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Indian Standard

PHOTOMETRY OF LUMINAIRES — METHODS OF MEASUREMENT

PART 3 LUMINAIRES FOR FLOODLIGHTING

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Price Group 8

Illumination Engineering and Luminaires Sectional Committee, ETD 24

CONTENTS

FOREWORD

This Indian Standard (Part 3) was adopted by the Bureau of Indian Standards, after the draft finalized by the Illumination Engineering and Luminaires Sectional Committee had been approved by the Electrotechnical Division Council.

The primary objective of this standard is to recommend the adoption of test procedures which will provide the capable result in measuring and reporting the photometric characteristics of the floodlighting luminaires. The recommendations are intended to provide guidance to photometric laboratories in selection of test apparatus, in the conduct of tests and in the presentation of the photometric data of floodlighting luminaires.

This standard (Part 3) is one of the series of Indian Standards which deals with the methods of photometry of luminaires. The series consist of the following parts:

Methods of Photometry of Luminaires:

Part 1 Luminaires intended for use of interior lighting;

Part 2 Luminaires for road and street lighting; and

Part 3 Luminaires for floodlighting.

In the formulation of this standard, assistance has been derived from CIE Publication 43 (TC-2.4) 1979 on Photometry of Floodlights.

Indian Standard

PHOTOMETRY OF LUMINAIRES – METHODS OF MEASUREMENT

PART 3 LUMINAIRES FOR FLOODLIGHTING

1 SCOPE

1.1 This standard (Part 3) is intended to cover the photometry of floodlights used for interior and exterior lighting purposes and equipped with incandescent or discharge (including tubular fluorescent) electric lamp or with reflector lamps. The recommendations relate to visually steady light and not to a flashing light.

1.2 The photometric measurements described in this standard relate to determining the luminous intensities in the projected beam which may be presented as a luminous intensity distribution diagram, iso-candela diagram or in tabulated form suitable for use in computer calculation. These intensities are deduced from illuminance measurements, the inverse square law of distances being supposed verified (*see* **4.4.2**). In some instances the measurement of other photometric quantities may be more appropriate, as for example the distribution of illuminance over a plane which may be relatively close to the luminaire such as with a 'wall washer' type luminaire. Such measurements are not dealt with in the report and will be covered in a separate Standard.

1.3 The photometric techniques recommended do not include the photometric of projectors for signalling purposes, road lighting lanterns, vehicle headlights (some of which are covered by other documents) nor 'image-forming' optical devices, although similar techniques may well be used for the photometry of such devices. In some cases recommendations may be prepared by other committees.

1.4 Light beams, in which the angle between the peak and the one half peak intensity direction is less than 2°C (that is 2 × 2°C, or 4°C to one half peak divergence for a symmetrical beam), require special methods of photometry which are not included.

2 DEFINITIONS

2.0 The definitions in **2.1** to **2.4** may only be used for distributions with a continuous reduction in luminous intensity at increasing angles of divergence from a single maximum. Particular beam shapes with more than one maximum are still under consideration.

2.1 One-Half Peak Divergence (In a Specified Plane Through the Maximum Intensity)

The angular extent of a beam which contains all the radius vectors of the polar curve of luminous intensity in the specified plane having lengths greater than 50 percent of the maximum.

2.2 Half-Peak Side Angle (In a Specified Half Plane Through the Maximum Intensity)

The angle between the direction of maximum luminous intensity and the direction in which the floodlight has a luminous intensity of 50 percent of the maximum measured in the specified half-plane.

NOTE — The half peak side angle is of special interest for luminous intensity distributions which have only one plane of symmetry or are asymmetrical. The luminous intensity distribution through a single plane 'ab' illustrated in rectangular cartesian coordinates in Fig. 1 has a half peak side angle of 'β 1' in half plane 'a' and 'β 2' in half plane 'b'. The one half peak divergence is in this case (β 1 + β 2).

Both the measuring distance, **4.4.3** and the number of test angles, **6.10**, are determined by 'β 1' which is the smaller half peak side angle.

For practical purposes, the half peak side angle for this floodlight could be stated as follows:

The half peak side angles of the floodlight in plane 'ah' are '+ β 1 and – β 2'.

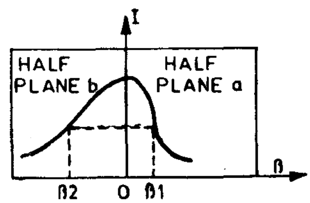


FIG. 1 LUMINOUS INTENSITY DISTRIBUTION

2.3 Inner Beam of a Floodlight

The solid angle containing all directions of luminous intensities greater than or equal to 50 percent of the maximum intensity.

2.4 Outer Beam of a Floodlight

The solid angle containing all directions of luminous intensities greater than or equal to 10 percent of the maximum intensity.

2.5 Light Output Ratio

Ratio of the light output of a floodlight, measured under specified practical conditions, to the sum of the individual light outputs of the lamps operating outside the floodlight under specified conditions.

2.5.1 The 'specified conditions' should be the standard test conditions specified in **5.1**.

NOTE — The light output ratio measured according to the specification in **5.1** is sometimes referred to as 'Light output ratio luminaire'.

2.6 Reference Axis

An axis used in the photometric measurements as a reference direction to correlate the photometric performance with the practical aiming of the floodlight.

NOTE —Usually the reference axis chosen is the axis of symmetry of the floodlight, if any. In all cases, the identification of the reference axis must be clearly defined by the manufacturer or if not by the photometric laboratory.

2.7 Photometric Light Centre

The intersection of the reference axis with the front glazing or the light emittting area in the plane of the front aperture of the floodlight.

2.8 Auxiliary Axis

An axis containing the photometric light centre, perpendicular to the reference axis, linked to the floodlight and defined with reference to its mechanical shape.

NOTE — The auxiliary axis is used together with the reference axis for defining the attitude of the floodlight in space. With rectangular shaped floodlights used with the longitudinal or transverse axis of the light emitting part in a horizontal plane, the auxiliary axis should always correspond to the horizontal axis of that part. For rotationally symmetric floodlights the choice of the auxiliary axis may also depend on the orientation of the light source.

2.9 Distribution of Luminous Intensity

The variation of luminous intensity expressed with reference to all directions from the perference axis.

2.9.1 The luminous intensity distribution may be presented in the form of tables or a family of curves. Unless otherwise specified, the distribution of luminous intensity is defined as that measured with the reference and auxiliary axes in a horizontal plane.

2.9.2 The luminous intensity is based on a total luminous flux of 1 000 lumen from all the lamps in the floodlight when operated under standard conditions.

NOTES

1 The luminous intensity distribution of floodlights fitted with certain types of light sources is dependent on the orientation in space of the floodlight.

For instance, in the case of metal halide lamps the displacement of the arc within its tube and possibly a variation of the luminance distribution along the arc may cause a significant change in the maximum intensity, its direction and the half peak side angle when the floodlight changes its orientation in space.

If such a floodlight is designed to operate in an orientation other than that with a horizontal reference axis, it should be measured in that orientation. In this case, the manufacturer must specify the direction of the reference axis to be examined.

2 For floodlights in which the light source cannot be separated from the optical system, for example, sealed beam lamps, the luminous intensity distribution is given for 1 000 lumen from the sealed beam lamp itself.

2.10 Service Correction Factors

Correction factors that are applied to convert the luminous intensity distribution measured under laboratory conditions to those that will be produced in the practical situation. Correction factors are applicable only if the practical service conditions lead to a change of the luminous flux without at the same time introducing changes in the shape of the light distribution, for example, by displacement of the arc, changes of luminance along the arc, etc.

2.10.1 The practical service conditions may be other orientation or different ambient temperature than those corresponding to the standard test conditions (*see also* **5.2.1** and **6.13**).

2.11 Types of Floodlight

For the purpose of photometric measurements floodlights are divided into two groups with regard to their half-peak side angle and into four groups with regard to the symmetry of the luminous intensity distribution.

NOTE — The classification used for applications may be different.

2.11.1 Grouping with respect to half peak side angle:

Group I — Floodlights having a half peak side angle in any half plane containing the maximum intensity smaller than or equal to 4°.

NOTE — Floodlights with a half peak side angle less than 2°C are not covered by this Standard (*see* **2.3**).

Group II — Floodlights having a half peak side angle in one or more half planes containing the maximum intensity greater than 4°.

2.11.2 Grouping with respect to the symmetry of the luminous intensity distribution:

a) Rotationally symmetric,
b) Symmetric about two planes,
c) Symmetric about one plane, and
d) Asymmetric.

2.11.2.1 Typical examples of the general groups with reference to their luminous intensity distribution are shown in the isocandela Fig. 2a-2d respectively. Isocandela curves have been drawn to represent the projection of the beam on the plane perpendicular to the reference axis of the floodlight. The intersections on this plane of reference axis, the direction of maximum intensity and the planes of symmetry, if any, are also illustrated.

2.12 Recommended Co-ordinate System for Presenting Luminous Intensity Distribution Data

The recommended co-ordinate system is that which has been chosen to present luminous intensity distribution data in a form that enables illuminance intensity distribution data in a form that enables illuminance calculations to be made in a simplified manner for floodlights which may be adjusted through various angles of tilt in elevation. In addition the system uses a measuring technique that employs a (Type B) goniometer with a fixed vertical axis; for some floodlights, however, it may be necessary to measure on another type goniometer (*see* Note in **6.2**).

NOTE — Details of various co-ordinate systems and goniometers that have been considered are provided in Annex B.

2.13 Ballast Lumen Factor

The ballast lumen factor is the ratio of the luminous flux of a reference lamp when operated with an appropriate objective production ballast to the luminous flux of the same reference lamp operated with its reference ballast.

Both production ballast and reference ballast shall be operated at their appropriate rated voltages, both being mounted in free air, and the reference lamp shall operate at all times in an ambient temperature of 25°C mounted in such a manner that its performance is not affected thermally by its associated ballast.

Alternatively, both luminous flux measurements may be made using a lamp not having reference characteristics, but complying with the requirements of the appropriate lamp specifications.

In the case of a production ballast which relies for lamp operation on several separate components, all these shall have objective characteristics.

The test conditions mentioned above refer to the conditions for measurement of luminous flux as specified in the appropriate lamp standard.

Lighting calculations based on photometric measurements as specified in this standard assume essentially that the lamp when operated from the ballasts supplied with the floodlights deliver nominal luminous flux when they are mounted under standard conditions as specified in **5.1**.

This may not be true in practice, for example, for technical and commercial reasons under rated ballasts may be used in the floodlights, and the user will in this case get a lower luminous flux than he expected. This error can be corrected by use of the ballast lumen factor. In all lighting calculations, the light output ratio and the luminous intensities should, therefore, be multiplied by the ballast lumen factor.

3 ACCEPTABLE ORDER OF ACCURACY FOR FLOODLIGHT PHOTOMETRY

3.1 The total effect of systematic and random errors in the goniometer should not exceed:

For measurement of luminous intensity	± 5 percent of actual intensity in a particular direction ±10 percent candelas per 1 000 lamp lumens whichever is the greater
OR	
For measurement of angular direction	For beams with a half peak side angle: Above 2° and less than 4° ± 0·1° 4° and less than 8° ± 0·2° Above 8° ± 0·4°

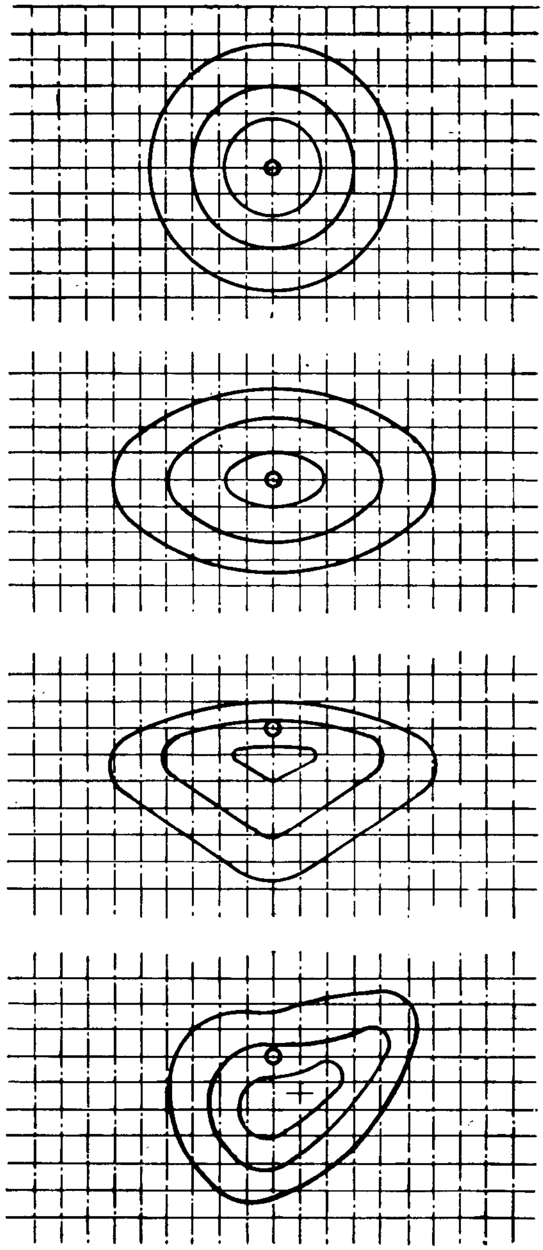
NOTE — Inaccurate angular adjustments greater than the tolerances stated above may lead to error in the measured luminous intensity in excess of 5 percent.

Fig. 2a Rotationally Symmetric Distribution

Fig. 2b Distribution Symmetrical about Two Planes

Fig. 2c Distribution Symmetrical about One Plane

Fig. 2d Asymmetric Distribution



KEY
0 : reference axis
+ : I_{max}
— - — : plane of symmetry

FIG. 2 TYPICAL ISO CANDELA DIAGRAMS

4 LABORATORY EQUIPMENT

4.1 Electrical Power Supplies and Indicating Instruments

Electrical power supplies should meet the following requirements:

a) The power supply shall have adequate current handling capacity for the load to be connected and should be stabilised;

b) It should allow the voltage to be set and maintained to 0·2 percent or better for measurements on tungsten filament lamps and to 0·5 percent or better for measurements on discharge lamps; and

c) If the supply is ac, the stabiliser should be of very low impedance and the waveshape such that the total harmonic content does exceed 3 percent; the harmonic content being defined as the root-mean-square (rms) summation of the individual harmonic components, taking the fundamental as 100 percent. This requirement may be relaxed if only filament lamp floodlights are to be measured.

Voltmeters, ammeters and wattmeters should comply with the IEC requirements for class index 0·5. Instruments for indicating rms values in circuits with waveform distortion shall be substantially free from error due to this distortion; preferably instruments should be of the electro-dynamic type, however, in some circumstances the moving iron type may be satisfactory.

NOTE — The requirement to hold the supply voltage to filament lamps within 0·2 percent of a set value does not necessarily imply a voltmeter of greater accuracy than the class index 0·5 specified above. For the relative method of photometry the requirement is related to the reading precision of the instrument and not its absolute accuracy, provided that its stability is adequate for example, self-heating error, zero creepage, etc.

Electrical indicating instruments should be checked at regular intervals. When appropriate, correction should be made to any instrument reading affected by the presence of another instrument in the circuit.

All electrical connections and leads shall be of low impedance and adequate for the circuit current especially with large wattage lamps. Voltmeter leads used with filament lamps should preferably be connected directly at the lampholder terminals.

4.2 Test Lamps

4.2.1 *Selection of Lamps for Test*

The lamps selected for test should comply with the relevant Indian Standards. If such specifications do not exist, the lamps should comply as closely as possible with the nominal specifications of the lamp manufacturer. The light centre position should be checked carefully, particularly for lamps fitted with a pre-focus type lamp cap.

Lamps for multiple lamp floodlights, if intended to be of the same type and wattage, should be matched for luminous flux within a spread of 3 percent when operated on the same supply and ballast circuit. They may then be used in calibration and test without regard to the luminous flux which might be obtained on the circuits of the floodlight ballasts.

The lamps should furthermore comply with the specifications given in **4.2.2, 4.2.3** and **4.3.4**.

4.2.2 *Diffusing Quality of the Lamp*

For lamps with a phosphor or diffuse coating of the tube, the diffusing quality of the lamp bulb should correspond to the average of the production.

NOTE — The method for measuring the diffusing quality of a lamp is under consideration.

4.2.3 *Ageing of Lamps*

All lamps should be aged until the luminous flux is shown by successive readings to be stable. Ageing should be carried out by cyclic operation of the lamps close to their electrical design specification for a recommended minimum period of 100 hours in the case of tungsten filament and tubular fluorescent lamps and 200 hours for other lamps. A suggested cycle consists of a 15 minute period off every 4 hours. The position of the lamps during ageing should be as follows:

Tungsten filament	Vertical cap up
Tungsten halogen	Filament horizontal
Tubular fluorescent	Horizontal
Low pressure sodium	Horizontal
High pressure mercury	Vertical cap up
Mercury halide	Horizontal
High pressure sodium	Horizontal

NOTES

1 For low pressure sodium lamps with a U-shaped tube the plane containing the two limbs should be vertical unless otherwise specified. Any lamp showing after ageing an abnormal distribution of metallic sodium should be discarded.

2 A lamp should be marked to ensure that in subsequent use it is operated in an identical position including its orientation about the long axis.

3 Any lamp that is intended to be used in either a horizontal or a vertical cap-up position should be checked for stability in both positions.

4.2.4 *Stability of Lamps*

Lamps should be regarded as stable when the variation in luminous flux during consecutive switch-on is not greater than $\pm$ 1 percent, and when the variation between the mean values for any consecutive burning condition is not greater than 2 percent.

NOTE — If for some types of lamps the above conditions are not fulfilled, the fact should be recorded in the test report.

4.2.5 *Test for Lamp Stability*

Tests may be made either by measurement of luminous flux in an integrating sphere or by measurement of luminous intensity in one direction at 90° to the lamp axis in a distribution photometer.

The lamp should not be moved between measurements.

For tubular fluorescent lamps the air should be draughtfree and the air temperature in the vicinity of the lamp should be stable throughout this test.

4.2.6 *Handling of Aged Lamps*

Aged lamps should be carefully handled. This is particularly important for low pressure sodium lamps both when hot and cold because a sudden movement can alter the distribution of sodium within the arc tube.

4.3 Photocells and Readout Equipment

4.3.1 *Performance of Photocells*

The photocell and its measuring circuit should be stable in operation and not subjected to fatigue when exposed to the maximum level of illuminance encountered.

The combination of photocell and measuring circuit on all its ranges should possess linear response to light up to the maximum level of illuminance encountered, including the peak value with pulsating light, for example, discharge lamps.

NOTE — Widely different illuminance values occur, both between measurements on different types of floodlight and, when using the relative method of photometry, between measurements on the bare lamp and on the floodlight.

To meet the requirements for linearity at high illuminance values a useful technique is to reduce by a known factor the illuminance falling on the photocell. This reduction must be effected evenly over the sensitive surface and by a means which is spectrally non-selective. Recommended light attenuating devices are a calibrated neutral filter, a diffusing medium, a wire mesh screen or a plate having in it a suitable aperture or several apertures used in combination with a diffusing medium to spread the light over the whole area of the photocell sensitive surface. A plate with an aperture to reduce the illuminated area on the photocell must not be used on its own but only in combination with a diffuser. With any of the above devices it is useful to have several of the above mentioned devices to provide a range of convenient attenuating factors.

The use of rotating sector discs is not recommended because of the risk of non-linearity due to the wide range in illuminance values and due to stroboscopic effect.

The spectral sensitivity of the photocell should closely follow the C.I.E. spectral luminous efficiency curve. It is recommended that the stability of the spectral response is checked periodically. A method of checking with colour filters is given in Annex A.

A photocell measures the average illuminance over its own area. If this area is too large measurement errors will occur at points in a beam where the gradient of the intensity distribution is changing rapidly, particularly in the peak intensity region of narrow beam floodlights. At points along the run back of the beam the effect may compensate itself and result in negligible error. Where striations in the beam are present it can be an advantage to average out the intensity variation. Ideally the photocell diameter used should be related to the beam width being measured and for narrow beams up to 4° half peak side angle value it is recommended that the photocell should not subtend an angle at the floodlight greater than 0·25°.

4.3.2 *Measurement of Photocell Output*

The output of the photocell should be measured to an accuracy of $\pm$ 1 percent. If automatic recording equipment is used for the measurement of photo current, it is important that the maximum inherent errors of the equipment are determined for example, delayed response to change in photo current, and lack of response (a finite 'dead zone') to small changes.

The readout equipment used with the photocell should be selected with due regard to the performance of the combination.

4.4 Test Distance

4.4.1 *General*

The test distance must be long enough to ensure that the requirements specified in **4** for accuracy in the measurement of luminous intensity are fulfilled.

The required test distance depends on the dimensions of the luminous part of the floodlight and on the beam width (determined by the half peak side angle).

In generalthe longest available measuring path in a laboratory will be used for floodlight measurements. A check on whether this distance is long enough for measurement of a particular floodlight can be made by the methods described in **4.4.2** and **4.4.3**.

4.4.2 *Check on the Test Distance by Means of the Inverse Square Law*

The maximum apparent luminous intensity I_{max} is measured with a photocell at different distance from the floodlight. For each measuring distance R, the apparent luminous intensity is calculated as:

$$I_{max} = ER^2$$

where E is the illuminance on the photocell (possibly only measured in arbitrary units). The apparent luminous intensity is plotted against the measuring distance R as shown in Fig. 3.

With increasing measuring distance the apparent luminous intensity will approach a horizontal line asymptotically, indicating that the approximation to the inverse square law is becoming closer.

It can be estimated from the shape of the plotted curve whether a chosen test distance is long enough.

The method requires, however, great stability of the lamp and the measuring device to give reliable results. Furthermore, the method may lead to false conclusions for certain types of floodlights, for example, those with a 'cross over point'. In general, therefore, the method described in **4.4.3** is recommended.

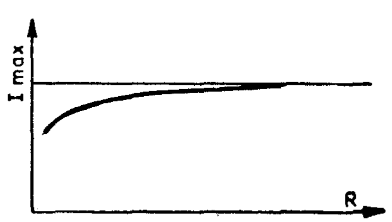


FIG. 3 APPARENT LUMINOUS INTENSITY CURVE DEPENDING ON MEASURING DISTANCE

4.4.3 *Check on the Test Distance by Means of the Half Peak Side Angle*

4.4.3.1 *Regular beams*

The smallest value of the half peak side angle (*see* **2.4**) is determined. The half plane in which this value is found is normally determined by visual inspection. Since a high degree of accuracy is not required for this determination a pilot measurement is easily carried out.

The dimension of the luminous part af the floodlight is measured in the plane which contains the smallest half-peak side angle provided R is limited to 20 m or subjected to maximum optical distance. Under this condition the luminous intensity distribution is also considered to have approached the final beam shape.

4.4.3.2 *Particular beams* — Under consideration.

5 CONDITIONS FOR MEASUREMENT

5.1 Standard Test Conditions

The following test conditions for the photometry of floodlights are standardized to promote compatibility between measurements made at different laboratories. As far as possible, measurements should be made in accordance with all conditions. If it is not possible to achieve a given condition, a measurement correction factor should be determined and applied. This may not be permissible for some conditions (*see* **5.2**).

5.1.1 *Mounting Attitude*

The reference axis and the anxiliary axis of the floodlight as defined in **2.6** and **2.8** should be set horizontal unless otherwise specified by the manufacturer.

5.1.2 *Air Movement and Ambient Temperature*

In the vicinity of the floodlight or bare lamp(s), air should be still. The objective ambient temperature should be 25°C.

5.1.3 *Lamp Orientation*

For bare lamp measurements the lamp should be mounted in the same orientation as that for which the nominal luminous flux is measured.

5.1.4 *Test Ballast*

The same ballast(s) should be used for testing the floodlight and the bare lamps(s). The ballast should be representative of the manufactures normal production.

5.1.5 *Operating Voltage*

The supply voltage to the floodlight should be measured in accordance with **4.1**. The voltage used should be as follows:

a) Floodlights for discharge (including tubular fluorescent) lamps and tungsten halogen lamps : the rated circuit voltage of the floodlight or lamp, and

b) Floodlights for filament lamps (except tungsten halogen lamps) : within the range of 90-100 percent of the rated voltage of the lamp.

NOTE — For measurements made by the relative method a reduced voltage is recommended, to improve consistency of lamp operation and to reduce the risk of lamp failure.

For measurements in absolute units the rated voltage should be used.

5.2 Practical Test Conditions

5.2.1 *Photometric Correction Factors*

In practice it is possible that the standard test conditions specified in **5.1** may not be achieved or that additional data may be required for the floodlight operating in service under conditions different to the standard conditions under which it was measured. In these instances correction factors will need to be determined. They are of the two types defined below and are determined as indicated in **6.12**:

a *Measurement correction factors* — These apply when it is not possible to measure floodlight in the laboratory under all of the standard test conditions. The factor is determined and applied to correct the measured data to the standard test condition before reporting it, and

b) *Service correction factors* — These apply when the service conditions differ from the standard test conditions (*see* **2.10**). They are determined in the laboratory and are provided to enable the user to modify photometric data measured under standard test conditions to that applicable to a particular service condition.

5.2.2 *Conditions for the Use of Correction Factors*

Both measurement and service correction factors may be determined and applied only if the particular condition results in a change in the luminous flux output of the light source without introducing any change in the shape of the light distribution. For example, with temperature dependent light sources such as tubular fluorescent lamps, measurement at a different temperature will only affect the light output. Altering the orientation of some light sources such as metal halide lamps results in a displacement of the discharge within the arc tube with a consequent change in the shape of the light distribution from the floodlight, so that a correction factor cannot be applied.

6 PROCEDURE

6.1 General

The photometry of a floodlight may be made either by the relative method or by the direct method. The measurement procedure for obtaining the light distribution pattern is identical for the two methods and they differ only in the calibration technique.

With the relative method no calibrated reference standards are used. The bare lamp is measured in the same arbitrary scale units as for the floodlight and, in principle, at the same distance. By calculation a factor is established to convert the intensity distribution readings on the floodlight in arbitrary scale units, to candelas per 1 000 lumen output from the bare lamp. However, when using this method the illuminance at the photocell from the bare lamp is often very much lower than that given by the floodlight. This introduces problems of measuring sensitivity and of linearity of the photocell measuring system over a wide range in values and special measuring techniques may have to be used. For example, the bare lamp may be measured at a short distance to obtain an adequate photocell illuminance and the results converted by the inverse square law to the longer distance used for the floodlight photometry (*see* **6.12.3**). An alternative technique is that outlined in the note to **4.3.1**.

The direct method requires the use of a lamp in the floodlight of known light output and also absolute calibration of the photometer. The photometer is calibrated in candelas either by using a calibrated directional intensity reference lamp or by measuring the illuminance at the photocell and converting to intensity using the inverse square law.

The choice between the two methods depends on many factors and each laboratory must choose the method best suited to its own testing facilities, bearing in mind the accuracy required (*see* **3**) and the types of floodlight to be tested. Some floodlights can only be measured by the direct method for example, where the lamp characteristics change significantly when operated outside the floodlight.

The measurement using the direct method can be quicker than using the full relative method, although with some of the alternative technique for bare lamp calibration in the relative method (*see* **6.9** and **6.12.3**), there may be little difference. The direct method requires that a range of suitable lamps calibrated for total light output is available to be used in the floodlights together with a range of lamps calibrated for directional intensity. If many different types of floodlights are to be measured this may be expensive unless the laboratory is able to calibrate its own reference lamps. Since the spectral power distribution of the lamps used in the floodlight may be very different to that of the calibrating lamp, the spectral sensitivity of the photocell is important (*see* **4.3.1**). A calibrated illuminance meter can be used as an alternative to directional intensity standards, but facilities for its periodic re-calibration will be needed.

The accuracy achievable by the relative method, provided linearity and sensitivity requirements are met, should be better than for the direct method since it does not rely on the use of calibrated devices whose calibration errors may be additive.

Detailed procedures for the measurement of floodlights are given in the following paragraphs.

NOTE – Mirror Goniometer Method is recommended for accurate measurements. However, in the absence of mirror Goniometer other method using conventional Goniometer may be used.

6.2 Choice of Goniometer

The recommended co-ordinate system is the *V-H* coordinate system as illustrated in **B-3**. In this system, a direction of measurement is defined by two angles:

a) An angle *H* which is the complement of the angle between this direction and the auxiliary axis (**2.8**); and

b) An angle *V* between two half-planes passing both through the auxiliary axis, the first including the direction of measurement and the second the (positive) reference axis (*see* **2.6**), taken as the origin of *V*.

A goniometer Type B that rotates around a fixed vertical axis relative to a stationary measuring position provides data in this system and is illustrated in Annex B, Fig. 10(a).

Other types of goniometers may be used provided they meet the requirements of **4.4** regarding test distance and the published data is presented in the recommended coordinate system.

NOTE — If the intensity distribution from a floodlight changes due to tilting the light soure, a Type C goniometer (Annex B, Fig. 11) may be preferred and the data transposed (*see* Annex C).

6.3 Selection of Floodlight for Test

The purpose of type testing, floodlights should be selected which are representative of the manufacturers regular production. Attention should be paid to all features which may affect the photometer performance. The optical parts should be clean and all components rigidly located in their designed positions.

If a floodlight incorporate or is supplied with a ballast, the blast should be representative of the manufacturers regular production its setting (lamp power delivered under conditions) and in power. The term ballast includes any components such as capacitors which may influence the light output of the floodlight. If ballast is not supplied with the floodlight a ballast should be selected which is typical of the type likely to be used in service. The setting should be as close as possible to be nominal in respect of lamp power delivered under reference conditions.

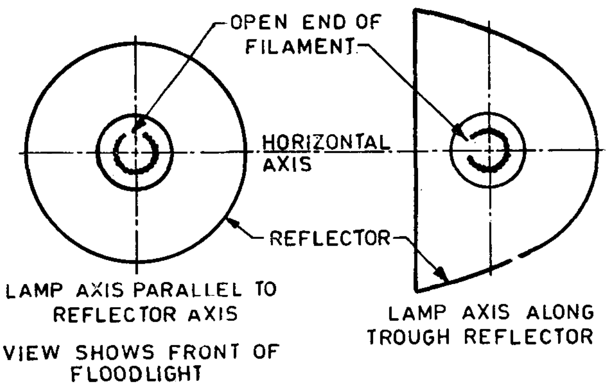
6.4 Mounting of Floodlight in Goniometer

The floodlight should be mounted in the goniometer with the auxiliary axis set horizontal unless otherwise defined by the manufacturer. The photometric light centre of the floodlight is placed coincident with the effective centre of rotation of the goniometer (*see* **2.7** and **2.8**).

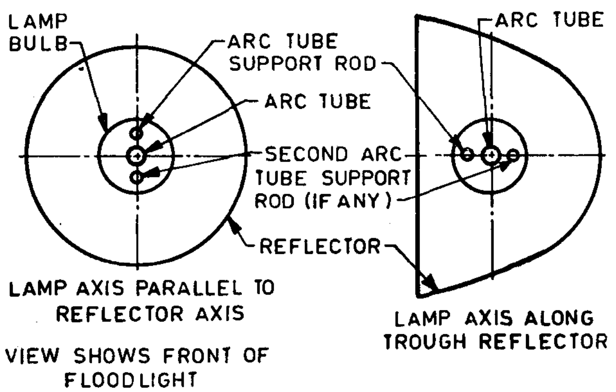
6.5 Lamp Orientation in the Floodlight

The lamp should be positioned so that its light centre is placed at the designed location in the floodlight. The lamp orientations recommended below are intended to provide minimum distortion of the beam shape and permit the most representative averaging of the two sides of the beam.

Where a prefocus type of lampholder is incorporated the lamp position determined by the lampholder is used. Where the lampholder is not such as to provide a fixed lamp location for example, as with an Edison screw lampholder, the lamp should be positioned in accordance with the principles illustrated in Fig. 4.



4(a) Filament Lamps with Clear or Pearl Bulb



4(b) Discharge Lamps with Single Arc Tube

FIG. 4 RECOMMENDED LAMP ORIENTATION IN THE FLOODLIGHT

For filament lamps with opal or similar diffusing finish the gap in the filament is ignored. Linear filament lamps, for example, tungsten halogen types should be treated in the same manner as for discharge lamps with a single arc tube. Low pressure sodium lamps with a U-bend arc tube should have the plane of the arc tubes in the orientation intended by the manufacturer.

6.6 Focusing

For adjustable focus floodlights the lamp position should be adjusted in accordance with the instructions of the manufacturer or client. The lamp positions used should be stated in the test report.

6.7 Position of Photocell Receptor

The photocell receptor should be placed, at the test distance defined in **4.4** and along the line of the measurement direction of the goniometer. With some type C-goniophotometers, the test distance may be fixed by the mechanical design and it should be checked that this distance is sufficient for measuring the floodlight being tested.

6.8 Screening of Stray Light

Stray light reaching the photocell shall be minimised. The photocell should be screened so that as far as possible it sees only the floodlight or bare lamp.

Where a mirror is used the photocell should be screened to see only the image of the floodlight in the mirror and so as not to receive light directly from any part of the floodlight itself. Any surfaces, such as the edges of screens which are parallel with the photocell/floodlight axis, should be grooved, angled or chamfered to a sharp edge to minimise reflections onto the photocell. All surfaces including the background to the floodlight that the photocell sees, should be finished in matt black, including the bevelled edges of mirrors. Screens should be arranged so that stray light from the floodlight only reaches the photocell after two or more reflections. Where this is not possible surfaces should be covered with black carpet, etc.

6.9 Mounting of Bare Lamp for Calibration of the Readings in the Relative Method

6.9.1 There are several techniques which can be used for measuring the luminous flux from the bare lamp and with it calibrating the photometer (*see* **6.13.3**).

In all cases the following mounting conditions apply:

a) The bare lamp, the same as that used in the floodlighting luminaire when measuring the luminous intensity distribution, should be mounted in the same attitude as that for which the photometric data of the lamp are normally prepared, for example, horizontal for low pressure sodium and tubular fluorescent lamps;

b) Lamps designated as universal mounting types can be tested in either a horizontal or vertical cap-up position provided the photometric data is published for the lamp in the position chosen. This position should preferably be the same as that when operated in the floodlight;

c) The orientation of the lamp during calibration should be defined in the test report. For that reason a plane of symmetry through the lamp construction should be identified and where possible marked for later use (*see* **6.13.3**). This plane may be related for example, to the filament gap of a general service tungsten lamp, the arc tube support of a vertical burning high pressure lamp or the longitudinal axis and lamp cap of a low pressure sodium lamp; and

d) Care must be taken in the method of mounting the bare lamp to minimize any obstruction caused by the mounting means.

NOTE — For same lamps (certain types of high pressure sodium and metal halide lamps) the nominal luminous flux is measured with the lamp operated under special conditions and will change when operated inside a floodlight. The calibration measurements on these lamps must be made under the special conditions defined by the lamp manufacturer.

6.10 Stabilisation of the Lamp, Floodlight and Photometer

The lamps, floodlight and measuring devices can be regarded having reached stability when the variation between three successive readings of luminous intensity or flux at intervals of not less than 15 minutes does not exceed 1 percent. Experience may show that a bare incandescent lamp is sufficiently stable within 10 minutes, and most gasecus discharge lamps after 30 minutes operation. For metal halide lamps, however, the stabilisation time may vary between 30 minutes and 6 h.

The stabilisation period for floodlights may be such greater than that for the respective bare lamp, particularly in the cases of tubular fluorescent lamps which may require periods in excess of 2 hours.

The care should be taken to stabilise the measuring circuits and associated devices.

6.11 Measurement of Floodlight

Readings of intensity in arbitrary scale units are taken in a sufficient number of directions appropriate to the beam pattern of the floodlight being tested and also to the required use of the data. For example, simplified data in a limited number of planes suitable for graphical presentation or complete data in tubular form for computer calculation. For graphical purposes it is usual to make measurements in any one plane out to the direction of measurement where the intensity falls compute the total light output in addition to the light flux contained within the beam, it will be necessary to make additional measurements out to say, 1 percent or to the cut-off points in any plane. The angular spacing in any one plane at which measurements are taken will depend on the shape of the intensity distribution and rate of change of intensity. If sufficient data are to be provided for computer processing a standardized tabular form is used with fixed angular spacings.

A preliminary investigation of the beam shape should be made to find the location and rate of the maximum changes in the intensity and the degree of asymmetry, if any.

This information will provide a guide to the angular spacings needed in measuring the intensity distribution and by using the half-peak side angle value, to verify that the test distance is adequate (*see* **4.4**).

Measurements on the floodlight are made in several *V* planes and at a series of directions *H* within each plane.

The following gives general guidance on the angular spacings required for measuring floodlights with conventional smooth beam patterns in the recommended coordinate system.

NOTE — Where a different coordinate system is used for measurement the results can be converted to the recommended system. Alternatively, setting angles in the particular coordinate system used for measurement can be derived to correspond to the required directions in the recommended system (*see* Annex C).

When complete data is required suitable for computer calculation the angular settings should be those given in the Tables 1 and 2, using from these are valves appropriate to the groups classification as defined in **2.11**.

For an isocandela diagram measurements will need to be taken in a sufficient number of planes to provide enough data for plotting the isocandela contours. Normally, intensity distribution curves are plotted for each plane and from these the angles at which particular intensity values occur can be read off and plotted on the isocandela diagram. The angles between planes and the angular spacing in those planes at which measurements are taken will generally be as indicated above for computer calculation. However, additional measurements may be needed particularly around the maximum intensity region where rapid changes may occur.

NOTE — Techniques have been used whereby simultaneous operation of both rotations on the goniometer, angular positions are recorded for a selected intensity value. This technique can be adapted to provide automatic plotting of the isocandela contours. These techniques, however, are only used where the number of isocandela diagrams required justifies the expense of suitable mechanical design features on the goniometer to permit convenient and quick operation.

Whichever of the above methods of measurement are used, it is always important to find and record the maximum intensity value and its direction.

6.12 Calibration of the Photometer

6.12.1 *General*

As outlined in **6.1**, for tests on most types of floodlights the photometer may be calibrated either by the direct method or by the relative method and detailed procedures are given in the following:

The calibration should be made either just prior to or immediately following the measurement on the floodlight. Its purpose is to provide a calibration factor by which to convert the photometer readings made on the floodlight in arbitrary, scale units to intensities in candelas related to a luminous flux output to 1 000 lumens from the bare lamp.

6.12.2 *Direct Method*

In practice, the intensity, of available reference lamps is limited for reasons of stability so that the illuminance at the photocell is usually much lower than that given by the floodlight and the reading R is small. This may cause problems with providing a photometer having sufficient sensitivity to record the low calibration illuminance combined with adequate linearity to measure correctly the high readings from the floodlight (*see* **4.3.1**).

One technique to overcome such problems, provided sufficient sensitivity is available, is to use a light attenuation device of known factor in front of the photocell when measuring the floodlight and to remove it for the calibration reading. The range in illuminance values to be measured by the photocell is thus reduced. Suitable attenuation devices are described in the Note in **4.3.1**.

Another technique is to mount the calibrated reference lamp nearer to the photocell to obtain a higher illuminance for calibration. With most reference lamps a distance as short as 2 m is permissible for the inverse square law to be applied because of its small dimensions. The photometer reading at the shorter distance is then reduced by the ratio of the squares of the distances to that which would be obtained if the reference lamp was placed at the same distance as the floodlight from the photocell.

A black background should be used behind the reference lamp, but not so close as to have significant luminance. This technique has the additional advantage that the floodlight can be left in position in the goniometer and a calibration can be made at any convenient stage in the measurement of the floodlight.

If the calibration is made with an illuminance meter, the procedure is, for a given angular setting of the floodlight, to record the photometer reading R and to measure the illuminance E at the photocell from the floodlight. The intensity of the floodlight is calculated using the inverse square law and the calibration factor k obtained from the following formula:

$$k = \frac{E \times d^2}{R} \times \frac{1\,000}{\phi}$$

where

k = calibration factor,

E = illuminance at the photocell in lux,

d = test distance in metres,

R = photometer reading in arbitrary photometer scale units, and

ϕ = luminous flux output of the lamp used in the floodlight in lumens.

It is essential that the calibration of the illuminance meter is ckecked regularly and calibration facilities for this should be available.

6.12.3 *Relative Method*

The method does not require the use of any calibrated reference lamps and all measurements are made on the photometer in arbitrary scale units. The luminous flux of the lamp used in the floodlight is obtained by calculation from a measurement of its intensity distribution in arbitrary scale units. Intensity measurements on the floodlight are made in the same arbitrary scale units.

Table 1

(*Clauses* 6.11 *and* 7.2)

Asymmetric Distribution				Distribution Symmetric About One Plane ($H = O$)				Distribution Symmetric About One Plane ($V = O$)			
Beam Width Group[1]				Beam Width Group[1]				Beam Width Group[1]			
I		II		I		II		I		II	
V	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*	*V*	*H*
-90	-90	-90	-90	-90		-90			-90		-90
-75	-75	-80	-80	-75		-80			-75		-80
-60	-60	-70	-70	-60		-70			-60		-70
-45	-45	-60	-60	-45		-60			-45		-60
-30	-30	-50	-50	-30		-50			-30		-50
-20	-20	-40	-40	-20		-40			-20		-40
-15	-15	-30	-30	-15		-30			-15		-30
-10	-10	-25	-25	-10		-25			-10		-25
-9	-9	-20	-20	-9		-20			-9		-20
-8	-8	-15	-15	-8		-15			-8		-15
-7	-7	-10	-10	-7		-10			-7		-10
-6	-6	-9	-9	-6		-9			-6		-9
-5	-5	-8	-8	-5		-8			-5		-8
-4	-4	-7	-7	-4		-7			-4		-7
-3	-3	-6	-6	-3		-6			-3		-6
-2.5	-2.5	-5	-5	-2.5		-5			-2.5		-5
-2.0	-2.0	-4	-4	-2.0		-4			-2.0		-4
-1.5	-1.5	-3	-3	-1.5		-3			-1.5		-3
-1.0	-1.0	-2	-2	-1.0		-2			-1.0		-2
-0.5	-0.5	-1	-1	-0.5		-1			-0.5		-1
0	0	0	0	0	0	0	0	0	0	0	0
0.5	0.5	1	1	0.5	0.5	1	1	0.5	0.5	1	1
1.0	1.0	2	2	1.0	1.0	2	2	1.0	1.0	2	2
1.5	1.5	3	3	1.5	1.5	3	3	1.5	1.5	3	3
2.0	2.0	4	4	2.0	2.0	4	4	2.0	2.0	4	4
2.5	2.5	5	5	2.5	2.5	5	5	2.5	2.5	5	5
3	3	6	6	3	3	6	6	3	3	6	6
4	4	7	7	4	4	7	7	4	4	7	7
5	5	8	8	5	5	8	8	5	5	8	8
6	6	9	9	6	6	9	9	6	6	9	9
7	7	10	10	7	7	10	10	7	7	10	10
8	8	15	15	8	8	15	15	8	8	15	15
9	9	20	20	9	9	20	20	9	9	20	20
10	10	25	25	10	10	25	25	10	10	25	25
15	15	30	30	15	15	30	30	15	15	30	30
20	20	40	40	20	20	40	40	20	20	40	40
30	30	50	50	30	30	50	50	30	30	50	50
45	45	60	60	45	45	60	60	45	45	60	60
60	60	70	70	60	60	70	70	60	60	70	70
75	75	80	80	75	75	80	80	75	75	80	80
90	90	90	90	90	90	90	90	90	90	90	90
1601[2]		1601[2]		821[2]		821[2]		821[2]		821[2]	

1) *See* **2.11**

2) Total number of values.

Table 2

(*Clauses* 6.11 *and* 7.2)

Distribution Symmetric About Two Planes				Rotationally Symmetric Distribution			
Beam Width Group[1]				Beam Width Group[1]			
I		II		I		II	
V	*H*	*V*	*H*	*V*	*H*	*V*	*H*
0	0	0	0	0	0	0	0
0·5	0·5	1	1		0·5		1
1·0	1·0	2	2		1·0		2
1·5	1·5	3	3		1·5		3
2·0	2·0	4	4		2·0		4
2·5	2·5	5	5		2·5		5
3	3	6	6		3		6
4	4	7	7		4		7
5	5	8	8		5		8
6	6	9	9		6		9
7	7	10	10		7		10
8	8	15	15		8		15
9	9	20	20		9		20
10	10	25	25		10		25
15	15	30	30		15		30
20	20	40	40		20		40
30	30	50	50		30		50
45	45	60	60		45		60
60	60	70	70		60		70
75	75	80	80		75		80
90	90	90	90		90		90
421[2]		421[2]		21[2]		21[2]	

[1] *See* **2.11**

[2] Total number of values.

In the conventional method both the lamp and the floodlight are tested in the same goniometer at the same distance from the photometer.

6.12.4 *Calibration Technique when Measuring Floodlights with a Coloured Light Source*

Most floodlights of this type use a discharge lamp so that the spectral energy distribution differs significantly from that of a filtered filament lamp. For this reason it is recommended that only the relative method of calibration is used to avoid problems with photocells having an imperfect correction to the CIE spectral luminous efficiency curve.

6.12.5 *Measurement of Floodlight having Tubular Fluorescent Lamps*

The measurement of floodlights using tubular fluorescent lamps presents special problems related to changes in lamp characteristics due to temperature, air movement and orientation.

6.13 Determination of Correction Factors

The types of correction factor are defined in **5.2.1** and the conditions for their use in **5.2.2**.

Both measurement and service correction factors are determined by making two corresponding measurements of either intensity in a given direction, the illuminance at a given point or of the total light output as follows.

6.13.1 *Measurement Correction Factors*

One measurement is made under standard test conditions and the second corresponding measurement of the same quantity made with a single variation from the standard test conditions.

The correction factor is the ratio of the measurement under standard test conditions to the measurement under the varied condition.

6.13.2 *Service Correction Factors*

These are determined in the same manner as for the measurement correction factors except that the ratio is reversed. The service correction factor is the ratio of measurement under the service condition to the measurement under the standard test condition.

6.13.3 *Monitored Photocell Method*

This is a particular case of a series of measurement correction factors applied during measurement by use of a monitoring photocell. It applies to goniometers where the orientation of the floodlight is altered during measurement resulting in a change of light output only. It cannot be applied where a change in light distribution shape occurs.

6.13.4 *Ballast Lumen Factor*

A reference lamp is operated in turn on the test ballast which should be representative of production and on the reference ballast if available under the standard measuring conditions for bare lamps. A measurement of the luminous flux of the reference lamp, or of a proportional quantity such as intensity shall be made in turn for the two arrangements. The ballast lumen factor is the ratio of the measurement with the test ballast to the measurement with the reference ballast.

7 PRESENTATION OF RESULTS

7.1 The results of intensity distribution measurements may be presented in various ways depending on the use to be made of the data and the particular format preferred by an individual laboratory. The following paragraphs give recommended presentations for light distribution data.

7.2 Tabular Data

If the measurements are intended for computer calculations they should be presented in tabular form.

The table should be given as indicated in Fig. 5 with the values in the row corresponding to one value of the angle *V* and varying values of the angle *H*.

In a similar way each column corresponds to one value of *H* and varying values of the angle *V*.

V= \ H=	-90	-	-	-	-	-	-	0	-	-	-	-	-	-	-	90
-90		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
-		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
-		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
-		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
-		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
-		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
-		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
-		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
-		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
+90		x	x	x	x	x	x	x	x	x	x	x	x	x	x	

FIG. 5 STANDARD FORM OF I-TABLE FOR FLOODLIGHT

Note that the column corresponding to $H = -90°$ and $H = 90°$ only contain one intensity value.

The values of *V* and *H* to be used in this table for different types of floodlights are specified in Tables 1 and 2.

7.3 Intensity Distribution Curves

Intensity distribution curves should be plotted on rectangular cartesian coordinates with the intensity values as ordinate and angle *H* or *V* as abscissa.

The curves shown will depend on the symmetry of the intensity distribution (*see* **2.11**). For rotationally symmetric distributions the curve shape in one-half plane only is sufficient, with a note to indicate that the distribution shown is the average of four-half planes. For distributions which are symmetric about two planes, the average half-plane distribution of each of the two planes should be shown. With other intensity distributions appropriate average half-plane or complete plane distributions will be required.

The curves should be sealed in candelas per thousand lamp lumens plotted against angle and it is usually sufficient to include only intensity values down to one tenth of the maximum.

In all instances the orientation of the floodlight and the direction of the planes relative to the floodlight should be noticed.

7.4 Isocandela Diagram

The intensity distribution of an asymmetric floodlight may be shown on an isocandela diagram, which can also be utilized when planning floodlighting installations. It is recommended that rectangular cartesian coordinates, with *H* values as abscissa and *V* values as ordinate should be used. The intervals in intensity values per thousand lumens used for the isocandela lines will depend on the particular distribution. It is recommended that these intervals should follow a geometric series such that the values of adjacent isocandela lines bear a nearly constant ratio to each other. For example, one such series can have values in the range 1 to 10 of 1 — 1·6 — 2·5 — 4 — 6·3 — 10. In this series the values increase in steps of about 60 percent and the series can be extended up or down as appropriate. An isocandela diagram plotted with this series of values rather than, say, 1 — 2 — 5 — 10 usually portrays a more meaningful concentration of the isocandela lines.

ANNEX A

(*Clause* 4.3.1)

METHOD OF CHECKING STABILITY OF SPECTRAL RESPONSE OF A PHOTO-ELECTRIC CELL USING COLOUR FILTERS

A-1 It is recommended that the stability of the spectral response of a photocell and associates filter be checked periodically. This can be done simply by using the cell to make periodic measurements of the luminous transmittances of three stable colour filters.

A-1.1 Measurements should be made at a normal illuminance level. High illuminance of photocell should always be avoided. It is recommended that, in the case of selenium photo-voltaic cells, the illuminance should not exceed a level at which the cell begins to show non-linearity. In practice this is commonly in the region of 200 lux for a cell operating with zero external resistance.

A-2 Periodic measurements should be made under identical test conditions to minimize errors due to extraneous effects. The light source should be an incandescent lamp operated at the same colour temperature on each occasion, usually 2 856 K. (C. I. E. Illuminant A).

NOTE — Filters with optically ground and polished surfaces and with characteristics similar to the following are satisfactory for this measurement:

Blue filter : Corning Type CS 1-62, Glass Type 5900 or Schott Type BG 28/1 mm alternative BG 23/3 mm.

Green filter : Corning Type CS 4-64, Glass Type 4010 or Schott Type VG 6/1 mm alternative VG 9/2 mm.

Red filter : Corning Type CS H, R, 2-61, Glass Type 2412 or Schott Type RG 1/3 mm.

a) The red filters may be sensitive to high temperature and should not be mounted close to the light source.

b) The thickness of the corning glasses is not specified since the manufacturer supplies polished filters in a 'standard stock thickness' which for the particular glass melt has been adjusted to provide the published spectral transmission characteristic identified by the colour specification number.

ANNEX B

(*Clauses* 2.12 *and* 6.2)

CO-ORDINATE SYSTEMS AND GONIOMETERS USED FOR THE PHOTOMETRY OF LUMINAIRES AND THEIR APPLICATION TO FLOODLIGHTS

B-1 Three co-ordinate systems most commonly used for the photometry of luminaires intended for road lighting and interior lighting purposes are designated the A — α, B — β and C — γ systems.

The C — γ system is defined in India Standard on Method of Photometery of the Luminaires, Part 2 For Road and Street Lighting (*see* CIE Publication No. 2, Photometric measurement on luminaires for Street Lighting).

NOTE — There is no internationally agreed definition of the A — α, B — β systems and practice differs in different countries (*see* DIN 5032 Blatt 4, IES Computer Symposium 1971 London 1972).

When applied to the photometry of these types of luminaires the reference axis is always vertical and directed to the nadir.

All systems consist of a bundle of planes with one axis of intersection, sometimes called the 'Axis of rotation'.

In each case a direction in space is characterized by an angle measured between two planes and an angle measured in one of the planes.

The systems differ with respect to the orientation of the axis of intersection in space in relation to the luminaire axis.

For testing floodlights similar systems are in use adapted to the horizontal reference axis, but the designation of the systems again vary in different countries.

The terms A — α, B — β and C — γ have therefore been avoided in this standard.

B-1.1 Co-ordinate system with the axis of intersection horizontal and coincident with the long axis of the luminaire (or lamp).

B-1.2 Co-ordinate system with the axis of intersection horizontal and at a right angle to the long axis of the luminaire (or lamp).

B-1.3 Co-ordinate system with the axis of intersection vertical through the lnminaire centre (C — γ system).

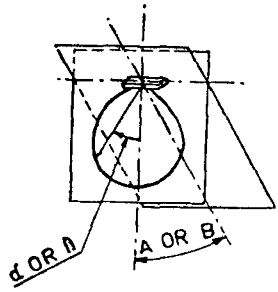


FIG. 6 MEASUREMENT OF α OR β (CASE I)

NOTE — This system is called A — α in some countries (Great Britain, France (and B — β in other countries (Germany).

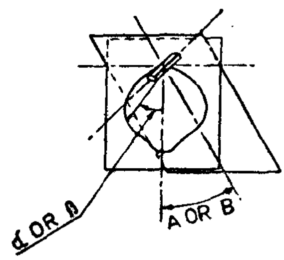


FIG. 7 MEASUREMENT OF α OR β (CASE II)

NOTE — This system is called B — β in some countries (Great Britain, France) and A — α in other countries (Germany).

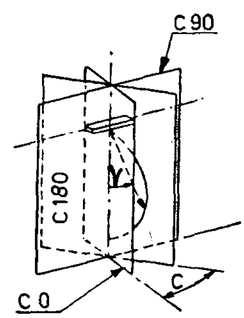


FIG. 8 CO-ORDINATE SYSTEM (C-γ)

B-1.4 None of these three system is directly recommended for the presentation of floodlight luminous intensity data.

B-2 GONIOMETER WITH FIXED HORIZONTAL AXIS (TYPE A) AND ITS RELATED CO-ORDINATE SYSTEM

With this system a rotation about the fixed horizontal axis represents a measurement taken around a great circle on a sphere having a vertical polar axis; a rotation about the movable X-axis represents a measurement taken around a small circle on the sphere as shown in Fig. (9b).

B-2.1 The coordinate system is shown in Fig (9c). To avoid any confusion with the formerly mentioned A — α and B — β systems, the angles between the planes are called *X* and the angles measured in the planes called *Y*. The arrows indicate the positive directions of the angles. The positive direction is to the left or up when viewing from the floodlight along the reference axis.

B-2.2 If a goniometer Type A is used for measurement of a floodlight, the angles *X* and *Y* should be set at the values specified in Annex C, if the results are to be reported in the standard format given in Fig. 5 and **7.1** (Table 1) for luminous intensity tables.

B-3 GONIOMETER WITH FIXED VERTICAL AXIS (TYPE B) AND ITS RELATED CO-ORDINATE SYSTEM

A rotation about the fixed vertical axis of the goniometer represents a measurement taken around a great circle on a sphere having a horizontal polar axis, a rotation about the horizontal axis represents a measurement taken around as small circle on the sphere as illustrated in Fig. 10 (b).

B-3.1 The floodlight is mounted in the goniometer with its auxiliary axis coincident with the movable horizontal axis and the photometric light centre situated at the intersection of the axes *H* and *V*. A fixed horizontal line from this intersection point, perpendicular to the fixed vertical axis of the goniometer is chosen as the direction of observation. Rotation of the goniometer about its vertical axis provides *H* angles and rotation of the floodlight about the horizontal axis provides *V* angles. The resultant distribution consists of a bundle of planes with one horizontal axis of intersection coincident with the auxiliary axis of the floodlight. The co-ordinate system is illustrated in Fig. 10 (c).

B-3.2 The arrows indicate the positive directions of the angles. The positive direction is to the left or up when viewing from the floodlight along the reference axis.

B-4 GONIOMETER WITH A PHOTOCELL OR MIRROR MOVABLE AROUND A HORIZONTAL AXIS

B-4.1 The goniometer is shown in Fig. 11. It is essentially a normal light distribution photometer.

It is characterized by having the floodlight suspended in a fixed orientation in space, movable only around a vertical axis. The photocell (or a mirror) is rotated around the floodlight in a vertical plane.

B-4.2 The error referred to in **2.9.2**. Note 1, will, therefore, not be found here, and provided the flatness of the mirror and the accuracy of the setting of the angles are such that the requirements for measuring accuracy stated in **3** can be complied with, and if the measuring distance complies with, the requirements in **4.4** — this goniometer will produce the most reliable results. If the goniometer is used for measurement of road lighting lanterns, and the angles, therefore, are measured from the nadir, the results will be produced in the C — γ system. For measurements of floodlights, however, the reference axis must be oriented horizontally, and the results will be given in the *X* — *Y* co-ordinate system [*see* Fig. 9 (c)].

B-4.3 If the same goniometer is used alternatively for measurement of road lighting lanterns and of floodlights, it must be possible to alter the zero point of the angular setting (for the angles γ and Y) between the nadir and the horizontal and *vice versa*.

B-5 SUMMARY

B-5.1 The A — α, B — β and C — γ co-ordinate systems all have the reference axis vertical directed to the nadir and are therefore not applicable to floodlights. The *X* — *Y* co-ordinate system provides data in a form that requires additional calculations for each angles of tilt of the floodlight being considered when working out illuminance data.

The *V* — *H* co-ordinate system provides data in a form that can simply be adapted for various angles of the floodlight in illuminance data calculations.

B-5.2 The Type B goniometer provides data directly in the *V* — *H* co-ordinate system. It has limitations only with light sources that are affected by change in relative orientation in space, these limitations, however, are generally less critical that those for a measurement in a Type A goniometer.

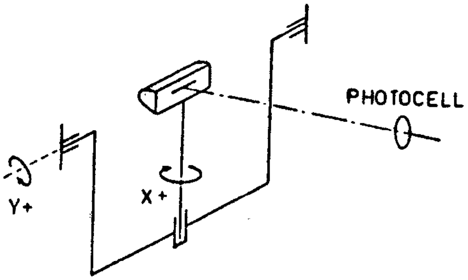


FIG. 9(a) GONIOMETER TYPE A

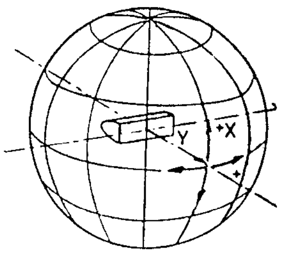


FIG. 9(b) REPRESENTATION ON A SPHERE OF THE *X-Y* CO-ORDINATE SYSTEM

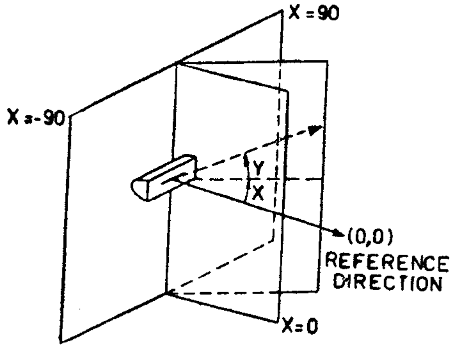


FIG. 9(c) *X-Y* CO-ORDINATE SYSTEM

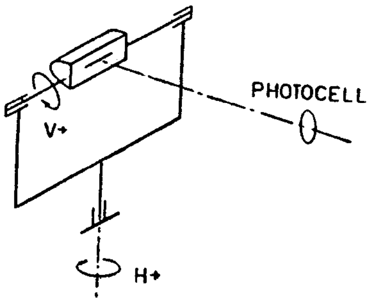


FIG. 10(a) GONIOMETER TYPE B

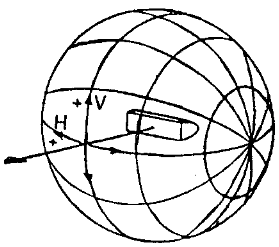


FIG. 10(b) REPRESENTATION ON A SPHERE OF THE *V-H* COORDINATE SYSTEM

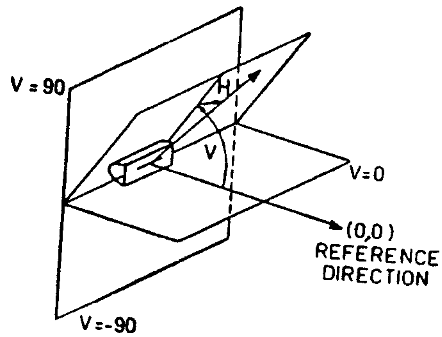


FIG. 10(c) *V-H* CO-ORDINATE SYSTEM

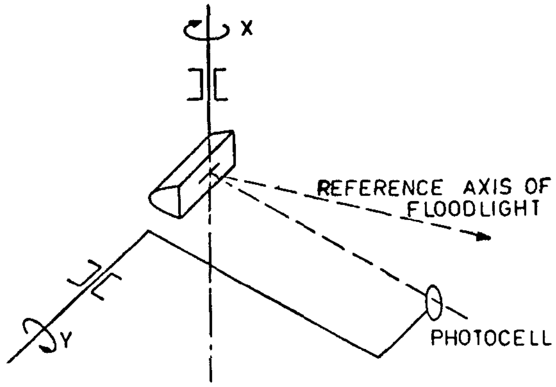


FIG. 11 GONIOMETER TYPE C

B-5.3 Type C goniometer provides data in the $X - Y$ co-ordinate system that can be transposed to $V - H$ co-ordinates as described in Annex C. The floodlight is not tilted during the test and this form of goniometer is recommended for use with light sources that are subject to change in luminous flux output with relative orientation in space.

ANNEX C

(*Clauses* 6.2 *and* 6.11)

THE USE OF TYPE A AND TYPE C GONIOMETERS IN CONNECTION WITH THE RECOMMENDED *V-H* CO-ORDINATE SYSTEM

C-1 Measurements of intensity distribution are being made with the floodlight mounted in a Type A or Type C goniometer, and the results to be reported in the $V - H$ co-ordinate system a practical procedure is to set the angles in the goniometers to correspond to the standard values of V and H given in **7.2**.

When the angles in the goniometers A and C are called X and Y (*see* Annex B) the following formulae can be used for finding the correct values of X and Y:

$$\tan X = \frac{\tan H}{\cos V}$$

$$\sin Y = \cos H . \sin V$$

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