



CIE 84 1989

The Measurement of Luminous Flux

XIN Hongzheng



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

1 Scope

- A: National standards lab.(illuminance or luminance distribution)
- B: Industry (sphere)
- C: Industry lab.(goniophotometer)

To cover all the methods ,

To put them in perspective relative to each other



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

2 Terminology

2.1 photometric:

- Luminous flux
- Luminous intensity ()
- Illuminance()
- Luminance()



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

2 Terminology

2.2 measuring instrument

Photometer

Integrating photometer

Integrating sphere, Ulbricht sphere

Box photometer

Photometer head

Acceptance area

Goniophotometer



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

3 Methods of measurement

Calculation from the luminous intensity distribution

Calculation from the illuminance distribution

Measurement with a sphere photometer by
photometric or spectral measurements

Measurement with a box photometer

Relative measurements via illuminance, luminous
intensity or luminance



3 Methods of measurement

Calculation of the luminous flux from the luminous intensity distribution is appropriate where measurements of the latter are already being made.(e.g. for luminaires)

The derivation of the luminous flux from a measurement of the illuminance distribution of a lamp is the method used in many national standards laboratories to set up the basic standards of luminous flux. The unit of luminous flux, the lumen, is thus established in terms of the SI base unit of luminous intensity , the candela. An accurate measurement of the spatial variation of the colorimetric properties of light sources and of their spectral power distribution can also be made using this method.

3 Methods of measurement

Luminous flux measurements using a sphere photometer are appropriate for:

- Measurements in industrial laboratories for production control
- Measurements by test houses and users
- The calibration of standard lamps (e.g. working standards) against higher order standard lamps, making extra corrections for errors due to geometric, spectral and light distribution differences between the lamps to be compared.
- The measurement of light sources with luminous fluxes varying with time (e.g. adjustable lamps, flashlamps)
- The measurement of luminous flux as a function of time.



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

3 Methods of measurement

A luminous flux measurement with a box photometer **only** presents a direct relationship between the luminous flux of the light source and the indirect illuminance at an arbitrary point at an inside surface of the box, **if** the reference light source and the light source to be measured have **the same spatial luminous intensity distribution, the same spectral distribution and same dimensions.**



3 Methods of measurement

Measurements of spectral radiant flux can be made with an integrating sphere photometer, for light sources where the spectral power distribution varies with direction (e.g. metal halide lamps). This method gives all the information necessary for the calculation of:

- Spectral power distribution
- Luminous flux
- Radiant flux
- Colour
- Colour rendering indices



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

3 Methods of measurement

The determination of the luminous flux of light sources via a measurement of illuminance, luminous intensity or luminance is often carried out in practice to determine the influence of specific parameters (e.g. ageing, temperature, position) . It usually takes the form of **a relative measurement**.

The method can also be used for measuring the luminous flux of fluorescent lamps in lighting installations.



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

3 Methods of measurement

The **method used** for the measurement of luminous flux **depends on the available equipment**. Equipment and method used are influenced by:

- The task of the photometric laboratory
- Economy
- Time consumption
- Acceptable measurement uncertainty.

4 Calculation of luminous flux from luminous intensity distribution

4.1 Measurement principle

According to the definition, the luminous flux Φ can be derived from the spatial distribution of the luminous intensity I by the relation

$$\Phi = \int_{\Omega} I d\Omega$$

where $\Omega = 4\pi$ sr, Total solid angle

The luminous intensity distribution can be measured with a goniophotometer



4.2 Measurement of luminous intensity distribution

The measurement of luminous intensity distribution is described in a separate Technical Report of the CIE. That report contains information about goniophotometers used for the measurement of luminous intensity distribution as well as data about the execution of the measurements.

4.3 Method of calculation

In order to evaluate the luminous flux, the luminous intensity should be integrated over the full solid angle as shown in the equation.

$$\Phi = \int_{\Omega} I d\Omega$$

The element of solid angle $d\Omega$ can be expressed trigonometrically as

$$d\Omega = \sin \epsilon d\epsilon d\eta$$

with

$d\Omega$ Element of solid angle

ϵ, η Angles depending on the chosen coordinate system;

ϵ elevation angle with $\epsilon=0$ at zenith and η azimuth angle

The angles ϵ and η should be substituted to accord with the coordinate system used during the measurement of luminous intensity distribution.

4 Calculation of luminous flux from luminous intensity distribution

- In a practical evaluation the integrals are replaced by sums. In that case the luminous flux can for example be calculated according to the following formulae:

- A-PLANES:...

- B-PLANES:...

- C-PLANES:
$$\Phi = \Delta C \sum_{m=1}^M \sum_{n=1}^N I(\gamma, C) \{ \cos[(n-1)\Delta\gamma] - \cos(n\Delta\gamma) \}$$

$\Delta\gamma$ corresponds to π/N , while ΔC are given by $2\pi/M$

The smaller the angular steps that are chosen, the more accurate will be the resulting determination of luminous flux. Steep luminous intensity distributions require smaller angular steps.



4 Calculation of luminous flux from luminous intensity distribution

4.4 Sources of error

Specific errors in the determination of the luminous flux through an evaluation of the luminous intensity distribution can be caused by:

- Errors in the measurement of luminous intensity
- Too large step angles
- Shading of the light source by mechanical parts of the goniophotometer and the holder for the light source
- Instability of the light source during measurement
- Instability of the mechanical arrangement of the photometer.

5 Calculation of luminous flux from the illuminance distribution

5.1 Measurement principle

By definition, the luminous flux Φ can be derived from the distribution of illuminance E over a closed surface A around the light source using the relation

$$\Phi = \int_A E dA$$

The illuminance distribution can be measured by means of a goniophotometer over a spherical surface around the light source. **It is not necessary** for the light source to be exactly at the centre of the imaginary sphere. **It is, however, recommended that** it should be positioned **as close to the centre of the sphere as possible.**



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

5 Calculation of luminous flux from the illuminance distribution

The minimum distance between the centre of the sphere and the photometer head **depends on** the largest dimension of the light source to be measured, for purely mechanical reasons. It may be smaller than the limiting photometric distance **as long as the illuminance meter still evaluates illuminance correctly in terms of direction** (cosine response), etc.



5 Calculation of luminous flux from the illuminance distribution

5.2 Types of goniophotometer

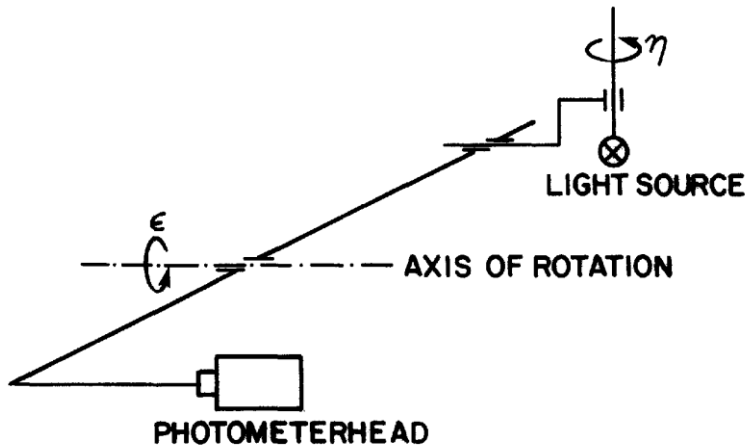
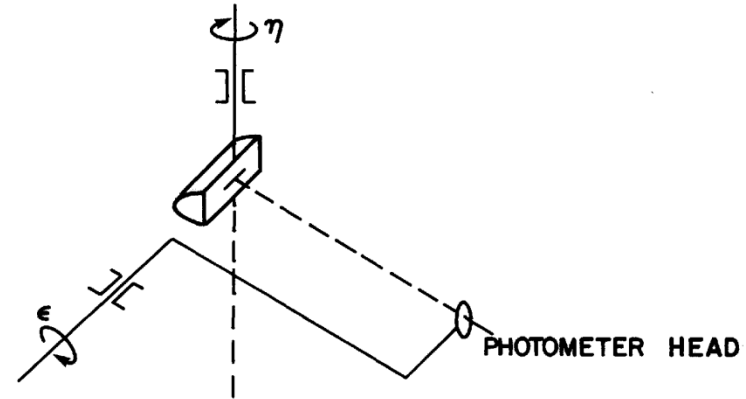
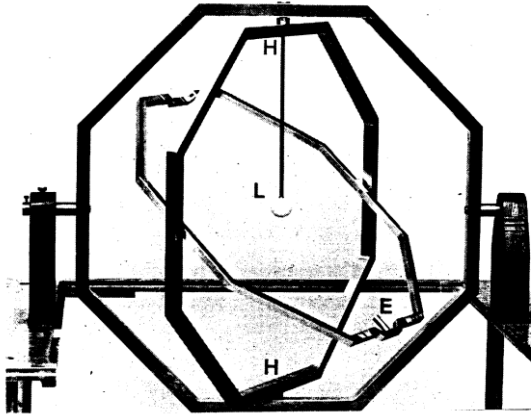
It is possible to distinguish between the different types of goniophotometer used for the measurement of illuminance distribution. In all of them the light source to be measured is operated in the prescribed burning position.

5.2.1 Goniophotometer with light source in a fixed position

5.2.2 Goniophotometer with the light source rotated about a spatially fixed light centre

5.2.3 Goniophotometer with the light source rotated about a vertical axis with a moving light centre

5 Calculation of luminous flux from the illuminance distribution



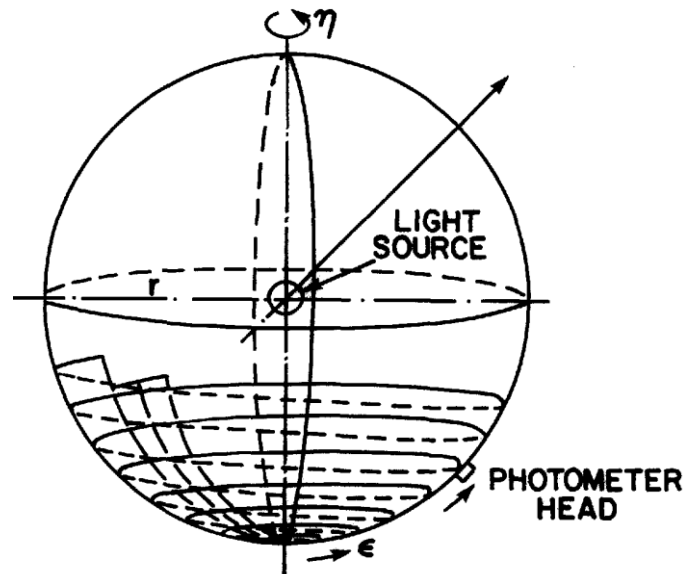
5 Calculation of luminous flux from the illuminance distribution

5.3 Measurement of illuminance distribution

5.3.1 Movement of the photometer head

There are several possibilities for measuring illuminance distribution:

...





5 Calculation of luminous flux from the illuminance distribution

5.3.2 Angular step sizes

The determination of the luminous flux becomes the more accurate the smaller the step sizes for rotation in the polar ($\Delta\theta$) and azimuth ($\Delta\phi$) angles.

For an accurate measurement, especially for light sources with a steep luminous intensity distribution, angular step sizes of $\Delta\theta = \Delta\phi = 0.1$ could be required. For light sources with a broad luminous intensity distribution larger angular step sizes can be chosen.



5 Calculation of luminous flux from the illuminance distribution

5.3.3 Speed of rotation

Light sources, the luminous flux of **which depends on the ambient temperature and the air speed**, may only be turned around the vertical axis at a limited speed of rotation. Some light sources can also be **influenced by material moving** inside the light source. Where there is a possibility of moving particles, especially drops of e.g. Na, Hg, the accelerations should be less than one tenth of standard gravity.



5 Calculation of luminous flux from the illuminance distribution

Note:

The permitted **speed of rotation can be determined by:**

- Measuring the luminous flux of the light source as a function of the speed of rotation
- Measuring the illuminance at a position along the axis of rotation of the light source, which is not shaded by parts of the lamp holder, as a function of the speed of rotation.

The speed of rotation, at which the luminous flux starts changing (usually decreasing), **should not be exceeded** during the measurement. A uniform movement of the photometer head without vibration is required. For this the mechanical system **has to be well balanced**.



5 Calculation of luminous flux from the illuminance distribution

5.4 Angle encoding

In order to measure the illuminance at a defined position of the photometer head, two angles have to be set and measured. The use of **absolute angle encoders**, where the starting position need not be adjusted, is recommended.

The set positioning is maintained even after switching off the power supply. **Other means of angle encoding**, e.g. stepping motors, are also in use. The indication of the angles should be accurate to within approximately $0,1^{\circ}$.



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

5 Calculation of luminous flux from the illuminance distribution

5.5 Illuminance meter

The accuracy of luminous flux measurements made by means of an evaluation of the illuminance distribution **is determined decisively** by the quality of the illuminance meter used. It should be of **a very high quality**.

5 Calculation of luminous flux from the illuminance distribution

5.6 Data acquisition and calculation of luminous flux

In all goniophotometers where luminous flux is determined by evaluating the illuminance distribution, this distribution is measured on a spherical surface around the light source. In that case the luminous flux is given by equation as:

$$\Phi = \int_{(A)} E \, dA = r^2 \int_{\varepsilon=0}^{\pi} \int_{\eta=0}^{2\pi} E(\varepsilon, \eta) \sin \varepsilon \, d\varepsilon \, d\eta$$

A Sphere surface

E Illuminance on area element dA of the sphere surface

r Sphere radius

ε Polar angle

η Azimuth angle



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

5 Calculation of luminous flux from the illuminance distribution

When the light source or the detector is moving continuously during a measurement there can be quite large changes in the illuminance at the photometer head due to spatial or, in the case of AC powered lamps, temporal changes in the output. An exact measurement of the local illuminance is therefore only possible if the light source and the detector head are stationary during the measurement. This leads **to long measuring times and is therefore not generally practicable** .



5 Calculation of luminous flux from the illuminance distribution

Methods for the determination of the "correct" illuminance, which is applicable for a defined area element or a defined direction (characterized by the angles ε and η), differ and cannot be described in a generalized way.

On the whole the measurement accuracy is influenced significantly by the angular step sizes $\Delta\varepsilon$ and $\Delta\eta$, the angular velocities $d\varepsilon/dt$ and $d\eta/dt$ and the integration time of the illuminance meters (for 50 Hz AC supplies usually > 20 ms) .



5 Calculation of luminous flux from the illuminance distribution

The illuminance integration given by equation can be carried out by:

- **Direct electronic integration** with display of the luminous flux after evaluation of the illuminance distribution over the whole surface of the sphere.
- **Acquisition of the measured illuminance values at all the positions** of the photometer head, storage of these values **and evaluation e.g. by means of a desktop computer.**



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

5 Calculation of luminous flux from the illuminance distribution

In a direct electronic integration weighting of the illuminance according to the sine of ε is usually achieved by using a sinepotentiometer. In these potentiometers, even with precision components, large errors can occur at small values of ε , which reduce the accuracy when measuring light sources with steep luminous intensity distributions. **For equal angular step sizes numerical calculation will therefore usually be more accurate than direct electronic integration.**

In numerical calculation **it is also possible to determine partial luminous fluxes** in certain sections of solid angle, e.g. the upper or lower hemisphere, separately.



5 Calculation of luminous flux from the illuminance distribution

5.7 Stray light...

5.8 Missed luminous flux...

5.9 Summary of error sources

- Deformation of mechanical parts of the goniophotometer (frame, revolving arm)
- Uncertainty regarding the distance between the acceptance area of the photometer head and the centre of revolution
- Uncertainty with respect to the position of the photometer head Irregular rotation
- **Too** large angular steps
- Measurement uncertainty of the illuminance meter

5 Calculation of luminous flux from the illuminance distribution

- Too great an angular velocity : Influence on the light output of the source. Prevention of the proper temporal integration of the luminous **flux**
- Missed luminous flux and shading
- Stray light
- Uncertainty regarding the photometric calibration of the calibration standard
- Instability of the light source or other parts of the system (e.g. amplifier) during the measurement.



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

5 Calculation of luminous flux from the illuminance distribution

5.10 Characterization checklist

Mechanical construction:...

Geometry:...

Positioning:...

Illuminance meter and data processing:...



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

5 Calculation of luminous flux from the illuminance distribution

5.11 Calibrating and testing

5.11.1 Calibration

Goniophotometers for the determination of luminous flux from the illuminance distribution are usually calibrated by means of **luminous intensity standard lamps**. The calibration applies to the illuminance meter used in the goniophotometer, for which the illuminance is calculated from the luminous intensity of the standard lamp via **the photometric distance law**.



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

5 Calculation of luminous flux from the illuminance distribution

5.11.2 Testing

In addition the goniophotometer can be tested by three different methods:

5.11.2.1 Luminous flux standard lamp

5.11.2.2 Luminous intensity standard lamp

5.11.2.3 Calibrated illuminance meter



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

5 Calculation of luminous flux from the illuminance distribution

5.11.3 Intercomparison

A good method for finding the uncertainty of the measurement of luminous flux obtained with a specific goniophotometer is to compare results for the same lamps measured at different well qualified laboratories. A comparison of the results of measurements on the same lamps obtained with different photometers (e.g. a goniophotometer and an integrating sphere photometer) may also give useful information.



6 Measurement with an integrating sphere

6.1 Measurement principle

The luminous flux of a light source can be measured in a sphere photometer by a comparison with a luminous flux standard lamp. In making the measurement, the light source and the standard lamp are placed successively at the same location in the integrating sphere. **The indirect illuminance** on the sphere surface is taken as a measure of the luminous flux.

A sphere photometer **consists of an integrating sphere, a photometer head** with read-out unit and - if applicable - means for data acquisition, as well as an electrical supply for the measuring equipment.

6 Measurement with an integrating sphere

6.2 Sphere theory

Luminous flux can be measured in a sphere photometer by means of a comparison with the luminous flux of a luminous flux standard lamp. According to Ulbricht's theory, the luminous flux of the light source is related to the indirect illuminance E_{ind} on the internal surface of the integrating sphere by

$$\Phi = E_{ind} \cdot \frac{1 - \rho}{\rho} A$$

$$k = \frac{1 - \rho}{\rho} A$$

$$k = \frac{\Phi_N}{E_{ind,N}}$$

$$\Phi = \Phi_N \cdot \frac{E_{ind}}{E_{ind,N}}$$



6 Measurement with an integrating sphere

6.3 Spectral method

An important parameter of a light source is the spectral radiant flux $\Phi_{e\lambda}$, from which several quantities can be calculated:

- Luminous flux
- Radiant flux
- Radiant flux effective for photobiological effects
- Colour (tristimulus values, correlated colour temperature)
- Colour rendering properties (special (Ri) and general (Ra) colour rendering indices)

6 Measurement with an integrating sphere

The spectral radiant flux of a light source can be measured with an integrating sphere photometer, where **the $V(\lambda)$ -evaluating photometer head is replaced by a monochromator combined with an appropriate detector**. In this way, the spectral irradiance $\Phi_{e\lambda,ind}$ is measured - instead of the indirect illuminance E_{ind} - as a function of the wavelength.

When spectral measurements are used in this way, **the spectral reflectance of the sphere wall and the relative spectral responsivity of the radiometer head do not influence the results**. The effect of a difference in the spatial flux distributions between the standard lamp and the light source to be measured is the same as for luminous flux measurements with an integrating sphere photometer.

6 Measurement with an integrating sphere

A standard lamp of known spectral radiant flux $\Phi_{e\lambda,N}$ must be used.

The spectral radiant flux $\Phi_{e\lambda,X}$ of a light source to be measured can be obtained from the relation

$$\Phi_{e\lambda,X} = \Phi_{e\lambda,N} \frac{Y_{\lambda,X}}{Y_{\lambda,N}} = \frac{1}{s(\lambda)} \cdot Y_{\lambda,X}$$

- $s(\lambda) = Y_{\lambda,N}/\Phi_{e\lambda,N}$ Spectral responsivity of the sphere radiometer
- $Y_{\lambda,X}$ Output signal for light source X at wavelength λ
- $Y_{\lambda,N}$ Output signal for standard lamp N at wavelength λ
- $\Phi_{e\lambda,N}$ Spectral radiant flux of the standard lamp **N**.

6 Measurement with an integrating sphere

The luminous flux Φ_X of the light source to be measured can be calculated from the known luminous flux Φ_N and known relative spectral power distribution $S_{\lambda,N}$ of the standard lamp:

$$\Phi_X = \Phi_N \frac{\int_0^{\infty} S_{\lambda,N} \cdot (Y_{\lambda,X} / Y_{\lambda,N}) \cdot V(\lambda) \cdot d\lambda}{\int_0^{\infty} S_{\lambda,N} \cdot V(\lambda) \cdot d\lambda} =$$

$$= K_m \int_0^{\infty} (Y_{\lambda,X} / s(\lambda)) \cdot V(\lambda) \cdot d\lambda$$

$K_m = 683 \text{ lm/W}$ Maximum spectral luminous efficacy.

For color,...

Other than spectral solutions,...



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

6 Measurement with an integrating sphere

6.4 Box-photometer

A comparison of the luminous flux of light sources of the same type can also be performed using a box-photometer, in which an arbitrarily shaped box or rectangular cavity is used instead of an integrating sphere.



6 Measurement with an integrating sphere

6.5 Integrating sphere

6.5.1 Sphere diameter

...sufficient distance between the light source and the sphere wall to permit adequate multiple reflections of the light within the sphere without undue interference from the source itself. ... for compact lamps should be **at least 10 times** and for tubular lamps at **least twice the largest dimension** of the light source. Thus the sphere diameter for measuring fluorescent lamps of 1,5 m length should be **3 m** (for less critical measurements ...2 m ...).



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

6 Measurement with an integrating sphere

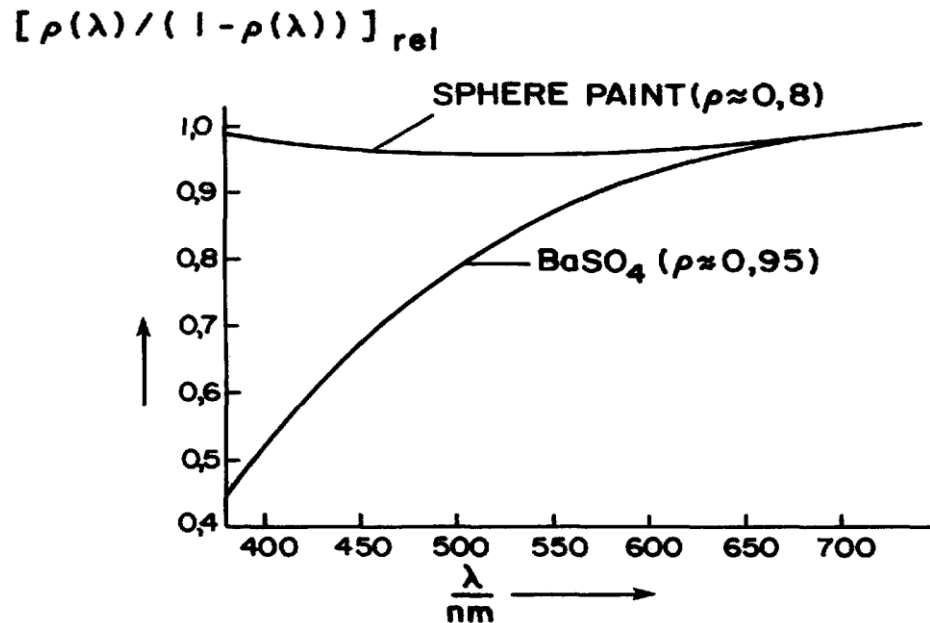
The choice of sphere diameter is also determined by the power dissipation of the light source to be measured.

The responsivity of a sphere photometer varies with the inverse square of the sphere diameter.

The integrating sphere should be made in such a way that no stray light can enter the sphere from the outside.

6 Measurement with an integrating sphere

6.5.2 Sphere paint

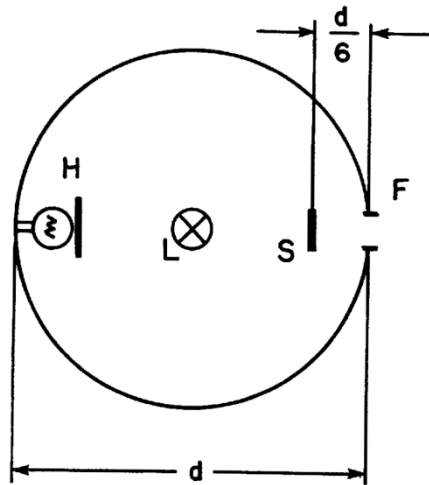


...repainted as often as once a year, depending on the application and the environment, to keep the influence of ageing and pollution to a minimum.

6 Measurement with an integrating sphere

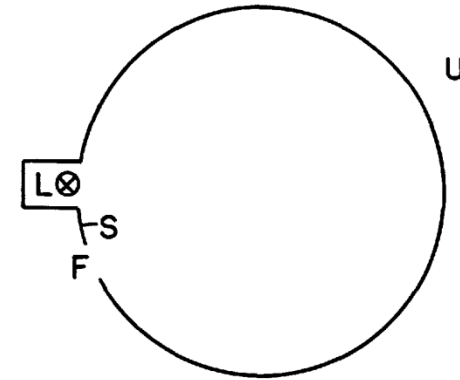
6.5.3 Arrangement of light source and screen

A screen should be mounted inside the integrating sphere in such a way that no direct light from the source can reach the photometer head.



L Light source
S Screen
F Sphere port for photometer head

H Auxiliary lamp with screen
d Sphere diameter



L Light source
F Sphere port for photometer head
S Screen
U Integrating sphere

6 Measurement with an integrating sphere

6.5.4 Influences of objects in the sphere and auxiliary lamp.

All objects in the sphere influence the result of the measurement. They should therefore be as small as possible. The light source itself also absorbs radiation.

The influence can be determined and corrected by making an additional measurement with an auxiliary lamp.

...should be positioned opposite to the photometer head and should illuminate the inside surface of the sphere diffusely.

... a small white screen ...

...with a top reflectorized bulb then ...

...flux of the auxiliary lamp must not change with time.



6 Measurement with an integrating sphere

6.6 Illuminance meter

The acceptance area ... a good diffusing material, ...and fitted tightly into and flush with the inner wall of the sphere. ...size small. ...thermostated photometer head is recommended. ...at about the same height as the light source.

... high quality It is especially important: relative spectral responsivity closely approximates to the **CIE $V(\lambda)$** ...

...Spectral method, a spectroradiometer is employed instead of an illuminance meter



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

6 Measurement with an integrating sphere

6.7 Data acquisition

...digital...

Electrical parameters
calculation



6 Measurement with an integrating sphere

6.8 Luminous flux standard lamps

The results of luminous flux measurements made in the sphere photometer by the substitution principle will be correct if the light source to be measured and the luminous flux standard lamp used have

- The same spectral distribution
- The same dimension and shape
- The same spatial light distribution.

OR?

recommended that at least 3 standard lamps

6 Measurement with an integrating sphere

6.9 Execution of measurements

$$\Phi = \Phi_N \cdot \frac{Y}{Y_N} \cdot \frac{Y_{HN}}{Y_H}$$

Same type and dimension

Same spectral distributions

Light distribution...

large power dissipation...



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

6 Measurement with an integrating sphere

6.10 Testing and correction

6.10.1 Correction for the influence of the sphere paint

6.10.2 Corrections for incandescent lamp measurements

6.10.3 Correction for measuring fluorescent lamps

6.10.4 Test for stability with time



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

6 Measurement with an integrating sphere

6.11 Sources of error

Different spectral distributions...

Different spatial luminous flux distributions...

Different dimensions and absorption ...

Changes in the reflectance of the inner sphere wall (ageing)...

Uncertainty of the illuminance measurement...

Instability of the light source during the



6 Measurement with an integrating sphere

6.12 Characterization of sphere photometers

- Sphere diameter
- Positioning of screens and any auxiliary lamp
- Data on any auxiliary lamp (type, nominal voltages etc.)
- Spectral function $\rho(\lambda) / (1 - \rho(\lambda))$ of the sphere paint
- Data on the illuminance meter used
- Details on data acquisition and display
- Data on the smallest measurable luminous flux

7. Determination of luminous flux via illuminance, luminous intensity or luminance

7. Determination of luminous flux via illuminance, luminous intensity or luminance

7.1 Measurement principle

$$\Phi = c_E \cdot E = c_I \cdot I = c_L \cdot L$$

...the applicable factor of proportionality (C_E , C_I , C_L) is determined.

For some lamps a proportionality between Φ and E , I or L may also hold for the lamp type, and not only for the individual lamp

7. Determination of luminous flux via illuminance, luminous intensity or luminance

7.2 Measurement and calibration

...the measuring geometry, for which the factors of proportionality apply, has to be fixed...

7.3 Characterization

- Lamp type, for which the facility is used
- Quantity to be measured
- Measurement geometry and measuring arrangement
- Factor of proportionality and its standard deviation
- Data on the illuminance or luminance meter used.



8. General measurement conditions

8.1 Operating conditions

...unless otherwise agreed, under the conditions specified in the relevant IEC recommendations and national standards. Specifically, it must be stated whether the measurements are to be made at nominal voltage, current or power. This ensures that within the unavoidable measurement uncertainty, the results can be compared with values measured at other locations.

The measuring and operating facilities should influence the values of the quantities to be fixed as little as possible. Unavoidable influences should be taken into account in the evaluation of the measurements uncertainties.

- Calibrations... directly or indirectly by comparison with internationally recognized standards.

8. General measurement conditions

8.2 Ageing

The operating parameters of **lamps change over their life-time** to varying degrees. Changes are especially pronounced over the first part of their life-time. In order to achieve sufficient repeatability of measurements it is therefore necessary to age the lamps.

The duration of ageing for the different types of lamps is **specified in the relevant** IEC recommendations and national standards.



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

8. General measurement conditions

8.3 Burning Position

The operating position of a light source should comply with the relevant IEC recommendation and national standards or with the specification laid down by the manufacturer and appropriate to the application. The burning position must be stated in the measurement report.

8. General measurement conditions

8.4 Ambient temperature

Discharge lamps...a draught-free ... that the convection flow of the surrounding air is not impaired.

... ambient temperature of **25 °C**. ...strongly temperature dependent...tolerance ± 1 °C, other light sources ± 3 °C.

If measurements are made at different ambient temperatures this temperature should be stated.

...a resolution at least **0.1 °C**at about the same height...

...goniophotometer, exceed half the largest horizontal dimension by **0,5 m**..

...sphere, 20 cm and 1/3 of the sphere diameter, shielded..



8. General measurement conditions

8.5 Vibration and shock

When switched on, the lamp should not be subjected to accelerations exceeding 10 m/s^2 (4-3000 **Hz**) or positional changes exceeding 30 mm (up **to** 4 **Hz**). These constraints will be adequate for most lamps.



8. General measurement conditions

8.6 Stabilization period

...to ensure that all important parameters have reached a steady state by the time the measurements commence. During stabilization same operating. avoiding changes in the burning position and in the specified operating parameters (e.g. nominal voltage, power or current) The stabilization period required **depends on the type of light source and the operating conditions.** It should be checked initially by continuous monitoring of the readings. A light source can be considered to be stabilized, if these **readings no longer show a trend in a particular direction.**

Step....final state...



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

8. General measurement conditions

8.7 Electrical measurements

8.7.1 Measurement uncertainty

Loading error,

Report loading method

8. General measurement conditions

8.7.2 Power supply and operating mode

It is usually possible to measure DC more accurately than AC, since for AC, both the light source and the electrical measuring instruments are influenced by a number of variables, such as frequency, wave form and phase shift. Because of the strong dependence of the photometric quantities on the electrical parameters, the power supplies used should be as stable as possible.

The waveform of AC power supplies should be closely sinusoidal with a minimum of harmonics at other frequencies.

8. General measurement conditions

8.7.3 Wiring

Wiring, ballasts and electrical measuring instruments should be positioned and, if necessary, screened in such a way that any influence from external fields is avoided. For the measurement of lamp voltage or power, the use of a specially constructed lamp holder is recommended.

The special lamp holder should have four contacts, two for the current supply (I_L) and two separate ones for the voltage (U_L) directly at the lamp cap. **A four-electrode lamp holder** reduces the voltage measuring error to zero, because no measurable current flows through the measuring contacts, when a high impedance digital voltmeter is used.

8. General measurement conditions

8.7.4 Execution of the electrical measurements

...current measured by the ammeter must include the current through the voltmeter ... is generally to be preferred. If the current through the voltmeter is significant, however, it will be necessary to apply the appropriate correction.

The capacity of the circuit may influence the results, especially if higher frequencies occur as in the case of low pressure sodium vapour lamps. Grounding errors can substantially influence the measurements.

For accurate AC measurements on discharge lamps, instruments must be of the true rms type so as to take proper account of the harmonics. When measuring high frequency discharge lamps, special methods and instruments must be used.



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

8. General measurement conditions

8.7.5 Measurement circuit

In the case of discharge lamps IEC recommendations or corresponding national standards specify the circuits for the light sources to be measured.

8. General measurement conditions

8.8 Ballasts

Measurements on discharge lamps **must** be made with reference ballasts unless the lamp is controlled on current or power instead of voltage. If other ballasts are used (e.g. for measurements on luminaires), the ballast used should be stated in the measurement report.



8. General measurement conditions

8.9 Supply voltage

Measurements on incandescent lamps should preferably be performed with a DC supply because of the higher accuracy of the electrical measurements. Discharge lamps generally have to be operated on AC.

The supply voltage during ageing should be stable to within 0.5%, during the actual measurement to within 0.1 % and for calibrations with incandescent lamps as standards to within 0.02 %.

The total harmonic content of the AC supply should not exceed 3%. For the operation of high pressure lamps with a high proportion of reactive power the power supply should be chosen in such a way that the required reactive power can be met.

This implies that the source of supply shall have a sufficiently low impedance compared with the ballast impedance and care should be taken that this applies under all conditions of measurement.



Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting

Thank you!





Global
Efficient
Lighting
Centre

UNEP Collaborating Centre for Energy Efficient Lighting



CLIMATE TECHNOLOGY CENTRE & NETWORK

The Climate Technology Centre and Network (CTCN) fosters technology transfer and deployment at the request of developing countries through three core services: technical assistance, capacity building and scaling up international collaboration. The Centre is the operational arm of the UNFCCC Technology Mechanism, it is hosted and managed by the United Nations Environment and the United Nations Industrial Development Organization (UNIDO), and supported by more than 300 network partners around the world.

CTCN contact details:

Climate Technology Centre and Network

UN City, Marmorvej 51

DK-2100 Copenhagen, Denmark

+45 4533 5372

www.ctc-n.org

ctcn@unep.org