
 50.0 |   92    98    99    91    70    49    37    32    37    49    70
 52.5 |   45   100    82    70    56    35    25    20    25    35    56
 55.0 |   10    72    68    49    41    20    16    12    16    20    41
 57.5 |    9    21    44    33    21    10    10     9    10    10    21
 60.0 |    7     7    12    13    10     7     8     6     8     7    10
 62.5 |    7     5     3     3     5     4     5     4     5     4     5
 65.0 |    7     5     3     3     2     4     3     2     3     4     2
 67.5 |    6     4     2     2     3     3     2     2     2     3     3
 70.0 |    6     4     2     2     2     2     2     1     2     2     2
 72.5 |    5     3     2     1     2     2     1     1     1     2     2
 75.0 |    4     3     2     1     1     1     1     1     1     1     1
 77.5 |    3     2     1     1     1     1     1     1     1     1     1
 80.0 |    2     1     1     1     0     0     0     0     0     0     0
 82.5 |    1     1     0     0     0     0     0     0     0     0     0
 85.0 |    0     0     0     0     0     0     0     0     0     0     0
 87.5 |    0     0     0     0     0     0     0     0     0     0     0
 90.0 |    0     0     0     0     0     0     0     0     0     0     0
      |
      v
Gamma-angle
```

Date : 89-08-14

PHILIPS LIGHTING B.V.
Lighting Design and Engineering Centre
Computer Aided Lighting Design

Computer Aided Lighting Design
DATABASE 1.20 April 1989
Philips Lighting B.V.

Luminaire (INR) number : 73

Measuring code : LVO 4147
Luminaire type : HNF 003-W
Lamp type : SONT 400W

* I-Table *

Gamma-angle	220.0	230.0	240.0	250.0	_60.0	270.0	280.0	290.0	300.0	310.0	320.0 → C-plane
0.0	612	612	612	612	612	612	612	612	612	612	612
2.5	602	603	604	606	608	610	608	606	604	603	602
5.0	590	587	589	589	592	597	592	589	589	587	590
7.5	564	566	569	574	577	583	577	574	569	566	564
10.0	539	546	556	567	574	583	574	567	556	546	539
12.5	515	526	549	573	585	597	585	573	549	526	515
15.0	489	520	548	572	586	597	586	572	548	520	489
17.5	471	511	537	552	560	568	560	552	537	511	471
20.0	462	496	507	503	507	510	507	503	507	496	462
22.5	444	466	456	456	457	458	457	456	456	466	444
25.0	416	417	414	408	399	400	399	408	414	417	416
27.5	388	381	376	363	346	344	346	363	376	381	388
30.0	362	344	336	316	293	287	293	316	336	344	362
32.5	328	308	290	274	248	239	248	274	290	308	328
35.0	287	273	252	233	206	196	206	233	252	273	287
37.5	246	233	217	201	181	172	181	201	217	233	246
40.0	206	196	182	175	171	163	171	175	182	196	206
42.5	170	166	154	153	151	146	151	153	154	166	170
45.0	139	141	134	130	129	130	129	130	134	141	139
~~47.5~~	~~113~~	~~118~~	~~113~~	~~116~~	~~108~~	~~111~~	~~108~~	~~116~~	~~113~~	~~118~~	~~113~~
50.0	91	99	98	92	87	90	87	92	98	99	91
52.5	70	82	100	45	66	69	66	45	100	82	70
55.0	49	68	72	10	45	48	45	10	72	68	49
57.5	33	44	21	9	22	19	22	9	21	44	33
60.0	13	12	7	7	11	5	11	7	7	12	13
62.5	3	3	5	7	4	5	4	7	5	3	3
65.0	3	3	5	7	2	5	2	7	5	3	3
67.5	2	2	4	6	7	6	7	6	4	2	2
70.0	2	2	4	6	6	5	6	6	4	2	2
72.5	1	2	3	5	6	5	6	5	3	2	1
75.0	1	2	3	4	5	4	5	4	3	2	1
77.5	1	1	2	3	4	2	4	3	2	1	1
80.0	1	1	1	2	2	1	2	2	1	1	1
82.5	0	0	1	1	1	0	1	1	1	0	0
85.0	0	0	0	0	0	0	0	0	0	0	0
87.5	0	0	0	0	0	0	0	0	0	0	0
90.0	0	0	0	0	0	0	0	0	0	0	0

```
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Luminaire (INR) number          : 73

Measuring code                  : LVO 4147
Luminaire type                  : HNF 003-W
Lamp type                       : SONT 400W



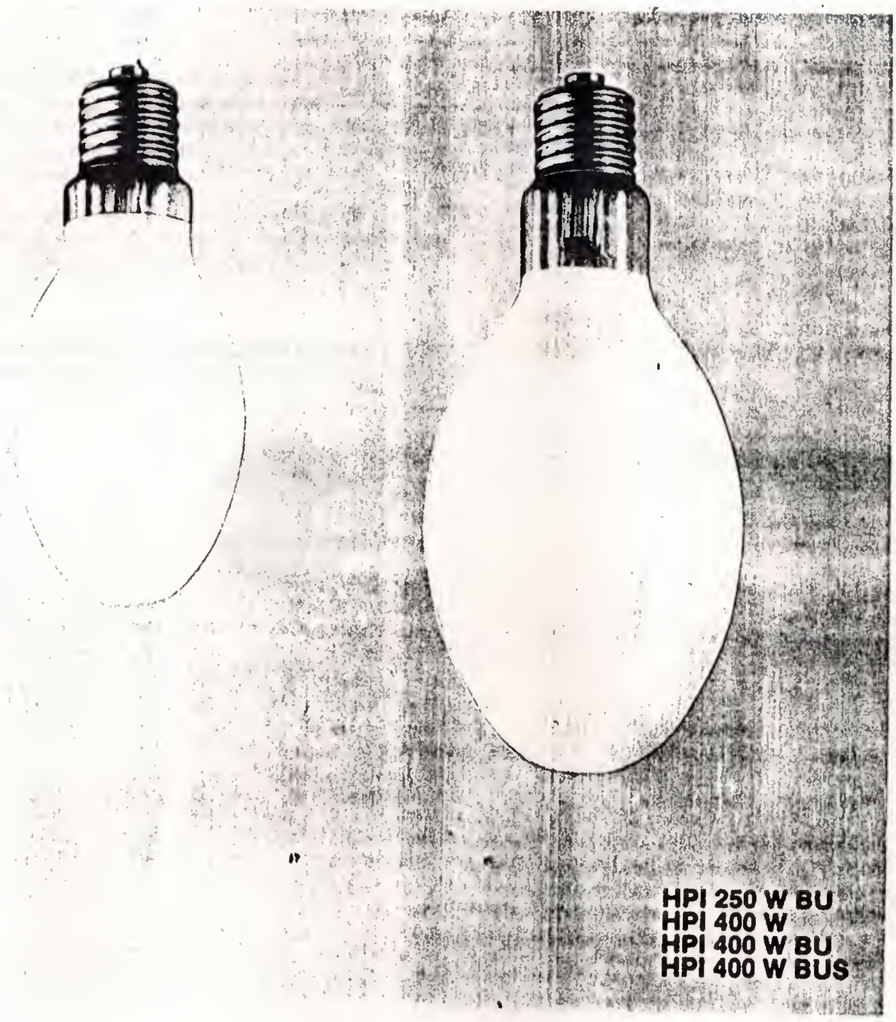
* I-Table *
-----------

       330.0 340.0 350.0 360.0
      +------------------------------------------------------------> C-plane
      |
  0.0 |  612   612   612   612
  2.5 |  600   600   599   602
  5.0 |  589   588   586   586
  7.5 |  565   565   565   564
 10.0 |  536   533   533   538
 12.5 |  510   508   507   509
 15.0 |  477   480   485   480
 17.5 |  450   450   457   453
 20.0 |  427   423   426   426
 22.5 |  410   399   401   407
 25.0 |  402   381   383   379
 27.5 |  387   355   350   343
 30.0 |  359   324   306   303
 32.5 |  325   292   264   257
 35.0 |  285   254   221   211
 37.5 |  237   214   178   164
 40.0 |  194   168   133   123
 42.5 |  153   127    99    86
 45.0 |  119    89    69    58
 47.5 |   90    63    49    45
 50.0 |   70    49    37    32
 52.5 |   56    35    25    20
 55.0 |   41    20    16    12
 57.5 |   21    10    10     9
 60.0 |   10     7     8     6
 62.5 |    5     4     5     4
 65.0 |    2     4     3     2
 67.5 |    3     3     2     2
 70.0 |    2     2     2     1
 72.5 |    2     2     1     1
 75.0 |    1     1     1     1
 77.5 |    1     1     1     1
 80.0 |    0     0     0     0
 82.5 |    0     0     0     0
 85.0 |    0     0     0     0
 87.5 |    0     0     0     0
 90.0 |    0     0     0     0
      |
      v
Gamma-angle
```

APPENDIX B

HPI LAMPS / HNF010-W FLOODLIGHT AND I-TABLE

HPI lamps



e metal halide gas-discharge lamps, for indoor and
vith the iodide additives indium, thallium and
mercury discharge. The discharge tube is
n ovoid, hard glass outer bulb with a fluorescent

IPI lamps operate on the same principle as all gas-
amps.
ne need for a light source with excellent colour
he discharge tube contains metal halide
s which have the effect of increasing the intensity
tion in the three spectral bands blue, green and
Consequently, the colour appearance and colour
re improved and the luminous efficacy increased.
cent coating on the inside of the outer bulb
ne light output and improves the colour rendering.
mensions are identical to those of the HPL-N
00W lamp types, so the HPI lamps can be
n the same optical systems as used for high-
ercury vapour lamps.
designated 'BU' (Base Up) can only be used in the
tion. Further, the 'BUS' (Base Up Self-starting)
lso only be used in the vertical position, moreover
t need an external ignitor.

- All the HPI lamps can be operated on choke type ballasts for mercury vapour lamps.
- Lamp characteristics:
  - Very high luminous efficacy
  - Excellent colour rendering
  - Reliable, long life
  - Stable lumen maintenance

Applications

- Industrial and commercial indoor lighting
- Public lighting
- Floodlighting
- Plant irradiation

Ballasts and ignitors

Metal halide lamps require high quality ballasts for optimum operation, as well as ignitors to ensure reliable ignition.
The BUS (Base Up Self-starting) lamps require only a ballast since a starting device is incorporated in the lamp.
For ballasts and ignitors see relevant leaflets.

Temperatures

Max. permissible base temperature: 250°C
Max. permissible bulb temperature: 350°C for 250 W
450°C for 400 W

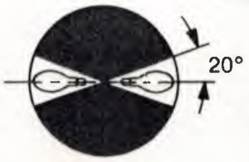
e

nance of this type of lamp can only be
ast on which it is operated complies with
lown by the lamp manufacturer. Moreover, the
ge may not fluctuate more than ± 5% from the
ballast.

ility of personal injury or damage to property
ering, the BUS (Base Up Self-starting) lamp
ncorporated in an enclosed luminaire.

s

o may only burn in a horizontal position ±20°.
mps may only burn in a vertical position ±15°.



5°

nd BUS

HPI 400 W

Dimensions

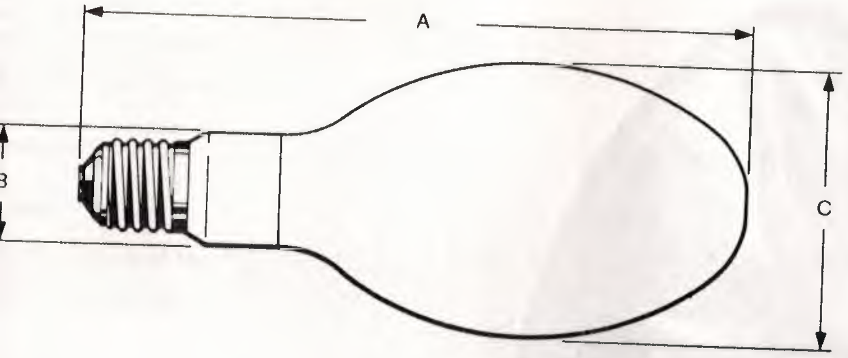
Lamp designation	A max.	B max.	C max.
HPI 250 W BU	227	53	92
HPI 400 W	292	58	122
HPI 400 W BU	292	58	122
HPI 400 W BUS	292	58	122

ase	Min. supply voltage for ignition¹) V		Average lamp voltage²)⁴) V	Average lamp current²)⁴) A	Lamp starting current A(max.)	Minimum permissible lamp wattage²) W	Average lamp wattage²)⁴) W	Maximum permissible lamp wattage²) W	Average luminous flux²)⁴) lm	Average luminance²)⁴) cd/cm²	Run-up time³)⁴) min.
	+20°C	—18°C									
40	200	200	125	2,2	3,2	210	250	290	17 500	3,7	3
40	200	200	125	3,4	6,0	330	390	450	27 600	3,5	3
40	200	200	125	3,4	6,0	340	400	460	30 600	3,8	3
40	200	200	125	3,4	6,0	340	400	460	30 600	3,8	3

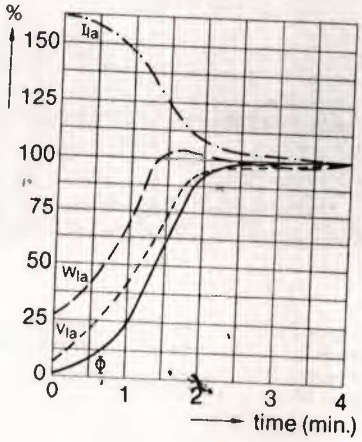
After 100 burning hours.
tes after which the lamp has reached 80% of its final luminous flux.
ng properties will be reached after 10-15 minutes.
al supply voltage and reference ballast for a free burning lamp.

cking data

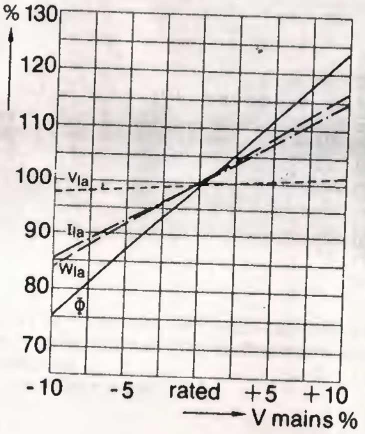
Ordering number	Nett weight g	Packing unit Qty	Weight kg	Dimensions cm	Volume m³
9280 767 098 . .	200	12	3,90	47 x 37,5 x 27,5	0,048
9280 731 098 . .	260	6	3,10	51 x 36 x 37	0,068
9280 743 098 . .	260	6	3,10	51 x 36 x 37	0,068
9280 747 098 . .	260	6	3,10	51 x 36 x 37	0,068



ypical curves



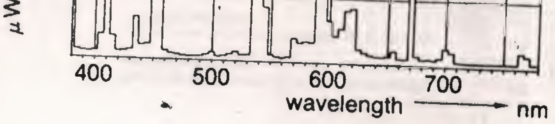
Lamp performance during starting period



Effects of mains voltage variations

a = lamp wattage
= lamp voltage
= lamp current
= luminous flux

rmalised spectral power distribution



LIPS

e with one of
ps:
oodlight lamp
W
apour fluores-
00 W
I/T 375 W me-

0 or 400 W
dium lamp.

onsists of two

a rear-hous-

pun aluminium
a cast-alumi-
o which the
et is attached
front-glass,
eflector by an
t ethylene-pro-
gasket
ale is mounted
minium ring.

st aluminium

ntains a high-
lder mounted
ng device, a
minal block
uminium cap,
ss by unauth-

s available in
ons:

oodlight np 1000 W 2,5° 6°	Floodlight lamp 1500 W 2 × 2,5° 2 × 7°	HPL-N 400 W 2 × 17° *)	HPL-N 700 W 2 × 22° *)
PI 0 W 13° *)	HPI/T 375 W 2 × 2° 2 × 4°		
ON 0 W 11° *	SON/T 250 W 2 × 2,5° 2 × 5°	SON 400 W 2 × 15° *	SON/T 400 W 2 × 2,5° 2 × 4°

ypes the difference between the narrow- and wide-beam versions.

- Lamp replacement is effected by removing the rear-cap without changing the position of the floodlight. Resetting is, therefore, unnecessary and servicing facilitated
- All fixing components are of stainless steel.

APPLICATIONS

- Stadium and sports ground lighting
- High-mast lighting
- Floodlighting of buildings
- Area lighting
- Docks
- Security lighting
- Marshalling yards

RDERING DATA

Designation	For lamps	Description	Ordering number	Weight kg
NNF 010	1 × Incandescent floodlight lamp 1000 W or 1500 W or 1 × HPL-N 700 W (max) or 1 × HPI 400 W – HPI/T 375 W or 1 × SON-SON/T 250 W or 400 W	Rear housing	9112 609 900 . .	4
		Complete reflector with narrow-beam front glass	9119 260 000 . .	8,5
		Complete reflector with wide-beam front glass	9119 260 001 . .	8,5

FLOODLIGHT FOR INCANDESCENT FLOODLIGHT LAMPS, MERCURY VAPOUR FLUORESCENT LAMPS, METAL HALIDE LAMPS OR HIGH-PRESSURE SODIUM LAMPS

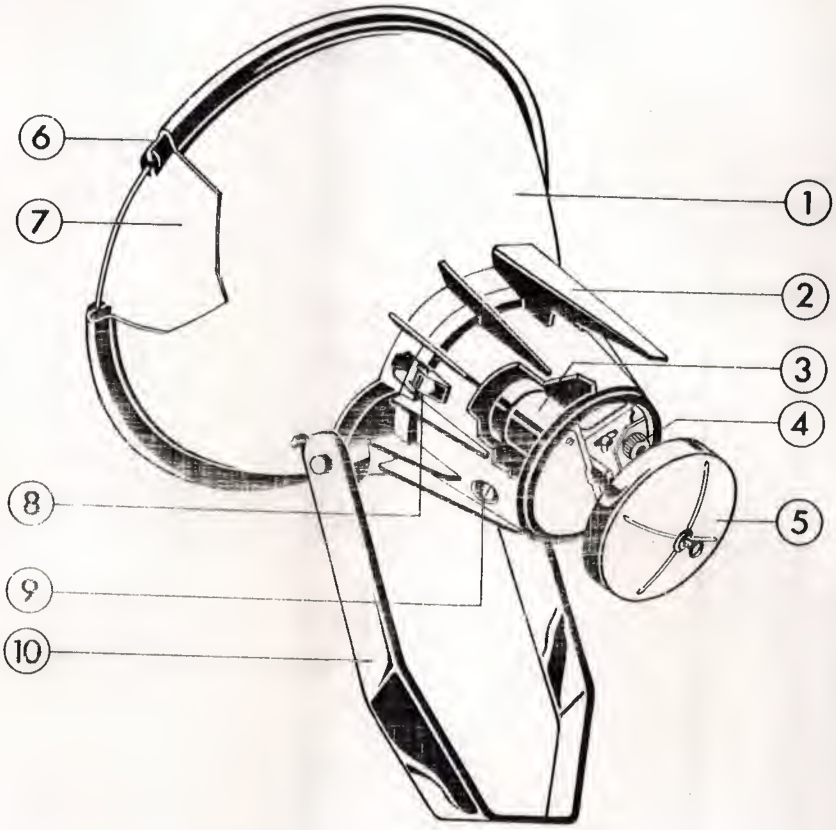
VIEW

sing

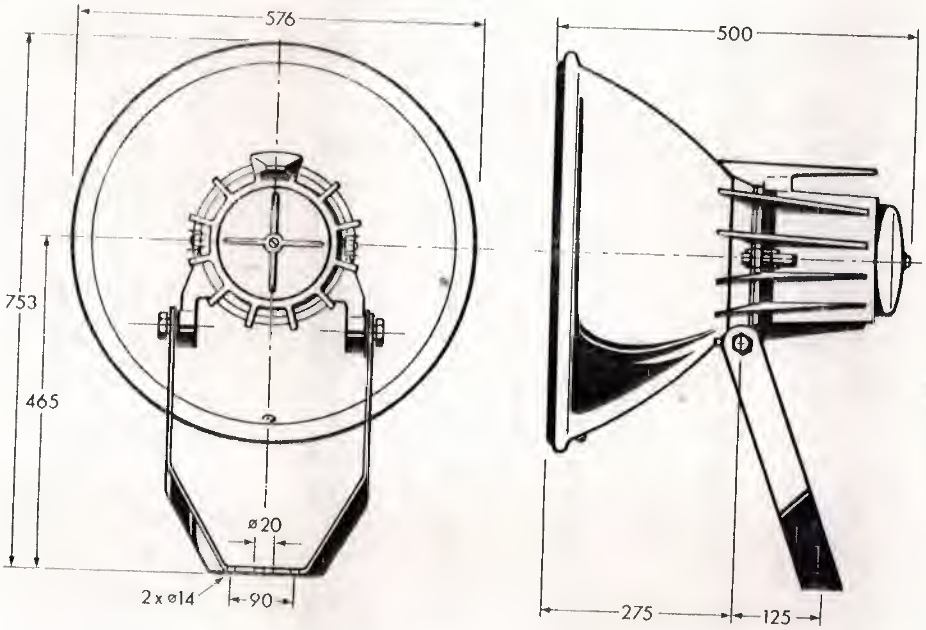
er

knob

s



DIMENSIONS



SIBILITIES

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PHILIPS LIGHTING                            |    LIGHT DISTR.BUTION OF . NNF 010-W          HPI 400
LIGHTING DESIGN AND ENGINEERING CENTRE      |              PROJECT NO:
EINDHOVEN - THE NETHERLANDS                 |                 CALC NO:       01                                        PAGE    1
                                                                                                              DATE  88-11-04

I-TABEL VALUES ARE GIVEN IN C/GAMMA  SYSTEM

FOR THE PLANES :

        270.00    285.00    300.00    310.00    315.00    320.00    325.00    330.00    335.00    340.00    345.00    350.00
        355.00      0.00      5.00     10.00     15.00     20.00     25.00     30.00     35.00     40.00     45.00     50.00
         60.00     75.00     90.00    105.00    120.00    130.00    135.00    140.00    145.00    150.00    155.00    160.00
        165.00    170.00    175.00    180.00    185.00    190.00    195.00    200.00    205.00    210.00    215.00    220.00
        225.00    230.00    240.00    255.00

AND FOR THE ANGLES :

          0.00     10.00     20.00     30.00     35.00     40.00     45.00     47.50     50.00     52.50     55.00     57.50
         60.00     62.50     65.00     67.50     70.00     72.50     75.00     77.50     80.00     82.50     85.00     87.50
         90.00     92.50     95.00     97.50    100.00    102.50    105.00    120.00    135.00    150.00    165.00    180.00

THE LUMINOUS FLUX OF THE LAMP IS          27600. LUMEN


THE I-TABEL IS GIVEN PER 1000 LUMEN
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PLANE---->
          270.0   285.0   300.0   310.0   315.0   320.0   325.0   330.0   335.0   340.0   345.0   350.0   355.0

ANGLE =

   0.0   1409.0  1409.0  1409.0  1409.0  1409.0  1409.0  1409.0  1409.0  1409.0  1409.0  1409.0  1409.0  1409.0
  10.0    989.0   988.5   988.8   988.3   987.7   988.3   987.6   988.7   987.7   987.8   988.4   987.8   988.0
  20.0    477.0   479.0   477.3   478.5   478.4   478.3   478.0   478.0   478.8   477.4   478.7   478.5   477.2
  30.0    228.0   229.5   229.1   228.4   229.3   229.0   229.2   229.5   229.5   229.6   228.6   229.6   228.6
  35.0    155.0   156.0   155.5   156.0   155.6   155.9   156.0   155.8   155.5   155.4   155.4   156.3   155.6
  40.0    105.0   105.5   105.4   105.5   105.5   105.5   105.5   105.3   105.6   105.5   105.6   105.7   105.3
  45.0     67.0    67.3    67.4    67.3    67.3    67.4    67.3    67.4    67.2    67.4    67.5    67.5    67.3
  47.5     52.5    52.5    52.5    52.5    52.5    52.5    52.5    52.5    52.5    52.5    52.5    52.5    52.5
  50.0     38.0    38.4    38.4    38.3    38.3    38.3    38.3    38.3    38.3    38.3    38.3    38.3    38.4
  52.5     28.0    28.0    28.0    28.0    28.0    28.0    28.0    28.0    28.0    28.0    28.0    28.0    28.0
  55.0     18.0    18.6    18.4    18.4    18.6    18.2    18.6    18.5    18.6    18.6    18.4    18.1    18.6
  57.5     15.0    15.1    15.3    15.1    15.2    15.1    15.2    15.2    15.3    15.2    15.2    15.3    15.3
  60.0     12.0    12.0    12.0    12.0    12.0    12.0    12.0    12.0    12.0    12.0    12.0    12.0    12.0
  62.5      7.9     7.7     7.8     7.7     7.5     7.6     7.7     7.8     7.6     7.8     7.8     7.6     7.6
  65.0      3.0     3.4     3.3     3.2     3.2     3.3     3.2     3.2     3.2     3.3     3.2     3.4     3.4
  67.5      2.0     2.0     2.0     2.0     2.0     2.0     2.0     2.0     2.0     2.0     2.0     2.0     2.0
  70.0      1.0     0.6     0.3     0.6     0.8     0.7     0.7     0.4     0.8     0.7     0.9     0.9     0.6
  72.5      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  75.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  77.5      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  80.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  82.5      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  85.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  87.5      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  90.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  92.5      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  95.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  97.5      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 100.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 102.5      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 105.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 120.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 135.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 150.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 165.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 180.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
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```
              0.0       5.0      10.0      15.0      20.0      25.0      30.0      35.0      40.0      45.0      50.0      60.0      75.0

ANGLE =

     0.0   1409.0    1409.0    1409.0    1409.0    1409.0    1409.0    1409.0    1409.0    1409.0    1409.0    1409.0    1409.0    1409.0
    10.0    989.0     988.0     987.8     988.4     987.8     987.7     988.7     987.6     988.3     987.7     988.3     988.8     988.5
    20.0    477.0     477.2     478.5     478.7     477.4     478.8     478.0     478.0     478.3     478.4     478.5     477.3     479.0
    30.0    228.0     228.6     229.6     228.6     229.6     229.5     229.5     229.2     229.0     229.3     228.4     229.1     229.5
    35.0    155.0     155.6     156.3     155.4     155.4     155.5     155.8     156.0     155.9     155.6     156.0     155.5     156.0
    40.0    105.0     105.3     105.7     105.6     105.5     105.6     105.3     105.5     105.5     105.5     105.5     105.4     105.5
    45.0     67.0      67.3      67.5      67.5      67.4      67.2      67.4      67.3      67.4      67.3      67.3      67.4      67.3
    47.5     52.5      52.5      52.5      52.5      52.5      52.5      52.5      52.5      52.5      52.5      52.5      52.5      52.5
    50.0     38.0      38.4      38.3      38.3      38.3      38.3      38.3      38.3      38.3      38.3      38.3      38.4      38.4
    52.5     28.0      28.0      28.0      28.0      28.0      28.0      28.0      28.0      28.0      28.0      28.0      28.0      28.0
    55.0     18.0      18.6      18.1      18.4      18.6      18.6      18.5      18.6      18.2      18.6      18.4      18.4      18.6
    57.5     15.0      15.3      15.3      15.2      15.2      15.3      15.2      15.2      15.1      15.2      15.1      15.3      15.1
    60.0     12.0      12.0      12.0      12.0      12.0      12.0      12.0      12.0      12.0      12.0      12.0      12.0      12.0
    62.5      7.9       7.6       7.6       7.8       7.8       7.6       7.8       7.7       7.6       7.5       7.7       7.8       7.7
    65.0      3.0       3.4       3.4       3.2       3.3       3.2       3.2       3.2       3.3       3.2       3.2       3.3       3.4
    67.5      2.0       2.0       2.0       2.0       2.0       2.0       2.0       2.0       2.0       2.0       2.0       2.0       2.0
    70.0      1.0       0.6       0.9       0.9       0.7       0.8       0.4       0.7       0.7       0.8       0.6       0.3       0.6
    72.5      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    75.0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    77.5      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    80.0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    82.5      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    85.0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    87.5      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    90.0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    92.5      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    95.0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
    97.5      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
   100.0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
   102.5      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
   105.0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
   120.0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
   135.0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
   150.0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
   165.0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
   180.0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
```

ANGLE =

	90.0	105.0	120.0	130.0	135.0	140.0	145.0	150.0	155.0	160.0	165.0	170.0	175.0
0.0	1409.0	1409.0	1409.0	1409.0	1409.0	1409.0	1409.0	1409.0	1409.0	1409.0	1409.0	1409.0	1409.0
10.0	989.0	988.5	988.8	988.3	987.7	988.3	987.6	988.7	987.7	987.8	988.4	987.8	988.0
20.0	477.0	479.0	477.3	478.5	478.4	478.3	478.0	478.0	478.8	477.4	478.7	478.5	477.2
30.0	228.0	229.5	229.1	228.4	229.3	229.0	229.2	229.5	229.5	229.6	228.6	229.6	228.6
35.0	155.0	156.0	155.5	156.0	155.6	155.9	156.0	155.8	155.5	155.4	155.4	156.3	155.6
40.0	105.0	105.5	105.4	105.5	105.5	105.5	105.5	105.3	105.6	105.5	105.6	105.7	105.3
45.0	67.0	67.3	67.4	67.3	67.3	67.4	67.3	67.4	67.2	67.4	67.5	67.5	67.3
47.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5
50.0	38.0	38.4	38.4	38.3	38.3	38.3	38.3	38.3	38.3	38.3	38.3	38.3	38.4
52.5	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
55.0	18.0	18.6	18.4	18.4	18.6	18.2	18.6	18.5	18.6	18.6	18.4	18.1	18.6
57.5	15.0	15.1	15.3	15.1	15.2	15.4	15.2	15.2	15.3	15.2	15.2	15.3	15.3
60.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
62.5	7.9	7.7	7.8	7.7	7.5	7.6	7.7	7.8	7.6	7.8	7.8	7.6	7.6
65.0	3.0	3.4	3.3	3.2	3.2	3.3	3.2	3.2	3.2	3.3	3.2	3.4	3.4
67.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
70.0	1.0	0.6	0.3	0.6	0.8	0.7	0.7	0.4	0.8	0.7	0.9	0.9	0.6
72.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
77.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
82.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
85.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
87.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
92.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
97.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
102.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
105.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
135.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
150.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
165.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

```
  γ
ANGLE =

    0.0   1409.0  1409.0  1409.0  1409.0  1409.0  1409.0  1409.0  1409.0  1409.0  1409.0  1409.0  1409.0  1409.0
   10.0    989.0   988.0   987.8   988.4   987.8   987.7   988.7   987.6   988.3   987.7   988.3   988.8   988.5
   20.0    477.0   477.2   478.5   478.7   477.4   478.8   478.0   478.0   478.3   478.4   478.5   477.3 ← 479.0
   30.0    228.0   228.6   229.6   228.6   229.6   229.5   229.5   229.2   229.0   229.3   228.4   229.1   229.5
   35.0    155.0   155.6   156.3   155.4   155.4   155.5   155.8   156.0   155.9   155.6   156.0   155.5   156.0
   40.0    105.0   105.3   105.7   105.6   105.5   105.6   105.3   105.5   105.5   105.5   105.5   105.4   105.5
   45.0     67.0    67.3    67.5    67.5    67.4    67.2    67.4    67.3    67.4    67.3    67.3    67.4    67.3
   47.5     52.5    52.5    52.5    52.5    52.5    52.5    52.5    52.5    52.5    52.5    52.5    52.5    52.5
   50.0     38.0    38.4    38.3    38.3    38.3    38.3    38.3    38.3    38.3    38.3    38.3    38.4    38.4
   52.5     28.0    28.0    28.0    28.0    28.0    28.0    28.0    28.0    28.0    28.0    28.0    28.0    28.0
   55.0     18.0    18.6    18.1    18.4    18.6    18.6    18.5    18.6    18.2    18.6    18.4    18.4    18.6
   57.5     15.0    15.3    15.3    15.2    15.2    15.3    15.2    15.2    15.1    15.2    15.1    15.3    15.1
   60.0     12.0    12.0    12.0    12.0    12.0    12.0    12.0    12.0    12.0    12.0    12.0    12.0    12.0
   62.5      7.9     7.6     7.6     7.8     7.8     7.6     7.8     7.7     7.6     7.5     7.7     7.8     7.7
   65.0      3.0     3.4     3.4     3.2     3.3     3.2     3.2     3.2     3.3     3.2     3.2     3.3     3.4
   67.5      2.0     2.0     2.0     2.0     2.0     2.0     2.0     2.0     2.0     2.0     2.0     2.0     2.0
   70.0      1.0     0.6     0.9     0.9     0.7     0.8     0.4     0.7     0.7     0.8     0.6     0.3     0.6
   72.5      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   75.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   77.5      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   80.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   82.5      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   85.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   87.5      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   90.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   92.5      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   95.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   97.5      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  100.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  102.5      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  105.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  120.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  135.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  150.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  165.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  180.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
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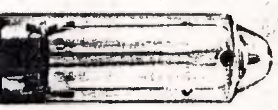
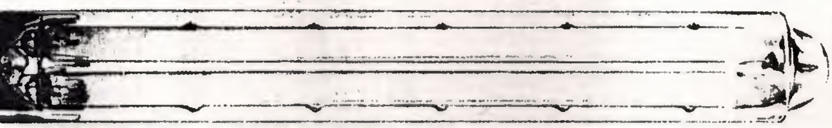
APPENDIX C

SOX LAMPS / SNF026-N FLOODLIGHT AND ISOLUX CURVE

SOX-E lamps





e sodium vapour lamps, type SOX-E, for outdoor and
ith a discharge tube enclosed in a clear tubular outer
hnologies have made it possible to increase the
even further, so that now the 200 lm/W barrier has
or the highest wattage lamp. SOX-E lamps attain
minous efficacy of any light source in the world.

arge tube is made of a special non-staining glass
es to collect the sodium and prevent it from settling
er surface of the discharge tube. This ensures
umen maintenance.
outer bulb, with an internal indium oxide layer,
ost of the infrared radiation back to the discharge
keeping it constantly at an optimum temperature of
°C.
m luminous efficacy can only be obtained in
on with an appropriate hybrid ballast.
conventional gear is possible.
features: • High visual acuity • Low luminosity
• Sharp contrast • Little glare
perature of the lamp, hence minimal breathing of
naire, resulting in very little internal soiling of the
system.

SOX-E 18 SOX-E 66
SOX-E 26 SOX-E 91
SOX-E 36 SOX-E 131

Applications

- Public lighting
- Security lighting
- Orientation lighting
- Marshalling yards
- Railway crossings
- Airports
- Harbours
- Docks
- Quarries
- Foundries
- Rolling mills

Ballasts and ignitors

For ballasts and ignitors, see relevant leaflets.

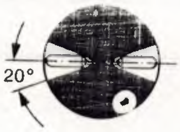
Temperatures

Max. permissible base temperature: 150°C
Max. permissible bulb temperature: 150°C

Dimensions

Lamp designation	A max.	B nom.	C max.
SOX-E 18	216	90	52
SOX-E 26	310	191	52
SOX-E 36	425	305	52
SOX-E 66	528	403	68
SOX-E 91	775	646	68
SOX-E131	1120	996	68

tions



d ordering data on optimum SOX-E hybrid gear

ual o watts	Base	Min. voltage for ignition[1][2] V +20° C	Min. voltage for ignition[1][2] V −18° C	Average lamp voltage[3] V[5]	Average lamp current[3] A[5]	Min. supply voltage for stable operation V	Average luminous flux[3] lm[5]	Average luminance cd/cm²	Run-up time[4] minutes	Ordering number
	BY 22	190	200	57	0,350	200	1800	8	15	9281 450 000 . .
	BY 22	190	200	83	0,350	200	3700	8	10	9281 457 229 . .
	BY 22	190	200	115	0,350	200	5700	8	10	9281 458 229 . .
	BY 22	190	200	115	0,620	200	10700	8	10	9281 459 229 . .
	BY 22	190	200	165	0,620	200	17000	8	10	9281 461 229 . .
	BY 22	190	200	235	0,620	200	26000	8	15	9281 451 000 . .

[2]) At lamp terminals. [3]) After 100 burning hours.
ninutes after which the lamp has reached 80% of its final luminous flux.
rid gear.

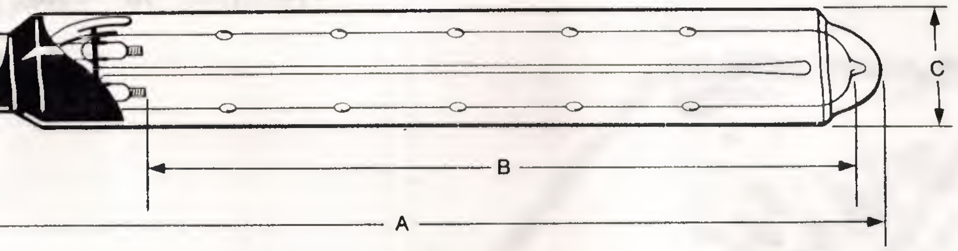
patibility

designed to operate on all existing SOX type , as they run with a lower current, optimum efficacy will only be achieved on control gear specially designed for SOX-E lamps. When run on other circuits a lower efficacy will be achieved.

utoleak transformer			Hybrid/ballast + ignitor			Optimum hybrid/choke*		
ctual mp watts	Total circuit watts W	Light output lm	Actual lamp watts W	Total circuit watts W	Light output lm	Actual lamp watts W	Total circuit watts W	Light output lm
—	—	—	—	—	—	18	27	1800*
30	52	3900	30	41	3800	27	36	3700*
38	59	5900	39	60	6100	35	46	5700
0	104	11000	68	92	10500	65	80	10700
3	141	17000	100	124	16500	90	106	17000
5	174	26000	135	166	24800	130	153	26000

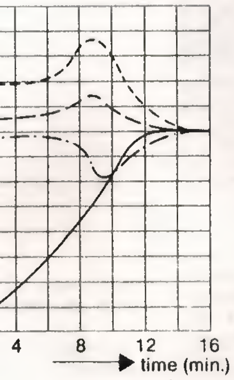
SOX-E 131 lamp is operated on hybrid-constant wattage gear, a capacitor of 10 μF has to be connected **across** the lamp.

Nett weight g	Packing unit Qty	Weight kg	Dimensions cm	Volume m³
145	20	3,38	34 x 28 x 29	0,028
230	12	4,94	36 x 29 x 39	0,041
310	9	5,47	30 x 29 x 52	0,045
510	9	7,70	35 x 35 x 61	0,075
740	9	11,35	33 x 32 x 96	0,101
1035	9	14,30	125 x 34 x 35	0,149

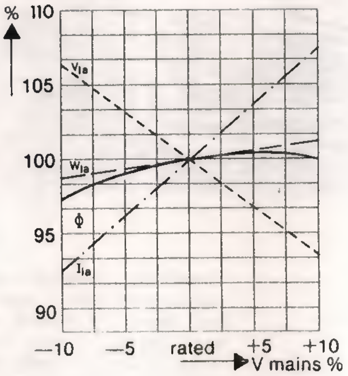


l curves

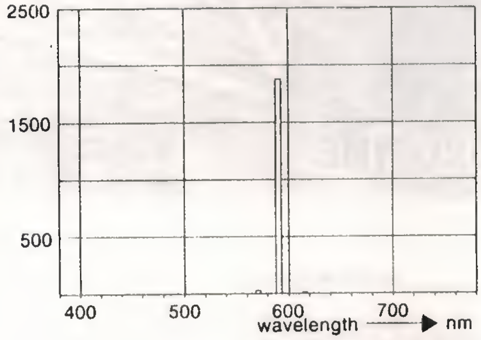
p performance during ing period



Effects of mains voltage variations



Normalised spectral power distribution

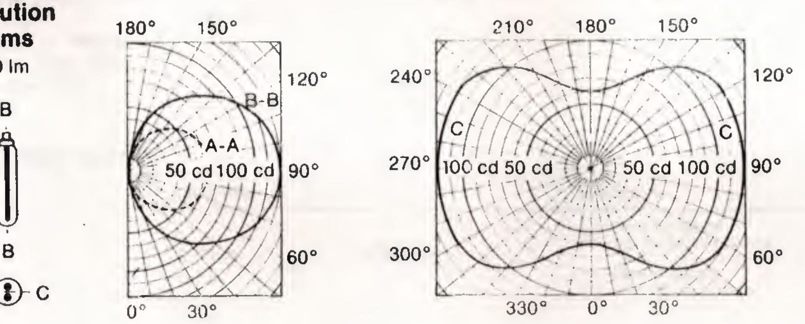


= lamp wattage I_{la} = lamp current
= lamp voltage Φ = luminous flux

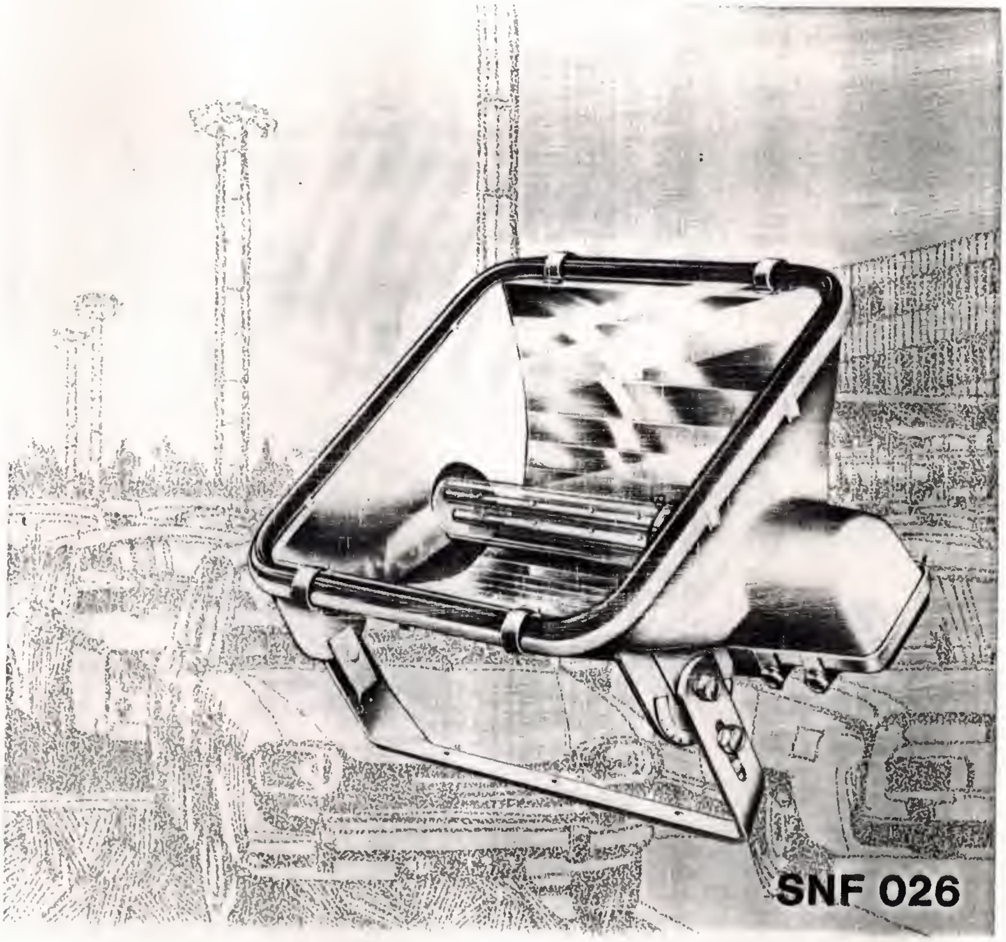
Note: Curves per lamp type will differ from these typical curves

light ution ms

) lm



ne SOX 90 W
dium lamp.



SNF 026 ✓

ear-cover: rug-
luminium con-

v copper-con-
lent corrosion
en in coastal
reas
beam versions,
eflectors are

2 12°
2 26°
minium reflec-
te beam con-

ent is effected
ne rear-cover,
servicing

- Easy-to-operate stainless-steel clips on the rear-cover; to be closed by hand and opened with a simple tool. The floodlight cannot be easily opened by unauthorized persons
- Cast-on beam aiming sight and protractor scale for quick daylight adjustment
- Ozone-resistant ethylene-propylene rubber gasket for jet-proof and dustproof sealing of the front glass. 4 extra safety clamps.

APPLICATIONS

- Sports grounds
- Floodlighting of buildings
- Marshalling yards
- Car parks
- Skating rinks
- High-mast lighting
- Area lighting

ERING DATA

Designation	For lamp	Description	Ordering number	Weight kg
SNF 026	I - SOX 90 W	Complete floodlight with narrow-beam reflector	9112 729 906 .	18
		Complete floodlight with wide beam reflector	9112 729 907 . .	18

FLOODLIGHT FOR LOW-PRESSURE SODIUM LAMPS

NG

np (4×)

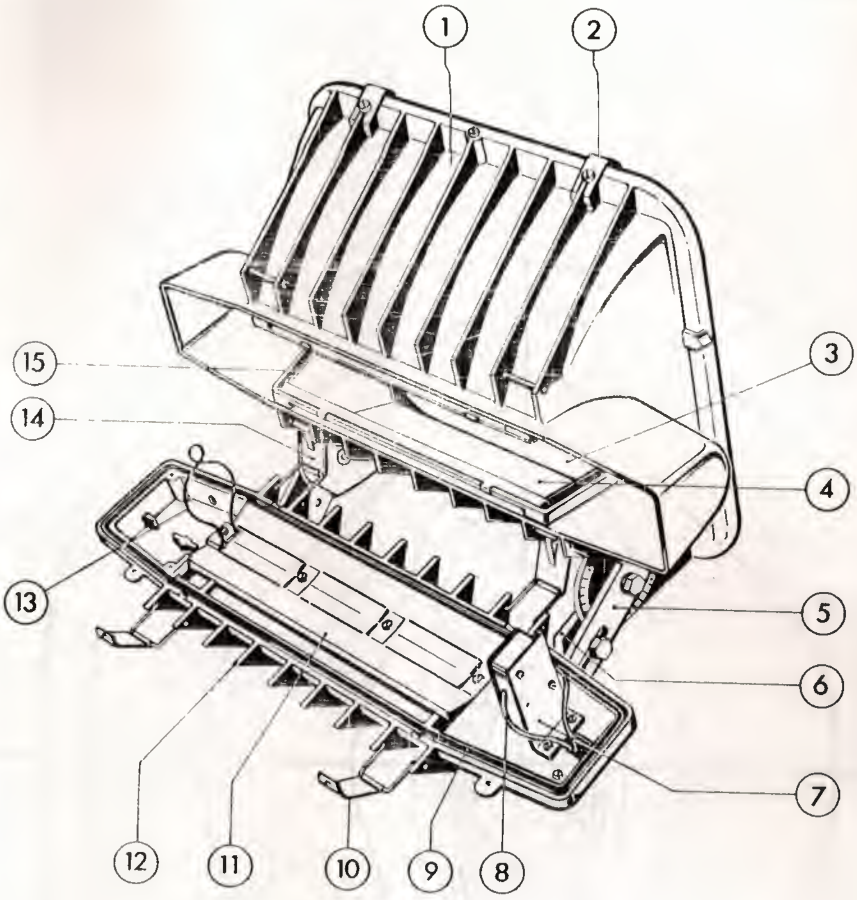
ket

2×)

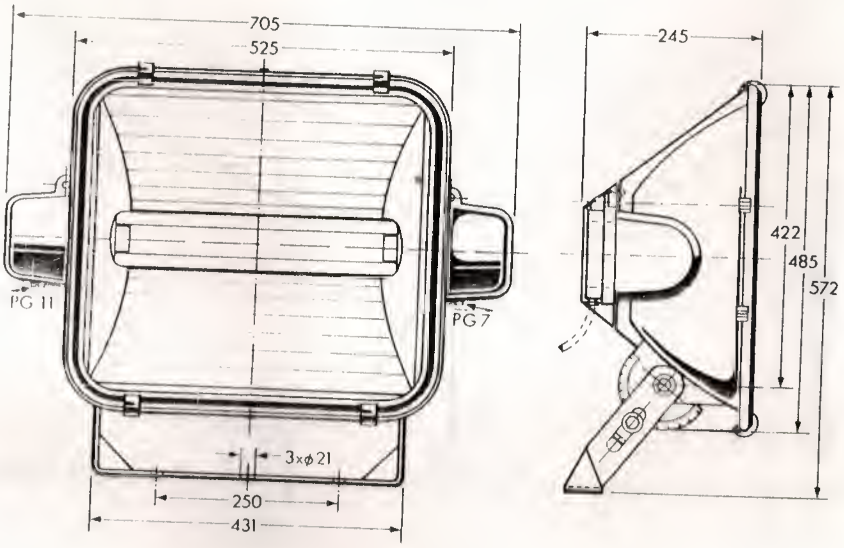
ver

m (2×)

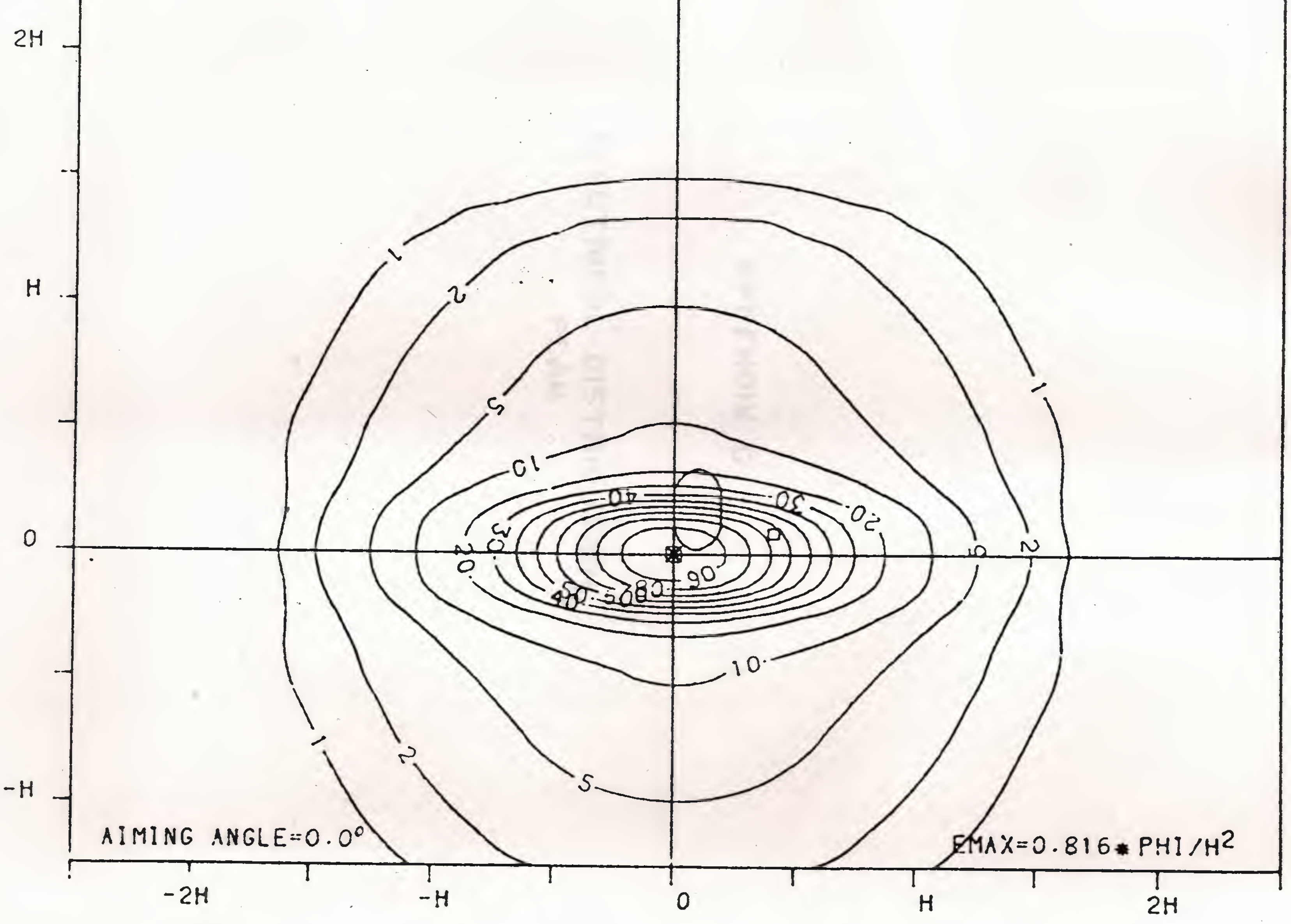
)



DIMENSIONS



TIES


2H
H
0
-H
-2H
H
0
H
2H
1
2
5
10
20
30
40
50
60
80
90
AIMING ANGLE=0.0°
EMAX=0.816*PHI/H²