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PHOTOMETRY OF FLOODLIGHTS

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BUREAU CENTRAL DE LA CIE
52, BOULEVARD MALESHERBES 75008 PARIS - FRANCE

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"Dieser Bericht wurde vom Technischen Komitee Nr. TC-2.4 der C.I.E. ausgearbeitet. Er entspricht der Mehrheit der Meinungen des Komitees, in dem die meisten Mitgliedsländer der C.I.E. vertreten sind und wird zum zukünftigen Studium empfohlen.

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NOTE PRELIMINAIRE.

"Ce rapport a été préparé par le Comité Technique C.I.E. N° TC-2.4. Il a été approuvé par la majorité du Comité, dans lequel sont représentés la plupart des Pays membres de la C.I.E., et il est recommandé pour une future étude.

Ce n'est pas une Recommandation officielle de la C.I.E. approuvée par les Comités Nationaux des Pays membres. Il faut noter que toutes les recommandations de ce rapport sont conseillées et non obligatoires".

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(formerly E-2.3)

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U.S.A.	A.R.Jaeger	A.C.Mc Namara
U.S.S.R.	J.B.Aisenberg	J.B.Aisenberg
Yugoslavia	V.Planinsek	V.Planinsek

Consultants :

Great Britain	J.G.Holmes
Great Britain	W.A.Price
Great Britain	J.C.Procter
Great Britain	R.H.Simons

SUMMARY

This report has been prepared by members of committee TC-2.4 during 1972-1977. It is intended to serve as a guide for industrial and national laboratories in the practical photometry of floodlights.

The report contains specifications for the standard conditions under which the tests should be carried out and the measuring accuracy to be desired.

It provides guidance for the selection of test apparatus and test procedures and specifications for the measurement of correction factors applicable to floodlights operated under practical conditions different from the standard test conditions.

The increasing use of computers in lighting calculations has made it desirable to include specifications for a standard system for the presentation of the light distribution of a floodlight.

ZUSAMMENFASSUNG

Diesen Bericht haben die Mitarbeiter des Komitees TC-2.4 in den Jahren 1972-1977 vorbereitet. Er ist als Leitfaden für die praktische Photometrie von Flutlichtscheinwerfer in industriellen und staatlichen Laboratorien gedacht.

Der Bericht enthält eine eingehende Beschreibung der Standardbedingungen, unter denen die Messungen erfolgen sollten, und Angaben über die anzustrebende Messgenauigkeit.

Er bildet ein Handbuch zur Auswahl geeigneter Messapparaturen und Messmethoden, und liefert Hinweise zur Darstellung der Korrekturfaktoren, die für die unter praktischen vom Standardfall abweichenden Bedingungen arbeitende Flutlichtscheinwerfer verwendbar sind.

Die zunehmende Verwendung von Datenverarbeitungsanlagen bei Lichtberechnungen liess es wünschenswert erscheinen, ein Standardsystem für die Darstellung der Lichtverteilung eines Flutlichtscheinwerfers einzuführen.

SOMMAIRE

Le rapport a été préparé par les membres du comité TC-2.4 de 1972-1977. Il est destiné à servir de guide aux laboratoires nationaux et industriels pour la photométrie pratique des projecteurs.

Le rapport contient les spécifications des conditions normales pour procéder aux essais et définir la précision souhaitable pour les mesures.

Il constitue un guide pour le choix des appareils de mesure et des procédures d'essais. Il donne des indications pour la détermination des facteurs de correction applicables aux projecteurs qui fonctionnent dans des conditions pratiques différentes des conditions normales d'essai.

L'utilisation croissante des ordinateurs pour les calculs d'éclairage a rendu souhaitable l'adjonction de la définition d'un système normalisé pour la représentation de la distribution lumineuse d'un projecteur.

LIST OF CONTENTS

	<u>Page</u>
<u>SECTION 1 - FOREWORD</u>	8
<u>SECTION 2 - SCOPE</u>	8
<u>SECTION 3 - DEFINITIONS</u>	9
3.1 One-half-peak divergence (in a specified PLANE through the maximum intensity)	9
3.2 Half peak side angle (in a specified HALF PLANE through the maximum intensity)	9
3.3 Inner beam of a floodlight	10
3.4 Outer beam of a floodlight	10
3.5 Light output ratio	10
3.6 Reference axis	10
3.7 Photometric light centre	10
3.8 Auxiliary axis	10
3.9 Distribution of luminous intensity	11
3.10 Service correction factors	11
3.11 Types of floodlights	11
3.12 Recommended coordinate system for presenting luminous intensity distribution data	13
3.13 Ballast lumen factor	13
<u>SECTION 4 - ACCEPTABLE ORDER OF ACCURACY FOR FLOODLIGHT PHOTOMETRY</u>	14
<u>SECTION 5 - LABORATORY EQUIPMENT</u>	15
5.1 Electrical power supplies and indicating instruments	15
5.2 Test lamps	16
5.2.1 Selection of lamps for test	16
5.2.2 Diffusing quality of lamp bulb	16
5.2.3 Ageing of lamps	16
5.2.4 Stability of lamps	17
5.2.5 Tests for lamp stability	17
5.2.6 Handling of aged lamps	17
5.3 Photocells and readout equipment	17
5.3.1 Performance of photocells	17
5.3.2 Measurement of photocell output	18
5.4 Test distance	19
5.4.1 General	19
5.4.2 Check on the test distance by means of the inverse square law	19
5.4.3 Check on the test distance by means of the half peak side angle	20
<u>SECTION 6 - CONDITIONS FOR MEASUREMENT</u>	21
6.1 Standard test conditions	21
6.1.1 Mounting attitude	21
6.1.2 Air movement and ambient temperature	21
6.1.3 Lamp orientation	22
6.1.4 Test ballast	22
6.1.5 Operating voltage	22
6.2 Practical test conditions	22
6.2.1 Photometric correction factors	22
6.2.2 Conditions for the use of correction factors	23

	<u>Page</u>
<u>SECTION 7 - PROCEDURE</u>	23
7.1 General	23
7.2 Choice of goniometer	24
7.3 Selection of floodlight for test	24
7.4 Mounting of floodlight in goniometer	25
7.5 Lamp orientation in the floodlight	25
7.6 Focusing	25
7.7 Position of photocell receptor	26
7.8 Screening of stray light	26
7.9 Mounting of bare lamp for calibration of the readings in the relative method	27
7.10 Measuring conditions	28
7.11 Stabilisation of the lamp, floodlight and photometer	28
7.12 Measurement of floodlight	28
7.13 Calibration of photometer	30
7.13.1 General	30
7.13.2 Direct method	30
7.13.3 Relative method	32
7.13.4 Calibration technique when measuring floodlight with a coloured light source	34
7.13.5 Measurement of floodlights having tubular fluorescent lamps	34
7.14 Determination of correction factors	35
7.14.1 Measurement correction factors	35
7.14.2 Service correction factors	35
7.14.3 Monitored photocell method	35
7.14.4 Ballast lumen factor	35
<u>SECTION 8 - PRESENTATION OF RESULTS</u>	35
8.1 Tabular data	36
8.2 Light distribution curves	39
8.3 Isocandela diagram	39
<u>APPENDIX A - METHOD OF MEASURING LINEARITY OF RESPONSE OF PHOTOCELL</u>	40
<u>APPENDIX B - METHOD OF CHECKING STABILITY OF SPECTRAL RESPONSE OF A PHOTOELECTRIC CELL USING COLOUR FILTERS</u>	41
<u>APPENDIX C - SOME COORDINATE SYSTEMS AND GONIOMETERS USED FOR THE PHOTOMETRY OF FLOODLIGHTS</u>	42
<u>APPENDIX D - THE USE OF TYPE A AND TYPE C GONIOMETERS IN CONNECTION WITH THE RECOMMENDED V-H COORDINATE SYSTEM</u>	48

1. FOREWORD.

The primary objective of this Technical Report is to recommend the adoption of test procedures which will provide acceptable results in measuring and reporting the photometric characteristics of floodlights. The recommendations are intended to provide a basis for uniform national standards, and to give guidance to industrial photometric laboratories in the selection of test apparatus, in the conduct of tests and in the presentation of floodlight performance data.

This Technical Report is not an officially agreed C.I.E. Recommendation and any recommendations in this report are advisory and not mandatory.

2. SCOPE.

- 2.1 These recommendations are intended to cover the photometry of floodlights used for interior and exterior lighting purposes and equipped with incandescent or discharge (including tubular fluorescent) electric lamps, or with reflector lamps. Similar techniques may be used for gas or oil operated floodlights. The recommendations relate to visually steady light and not to a flashing light.
- 2.2 The photometric techniques recommended do not include the photometry 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.
- 2.3 Light beams, in which the angle between the peak and the one-half peak intensity direction is less than 2° (i.e. $2 \times 2^\circ$, or 4° to one-half peak divergence for a symmetrical beam), require special methods of photometry which are not included. Information on such measurements is available in the literature, see for example :
- (a) "Photometry of Projected Light" by J.M. Waldram, Trans. Illum. Eng. Soc. (London), 16, 187, 1951.
 - (b) "Symposium on Searchlights" published by The Illuminating Engineering Society (London), 1948.
 - (c) "IES Guide for Photometric Testing of Searchlights", Illuminating Engineering, 53, 155, 1958.
 - (d) "Photometry of Projectors at the National Bureau of Standards", NBS Technical Note 198, issued December 17, 1963.
- 2.4 The photometric measurements described in this document 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 Clause 5.4.2. 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 document.

3. DEFINITIONS

The definitions 3.1, 3.2, 3.3 and 3.4 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.

3.1 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 % of the maximum.

3.2 Half-peak side angle (in a specified HALF PLANE through the maximum intensity)

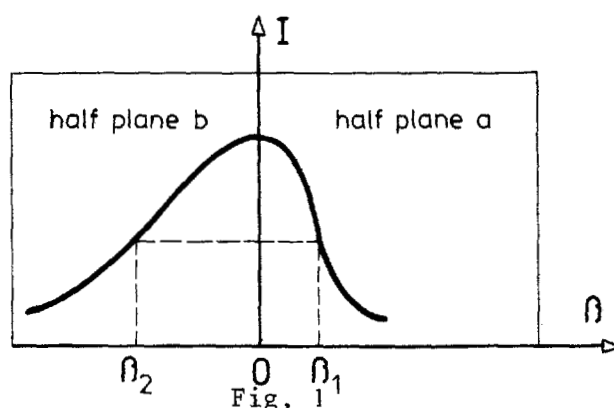
The angle between the direction of maximum luminous intensity and the direction in which the floodlight has a luminous intensity of 50 % of the maximum measured in the specified half-plane.

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 co-ordinates 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 ($\beta_1 + \beta_2$).

Both the measuring distance, Clause 5.4.3 and the number of test angles, Clause 7.12, 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 'ab' are $+\beta_1$ and $-\beta_2$ ".



3.3 Inner beam of a floodlight

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

3.4 Outer beam of a floodlight

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

3.5 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 (see International Lighting Vocabulary, CIE publication No. 17 (1970) (45-50-145)).

The "specified conditions" should be the standard test conditions specified in clause 6.1.

NOTE : The light output ratio measured according to the specification in clause 6.1 is sometimes referred to as "Light output ratio luminaire".

3.6 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.

3.7 Photometric light centre

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

3.8 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.

3.9 Distribution of luminous intensity

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

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.

The luminous intensity is based on a total luminous flux of 1000 lumen from all the lamps in the floodlight when operated under standard conditions. See Chapter 6.

Note 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.

Note 2 : For floodlights in which the light source cannot be separated from the optical system, e.g. sealed beam lamps, the luminous intensity distribution is given for 1000 lm from the sealed beam lamp itself.

3.10 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 e.g. by displacement of the arc, changes of luminance along the arc etc.

The practical service conditions may be other orientations or different ambient temperatures than those corresponding to the standard test conditions. See Clauses 6.2.1 and 7.14.

3.11 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.

Fig. 2a
Rotationally
Symmetric
distribution

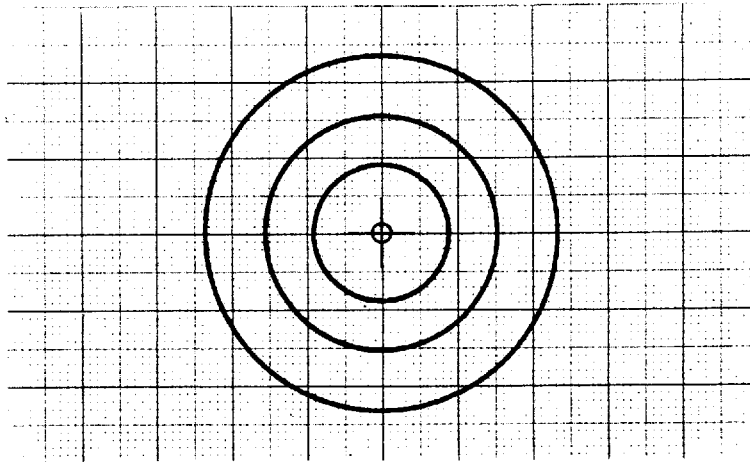


Fig. 2b
Distribution
symmetrical
about two
planes

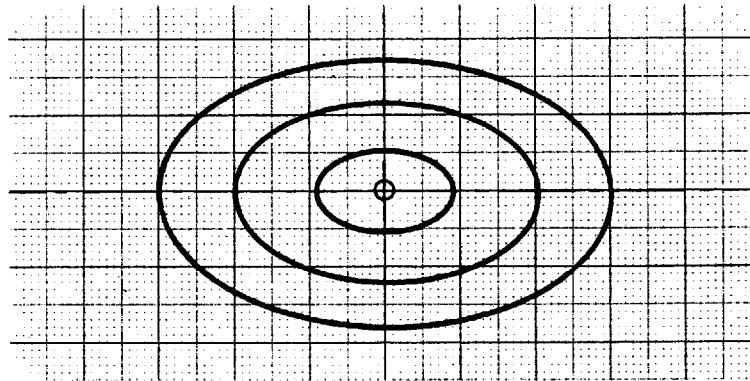
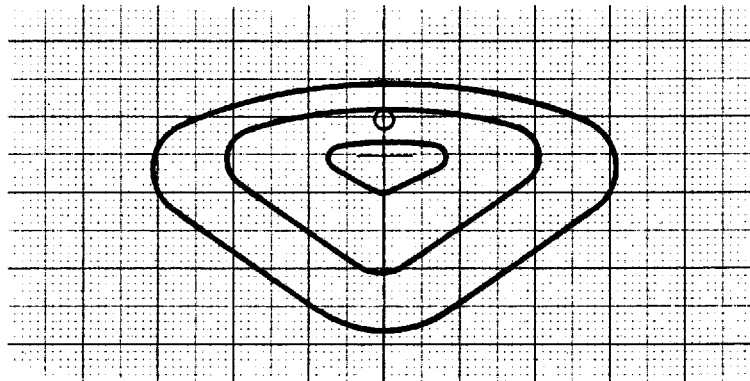


Fig. 2c
Distribution
symmetrical
about one
plane



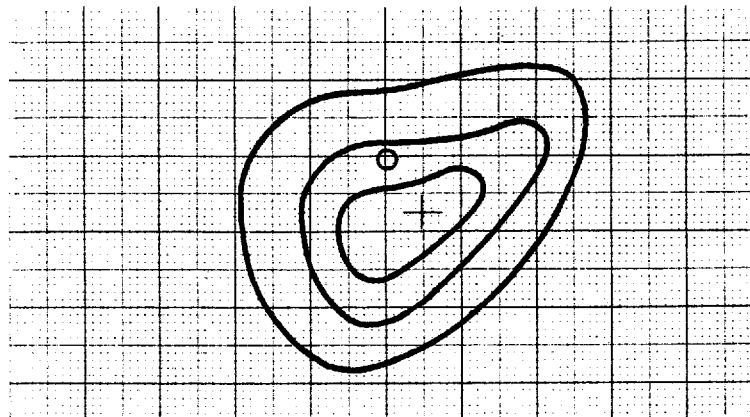
KEY

○ : reference axis

+ : I max

--- : plane of symmetry

Fig. 2d
Asymmetric
Distribution



TYPICAL ISO-CANDELA DIAGRAMS

3.11.1 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° are not covered by this document, see Clause 2.3.

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

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

- a. Rotationally symmetric
- b. Symmetric about two planes
- c. Symmetric about one plane
- d. Asymmetric.

Typical examples of the general groups with reference to their luminous intensity distribution are shown in the isocandela diagrams 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 the reference axis, the direction of maximum intensity and the planes of symmetry, if any, are also illustrated.

3.12 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 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 to Clause 7.2).

Note : Details of various co-ordinate systems and goniometers that have been considered are provided in Appendix C.

3.13 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.

Note : This definition has been proposed by I.E.C. committee 34-C.

The test conditions mentioned above refer to the conditions for measurement of luminous flux as specified in the appropriate lamp standard. See also 7.14.4.

Lighting calculations based on photometric measurements as specified in this document assume essentially that the lamps when operated from the ballasts supplied with the floodlights deliver nominal luminous flux when they are mounted under standard conditions as specified in clause 6.1.

This may not be true in practice, e.g. for technical and commercial reasons underrated 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.

4. ACCEPTABLE ORDER OF ACCURACY FOR FLOODLIGHT PHOTOMETRY

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

For measurement of luminous intensity : $\pm 5\%$ of the actual intensity
in a particular direction
or $\pm 10\%$ candelas per 1000 lamp
lumens which-ever is the
greater.

For measurement of angular direction : For beams with a half peak side
angle :
above 2° and less than 4° $\pm 0.1^\circ$
 4° and less than 8° $\pm 0.2^\circ$
above 8° $\pm 0.4^\circ$

Note : inaccurate angular adjustments greater than the tolerances stated above may lead to errors in the measured luminous intensity in excess of 5 %.

5. LABORATORY EQUIPMENT

5.1 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 % or better for measurements on tungsten filament lamps and to 0.5 % or better for measurements on discharge lamps.
- (c) If the supply is ac, the stabiliser should be of very low impedance and the waveshape such that the total harmonic content does not exceed 3 % ; the harmonic content being defined as the root-mean-square (r.m.s.) summation of the individual harmonic components, taking the fundamental as 100 %. 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 r.m.s. 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 % 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 e.g. 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.

5.2 Test lamps

5.2.1 Selection of lamps for test

The lamps selected for test should comply with the relevant I.E.C. recommendations. 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% 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 clauses 5.2.2 - 5.2.3 and 5.2.4.

5.2.2 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 by the I.E.C. committee 34A.

5.2.3 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.

Note :

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.