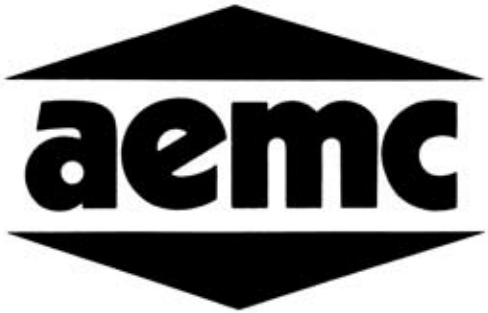


LIGHTMETER MODEL 814
INSTRUCTION MANUAL

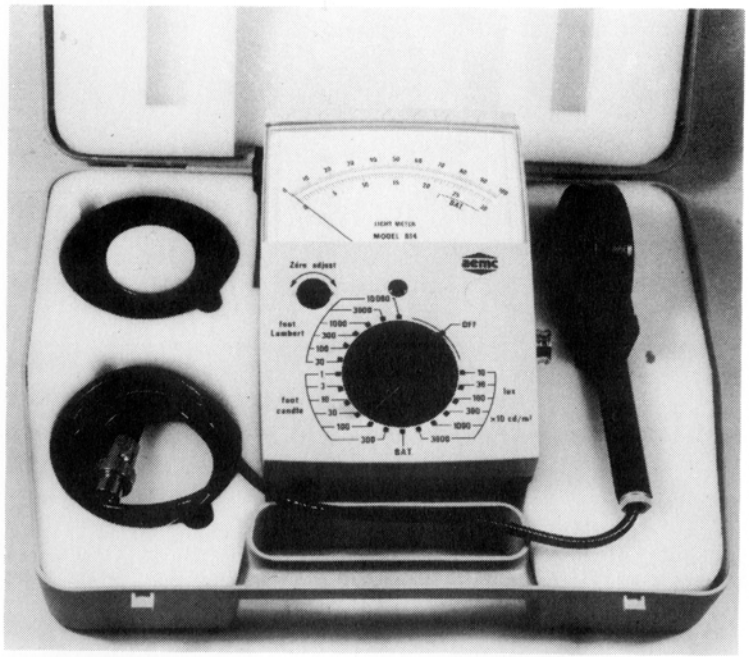
Electronic & Electrical Testing & Measuring Instruments for the Professional

DESCRIPTION

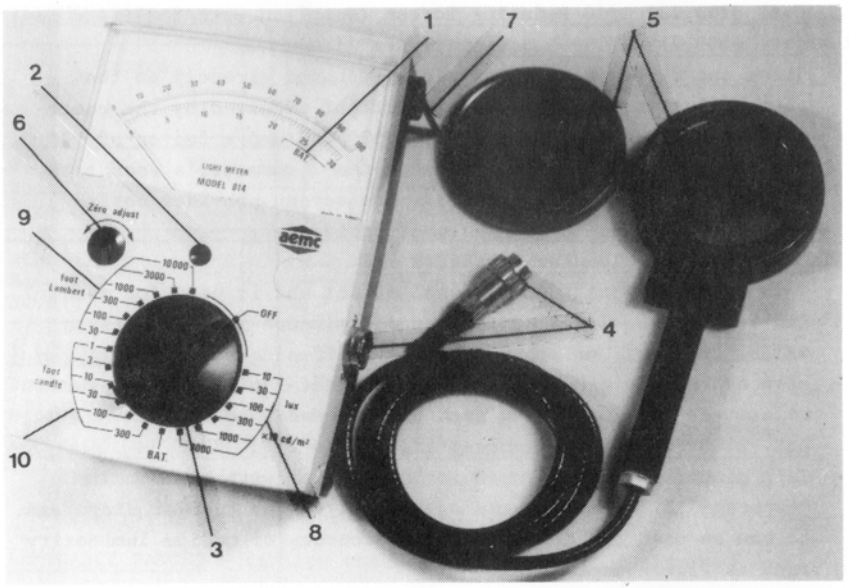
The AEMC LIGHTMETER MODEL 814 is the perfect instrument for conducting lighting surveys. It measures illumination directly and measures luminance when used with the optional Tubular Diaphragm LN1 (Cat. #100.239). This instrument has:

- Two illumination scales: footcandles (ftcd) and lux (metric)
- Two luminance scales: footlamberts (fl) and candelas per square meter (cd/m^2) metric

It is equipped with a detachable barrier-layer selenium photocell which is 2.6" (67 mm) in diameter and has an attachment cord 4½ feet long and a black metal protective cover. The photocell is corrected to the human eye response, as defined by the IEC Commission. The lightmeter is also supplied with a 1/10 reducing screen which assures cosine correction up to an 88° angle of incidence.



CONTROLS AND CONNECTOR IDENTIFICATION

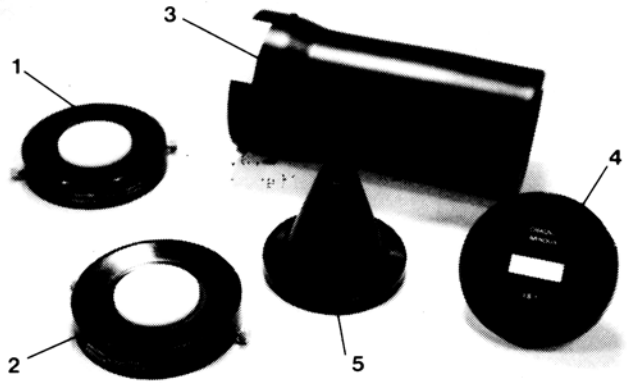


1. Battery check (rotary selector switch must be in "BAT." position)
2. Mechanical zero adjustment screw
3. Rotary selector switch
4. Photocell connector
5. Barrier-layer selenium photocell (removeable protective cover of black metal)
6. Electrical zero adjustment switch
7. Tilt stand
8. Metric ranges: illumination (lux) and luminance (cd/m^2)
9. Luminance range in footlamberts
10. Illumination range in footcandles

ACCESSORIES AND OPTIONAL ACCESSORIES

1. Cat. #100.237 1/10 Reducing Screen (Supplied with the instrument)
2. Cat. #100.238 1/100 Reducing Screen
   These two diffusing screens can be mounted directly on the photocell to reduce the amount of light received by the photocell (by a factor of 10 for Cat. #100.237 and a factor of 100 for Cat. #100.238) and to increase the lightmeter's operating range by a factor of 10 or 100. The screen provides cosine correction for up to 88° angle of incidence.
3. Cat. #100.239 Tubular Diaphragm LN1
   This diaphragm has a directional effect and is used for measuring luminance. It is suitable for luminance measurements on walls, ceilings, or other secondary diffusing sources. It can also be used to make measurements on self-luminous sources of relatively low luminosity such as TV screens or CRTs.
4. Cat. #100.240 Slit Diaphragm LS1
   This diaphragm must be used in conjunction with the Tubular Diaphragm LN1. When placed on the end of the tubular diaphragm, it can be used for measurements on sources of medium luminosity such as fluorescent tubes.
5. Cat. #100.242 Conical Diaphragm LS2
   This diaphragm must be used in conjunction with the Tubular Diaphragm LN1. When fitted onto the end of the tubular diaphragm, it can be used for measurements of sources of high luminosity such as high intensity incandescent lamps.

All three diaphragms can be used in direct contact with the surface being measured or can be used to take measurements at a distance.



SPECIFICATIONS

ILLUMINATION RANGES

Direct Ranges	lux	0-10-30-100-300-1000-3000
	ftcd	0-1-3-10-30-100-300
With 1/10 Reducing Screen	lux	0-100-300-1000-3000-10,000-30,000
	ftcd	0-10-30-100-300-1000-3000
With 1/100 Reducing Screen	lux	0-1000-3000-10,000-30,000-100,000-300,000
	ftcd	0-100-300-1000-3000-10,000-30,000

ILLUMINATION UNITS

footcandles (ftcd) or lux (metric) $1\ \text{lux} = \frac{1\ \text{lumen}}{\text{sq. meter}}$

equivalents: 1 footcandle = 10.764 lux

ACCURACY FOR ILLUMINATION MEASUREMENTS

Direct: 2% of the reading + 1% f.s.d.
With 1/10 reducing screen: add 2%
With 1/100 reducing screen: add 5%

LUMINANCE RANGES - require the use of optional diaphragm(s)

With Tubular Diaphragm	cd/m^2	100-300-1000-3000-10,000-30,000
	fl	30-100-300-1000-3000-10,000
With Tubular Diaphragm and Slit Diaphragm	cd/m^2	100,000-300,000
	fl	30,000-100,000
With Tubular Diaphragm and Conical Diaphragm	cd/m^2	1,000,000 - 3,000,000
	fl	300,000 - 1,000,000

LUMINANCE UNITS

footlamberts (fl) or candela per square meter (cd/m^2) in metric

equivalents: 1 footlambert = 3.425 cd/m^2

ACCURACY FOR LUMINANCE MEASUREMENTS

With Tubular Diaphragm only: $\pm$ 5% f.s.d.
With Tubular Diaphragm and Slit Diaphragm: additional 1%
With Tubular Diaphragm and Conical Diaphragm: additional 2%

SPECIFICATIONS - continued

PHOTOCELL

Barrier-layer selenium photocell 2.6" (67 mm) in diameter corrected to the human eye response as defined by the IEC Commission. With 4½ ft (1.5 m) attachment cord and black metal protective covering.

REDUCING SCREENS

Provide cosine correction up to 88 degree angle of incidence

METER

Sensitive taut-band suspension movement

SCALE LENGTH

4.3 inches (110 mm)

POWER

Five 1.5 V "AA" cells

BATTERY LIFE

200 hours, 6 mA consumption

REFERENCE TEMPERATURE

20 to 25°C (68°to 77°F)

TEMPERATURE RANGE

0 to 50°C (32°to 122°F)

STORAGE TEMPERATURE

-20°C to +70°C (-4°to +158°F)

DIMENSIONS

(instrument only) 7.75" x 5.4" x 2.25" (195 x 140 x 60 mm)

WEIGHT

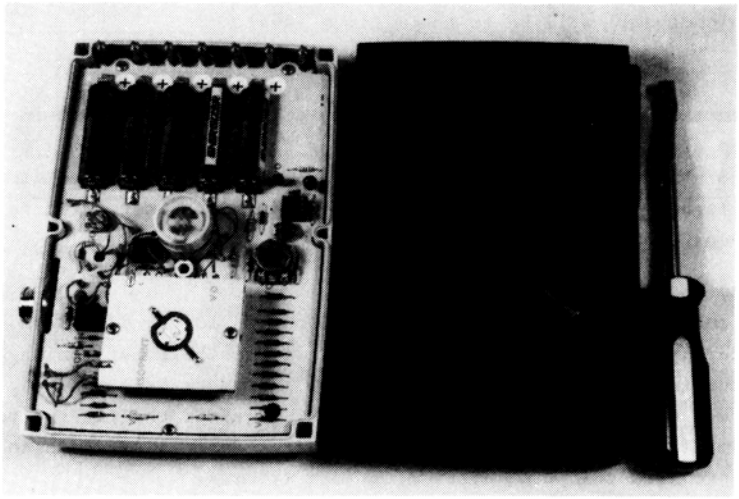
2 lb 4 oz (1 kg) (lightmeter and photocell)

Battery Test

Place the rotary selector switch in the BAT position. (The photocell does not have to be attached.) The pointer of the lightmeter should deflect to the BAT. section on the far right of the scale. If not, the batteries must be changed.

Battery Replacement

Place the rotary selector switch in the OFF position. Access to the battery compartment is from the back of the instrument. Unscrew the brass screw in the center back and remove the rear panel of the lightmeter. Replace the five 1.5 V "AA" cells, respecting polarity.



Mechanical Zero Adjustment

Place the rotary selector switch in the OFF position. The lightmeter must lie completely flat. Check to see if the pointer rests at zero. If not, adjust using the mechanical zero adjustment screw.

OPERATION - continued

Electrical Zero Adjustment

Connect the photocell to the lightmeter. Do not remove the black metal protective cover. Place the rotary selector switch on the 10 lux position. Using the electrical zero adjustment switch, bring the pointer to zero.

Preliminary Verification

Remove the photocell cover and expose the photocell for at least five minutes to a light source five or ten times stronger than the light to be measured. Under these conditions, the time response of the photocell will be at the minimum level.

Note:

When the photocell is exposed to the light from a 60 watt incandescent lamp at a distance of 50 cm (20") or the the light from a 60 watt fluorescent tube at a distance of 30 cm (12"), or exposed directly to daylight on a sunny day, it will receive sufficient light to obtain a measurement of 4000 lux.

Note:

If the photocell has been in total darkness for several days, the accuracy will be affected for a while after the conditioning described above in the preliminary verification procedure is completed. The effect on accuracy will be an error of 4% after the first five seconds of measurement, diminishing to a 1% error after 10 seconds and leveling off to less than 0.5% error after ten minutes.

ILLUMINATION MEASUREMENT

A. Direct measurement without cosine correction
   - -Place the photocell parallel to the source to be measured or directly on the surface if it is not a concentrated source.
   - -Set the rotary selector sitch in such a way that the pointer deflects in the last 2/3 of the scale on the righthand side.
   - -Multiply the meter reading by the coefficient indicated in the chart below.

Lux Range	Scale (Dial)	Coefficient	ftcd Range	Scale (Dial)	Coefficient
10	100	x 0.1	1	100	x 0.01
30	30	direct	3	30	x 0.1
100	100	direct	10	100	x 0.1
300	30	x 10	30	30	direct
1000	100	x 10	100	100	direct
3000	30	x 100	300	30	x 10

B. Measurement with cosine correction using reducing screens 1/10 or 1/100
   - -Place the reducing screen directly onto the photocell. Tighten the two screws to hold the reducing screen securely in position.
   - -Select the desired range using the rotary selector switch.
   - -When using the 1/10 reducing screen, multiply the reading by the coefficient indicated on the chart above and then by 10.
   - -When using the 1/100 reducing screen, multiply the reading by the coefficient indicated in the chart above and then by 100.

LUMINANCE MEASUREMENTS

A. Measurement using Tubular Diaphragm LN1 (Cat. #100.239)

- Place the Tubular Diaphragm LN1 directly onto the photocell. Tighten the two screws to hold the diaphragm securely in position.
- Direct the diaphragm in the direction of the surface which is to be measured. The diaphragm should be far enough away from the subject so that the intercepted surface is of sufficient dimension to entirely cover the surface intercepted at that distance by the solid angle of 0.01 steradian (sr). If not, bring the Tubular Diaphragm away from the suface to be measured. See Figures 1 and 2 page 13.
- Select the desired range using the switch on the Lightmeter.
- Multiply the reading displayed on the lightmeter by the coefficient indicated on the chart on the following page to obtain the measurement in candelas per square meter or in footlamberts.
- This method of measuring luminance from a certain distance is neccessary in order to avoid interference from reflected light. If the surface to be measured is directly emitting light (self-luminous or backlighted) such as a TV screen, the tubular diaphragm should be placed directly on the screen, providing that the entire cross-section (opening) of the diaphragm is covered by the screen.
- If the reading on the lightmeter is above 3000 cd/m^2 or 10,000 footlamberts, or if the emitting source is smaller than the diaphragm, the operator should use the Slit Diaphragm LS1 in conjunction with the Tubular Diaphragm LN1.

Diaphragm	Setting	Range cd/m^2	Scale (Dial)	Coefficient	Setting	Range fl	Scale (Dial)	Coefficient
LN1	10	100	100	direct	30	30	30	direct
	30	300	30	x 10	100	100	100	direct
	100	1000	100	x 10	300	300	30	x 10
	300	3000	30	x 100	1000	1000	100	x 10
	1000	10,000	100	x 100	3000	3000	30	x 100
	3000	30,000	30	x 1000	10,000	10,000	100	x 100
LN1 + LS1	1000	100,000	100	x 100	3000	30,000	30	x 1000
	3000	300,000	30	x 1000	10,000	100,000	100	x 1000
LN1 + LS2	1000	1,000,000	100	x 10,000	3000	300,000	30	x 10,000
	3000	3,000,000	30	x 100,000	10,000	1,000,000	100	x 10,000

LUMINANCE MEASUREMENTS - continued

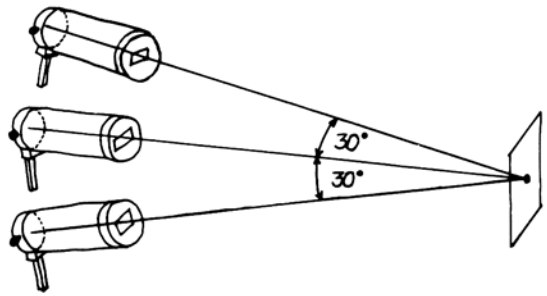
B. Measurements using Slit Diaphragm LS1 (Cat. #100.240)

- Place the Slit Diaphragm LS1 on the end of Tubular Diaphragm LN1.
- Proceed as above for taking measurements. (See Figures 1 and 2.)
- Multiply the reading on the lightmeter by the coefficient indicated on the chart on the previous page to obtain the measurement in candelas per square meter or in foot-lamberts.

C. Measurements using Conical Diaphragm LS2 (Cat. #100.241)

- Place the Conical Diaphragm LS2 on the end of Tubular Diaphragm LN1.
- Proceed as above for taking measurements. (See Figures 1 and 2.)
- Multiply the reading on the lightmeter by the coefficient indicated on the chart on the previous page to obtain the measurement in candelas per square meter or in footlamberts.

A note concerning the use of the Tubular Diaphragm LN1:
When conducting measurements from a distance, the axis of the Tubular Diaphragm can vary up to 30° in either direction from the axis which is perpendicular to the measured source without affecting the accuracy of the luminance measurement. (See example below.)



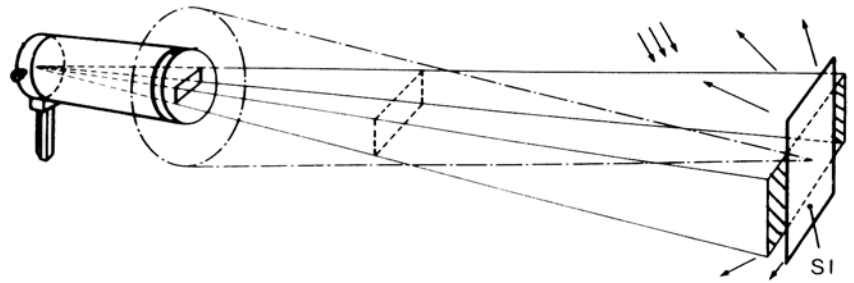


Figure 1
Incorrect use of the Tubular Diaphragm
When measuring luminance of surface S1, the surface intercepted by the solid angle of 0.01 steradians is not totally included by S1.

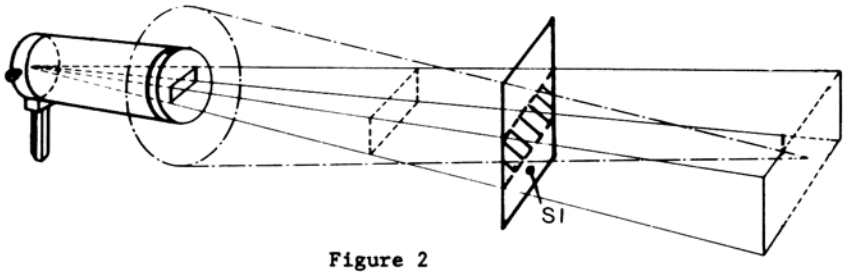


Figure 2
Correct use of the Tubular Diaphragm
When the photocell is held at this distance from S1, the surface intercepted by the solid angle of 0.01 steradians is totally included by S1.

WARNING

- Avoid exposing the photocell to intense infra-red light rays or to levels of high humidity for long periods of time.

COSINE CORRECTION

For a given surface, the real illumination (E2) for light which hits the photocell at an angle is multiplied by the cosine of the angle of incidence ($\cos\alpha$), resulting in a reading which is smaller than the reading would be if the same amount of light were to hit the photocell perpendicularly (E1). See Figure 3.

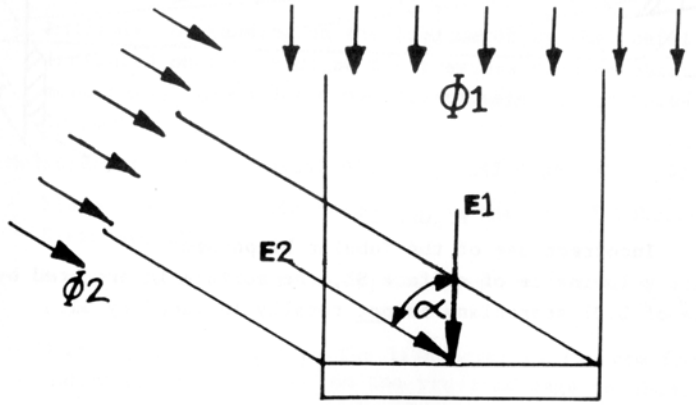


Figure 3

Luminous Flux $\phi 2 = \phi 1(\cos\alpha)$

Illumination E2 = E1($\cos\alpha$)

For a photocell not equipped with a cosine correction reducing screen (Cat.#100.237 or #100.238), the relationship described in the equations above does not hold true. In order for the photocell to sense light which strikes it at an angle (nonperpendicular light), it must be used with the cosine correction screen. This screen is made of a diffusing material and when luminous flux comes in contact with the photocell at an angle, the photocell receives a complimentary flux (ϕs) in addition to the main flux (ϕp). See Figure 4.

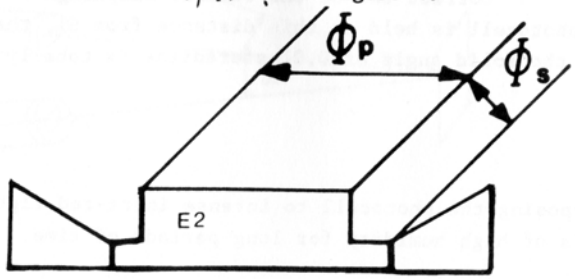


Figure 4

The geometry of the reducing screen has been designed to improve photocell response to non-perpendicular rays of light in a given proportion, as shown in Figure 5.

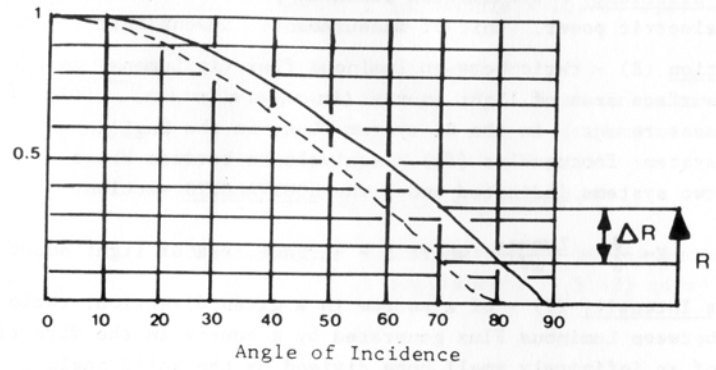


Figure 5

KEY:

---- Photocell without cosine correction

____ Photocell with cosine correction

For angles of incidence greater than 60 degrees, a photocell without a reducing screen results in a relative error greater than 50%.

Measurement is rarely conducted with a large angle of incidence when there is only one source of light. This is not the case when illumination comes from multiple sources, such as a combination of natural and artificial light. If the photocell is used without the reducing screen the effect of the natural light can be largely underestimated.

Luminous Flux ($\emptyset$) - total luminous power emitted from a source in every direction. Unit of measurement: Lumens

Luminous Efficiency - transmitted luminous power per Watt of electric power. Unit of measurement: Lumens/Watt

Illumination (E) - ratio between luminous flux (in Lumens) and surface area of light source (in square meters). Unit of measurement: in the Sl system: Lux; in the English system: footcandles (ft). Equivalents between these two systems indicated under the EQUIVALENTS section.

$$E = \frac{\emptyset}{S} = \frac{\text{Lumens}}{m^2}$$ where S = surface area of light source

Luminance Intensity (I) - of a source in a given direction: ratio between Luminous Flux generated by a source in the direction of an infinitely small cone divided by the solid angle of that cone. The Luminance Intensity corresponds to the visual perception of the brightness of a source. This concept is not limited to emitting sources. It also applies to light reflected by secondary sources. Unit of measurement: in the SI system: candela/m^2; in the English system: footlamberts.

$$I = \frac{\emptyset}{\Omega} = \frac{\emptyset\ (R^2)}{S}$$ where the solid angle (Ω) is expressed in steradians (sr).

One steradian is the solid angle which intersects a sphere making a square with sides which are equal in length to the radius of the sphere.

$$\Omega = \frac{S}{R^2}$$

where:

S=surface of the sphere

R=radius of the sphere

Ω=solid angle

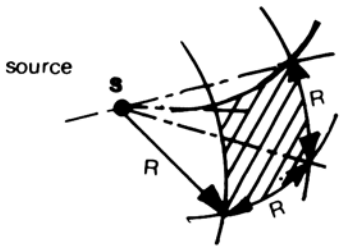


Figure 6

EQUIVALENTS

Illumination Units: U.S. System - 1 footcandle (ftcd)
International System (SI) - 1 lux = $\frac{1 \text{ lumen}}{\text{sq. meter}}$

Equivalents: 1 footcandle = 10.764 lux

Luminance Units: U.S. System - 1 footlambert (fl)
International System (SI) - 1 candela/sq.meter (cd/m^2)

Multiples: 10,000 cd/m^2 = 1 stilb

apostilb = $\frac{1}{\pi}$ (cd/m^2)

Equivalents: 1 footlambert = 10.764 apostilbs
1 footlambert = 3.425 cd/m^2