

PURPOSE OF ARTIFICIAL LIGHTING

General information

The lighting system affects people's vision, activity, safety and well-being, so it is essential that it fulfils the specific needs of users.

Work spaces

In places used for work activities, the lighting must allow objects to be easily identified and help perform the activity by limiting the onset of fatigue and making dangerous situations clearly recognisable.

Sales and display areas

In sales and display areas, lighting must help to examine the merchandise and highlight the objects on display, focusing on the colour rendering and taking into account the negative effects caused by light beams on the preservation of objects and the well-being of people

Premises for use by schools

The lighting in premises for use by schools should encourage attention and concentration, allow for easy recognition of teaching material and facilitate visual activities related to teaching.

Residential homes

Domestic lighting must ensure the best conditions for carrying out normal domestic activities; for special visual tasks, the requirements in the specific points of this standard apply.

Transit areas

In entrances, lobbies, staircases and transit areas, the lighting must allow the route and any danger points to be clearly identified.

Outdoor work places

For outdoor work places, the same requirements applied to indoor environments for the same visual tasks must be met during the hours of darkness.

Premises for recreational activities

For recreational activities, lighting must guarantee clear recognition of danger points and create a comfortable ambience.

PRESCRIPTION FOR ARTIFICIAL LIGHTING

General prescription

General lighting

An indoor environment must have general lighting aimed at creating the same, uniform visual conditions in the different areas of the room.

General lighting directed on work place

If the visual requirements are significantly different from one area of the room to another, it may be advisable to adapt the lighting to the specific requirements of each area. For rooms with fixed work places, a stable proportion of light fixtures installed and work places is recommended. If work places are moved, then the pre-existing conditions must be reassessed.

Localised lighting on single work place

Localised lighting on a single work place is only permitted if coordinated with the general lighting in the room. Additional lighting for a single work place may be necessary to meet specific requirements, i.e.:

- for activities in which challenging visual tasks are involved and for which the work is essentially carried out in restricted, clearly designated areas in the room;
- for visual tasks which require the identification of contrasts, outlines, shapes and structures. In this case, the light must come from pre-established, fixed or variable directions, must have specific chromatic characteristics or be able to create specific levels of luminance;
- in work places where the general lighting is insufficient;
- when a specific type of work is carried out on highly reflective surfaces.

Lighting requirements

An artificial lighting system must take the following parameters into account, in compliance with energy savings:

- lighting level and uniformity;
- luminance distribution;
- glare limitation;
- directionality of light;
- rendering colour and colour rendering;

In coordinating the general lighting with that of the individual work place, the working illumination refers to the work place.

The working illumination indicated refers to:

- the average ageing condition of the lighting system;
- the case of the equipped room or area thereof;
- the horizontal work surface in general at a height of 0.85 m from the floor, if not otherwise specified. For other work surface positions, the working illumination must refer to those specific positions (e.g. Vertical for assembling electrical control panels, for using blackboards, etc.);
- for transit areas in factories, their central areas, at a height of 0.2 m from the floor.

The coordination between a specific working illumination value and the visual task refers to a person with normal eyesight. A defect that cannot be corrected with optical instruments can be fully or partially compensated for with a high level of illumination.

For design purposes, the initial (project) illuminance levels must be obtained by multiplying the working illuminance level by the depreciation factor in order to take the ageing and soiling of the materials into account.

Lighting design elements

LUMINOUS FLUX (Fig. 1)

This is the amount of luminous energy emitted in the space by a source in a period of time. The luminous flux is identified by the symbol Φ , and is measured in lumens (lm). A lumen is equal to the luminous flux emitted within a unit solid angle from a point source placed at the centre of a sphere with a luminous intensity of 1 candela in all directions.

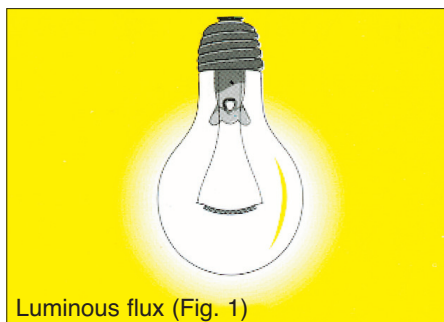
In the International System (I.S.), the unit of measure for the solid angle is the steradian (sr), from which the following relation:

$$1 \text{ lm} = 1 \text{ cd} \times \text{sr}.$$

Essendo il flusso luminoso una quantità di luce emessa per unità di tempo da una sorgente, dal punto di vista dimensionale, esso deve essere considerato una potenza perchè il rapporto tra una energia e un'unità di tempo.

Un'interessante estensione del concetto di flusso luminoso come potenza è il concetto di efficienza luminosa.

L'efficienza luminosa è il rapporto tra il flusso emesso dalla sorgente e la potenza impiegata per ottenere tale flusso, attraverso questa cifra è possibile valutare il risparmio di energia che una lampada può dare in confronto ad un'altra.



Luminous flux (Fig. 1)

LAMP TYPE	FLUX W	POWER lm	EFFICIENCY lm/W
INC clear	100	1380	14
ALO	300	5000	17
MBF	125	6300	50
FL comp.	24	1800	75
FL tubular	36	3350	93
JM	2000	180000	90
SAP-T	400	48000	120
SBP	90	13500	150

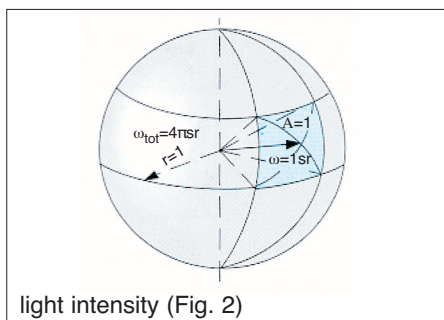
INTENSITÀ LUMINOSA (Fig.2)

Luminous intensity is the amount of light (I) emitted by a point source which propagates in a given direction.

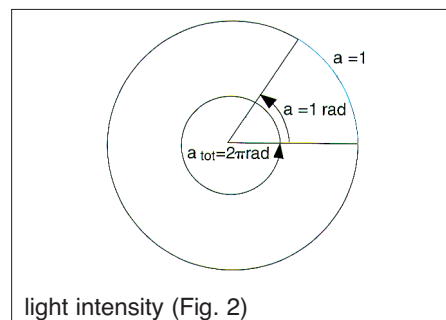
This intensity is defined as the flux ratio Φ emitted in any specified direction in a unit solid angle cone Φ ; which gives $I = d\Phi / d\Omega$. The unit of measurement is the candela (cd) which is considered the fundamental quantity of visible light in the I.S.

The 16th General Conference for Weights and Measurements in 1979 established that the intensity of 1 cd is equal to the intensity of a source that emits - in a solid angle of 1 sr - the frequency and power monochromatic radiation $\Phi = 1/683 \text{ W}$.

A standard international vision, defined by CIE (International Commission on Illumination), is used to determine the maximum relative visibility value for radiations at a 555 nm wavelength. This value corresponds to that of the source under consideration, which therefore has 1 lm.



light intensity (Fig. 2)



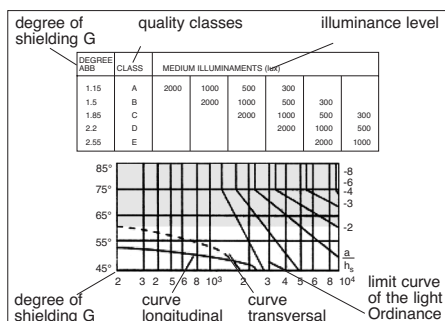
light intensity (Fig. 2)

LUMINANCE CHART (Fig.3)

This chart is used to determine the direct glare produced by each fixture.

Luminance values for the two curves, transversal (solid line) and longitudinal (dotted line) are plotted in relation to an observer looking towards the fixture from an angle of between 45° to 85°.

Limit curves define the area in which the luminance of the fixture cannot be considered as glare. Each curve refers to an average illuminance value on the working plane, and is divided into five CIE quality classes: if the luminance curve is on the left side of the limit curves, glare is considered as acceptable. The table shows the overview on glare limitations, indicating when and where to use a fixture with one quality classification (UNI 10380) as opposed to another.



abacus of luminances (Fig.3)

Class of quality	type of visual task or activity
A	very difficult visual task
B	visual task that requires high visual performance
C	visual task that requires normal visual performance
D	visual task that requires modest visual performance
E	or interiors where people are not located in a precise working position but move from one place to another with tasks that require modest visual performance

Lighting design elements

LUMINANCE (Fig. 4)

If the light source is greater than a point, its size becomes relevant and the above definition of luminous intensity can no longer be applied.

We must, therefore, introduce a new concept which determines the amount of light energy that is emitted by these surfaces, whether by light sources or by reflected light.

This photometric size is, therefore, the luminance (L), which is defined as the ratio between the source luminous intensity in the direction of an observer and the emitting surface as seen by the same observer (or apparent surface).

The unit of measurement is cd/m²; the fundamental relation is given by:

$$L = \frac{dI_{\alpha}}{dA \times \cos \alpha}$$

where I is the candela intensity at the angle α ;

A is the source area, $\cos \alpha$ is the cosine of the angle formed by the observer's eye and the normal to the source.

ILLUMINANCE (Fig.5)

The concept of illuminance is critical in illumination design. This value is useful to determine the amount of light that is emitted by a source and is present on a surface.

The illuminance (E) is the amount of the luminous flux incident on a surface:

$$E = \frac{d\Phi}{dA} \quad \text{lux} = \frac{\text{Lm}}{\text{m}^2}$$

$E = \text{lux} =$ where $d\Phi$ is the luminous flux incident on the surface, dA is the surface area struck by the flux. The unit of measurement of the illuminance is lux (lx) which is dimensionally expressed as lm/m².

POINT-TO-POINT METHOD (Fig.6)

The method used to calculate the illuminances on the horizontal surface in a specific point is commonly called "point-to-point" method. Its formula is:

$$E_p = \frac{I_p \times Klm \times \cos^3 \alpha}{h^2} \quad \text{dove:}$$

E_p = illuminance in lux in a point

I_p = intensity in candelas, referred to 100 lumens, in the relevant point

Klm = the luminous intensity of the lamp
 $\cos^3 \alpha$ = $\cos^3$ of the angle between vertical axis of the fixture and relevant point

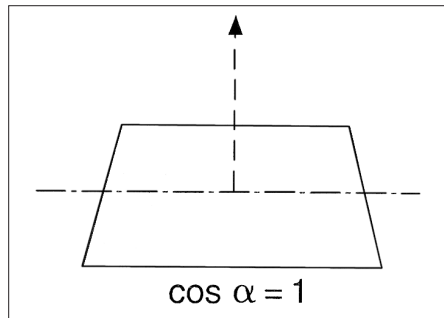
h^2 = the distance between the light source and the surface for the illuminance calculation

LUMINOUS EFFICIENCY (Fig.7)

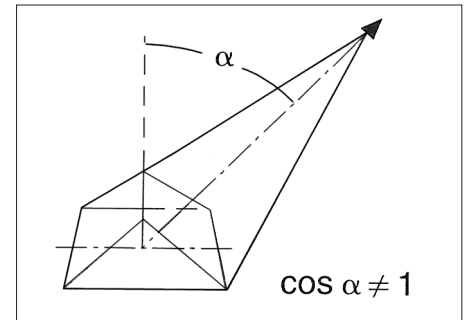
Luminous efficiency indicates the ratio of the total luminous flux emitted by the lamps to the flux effectively used by the fixture

$$n = \frac{\Phi_{\text{tot}}}{\Phi_u}$$

Since luminous efficiency is a ratio between two uniform quantities, it is dimensionless and is generally expressed as a percentage value.



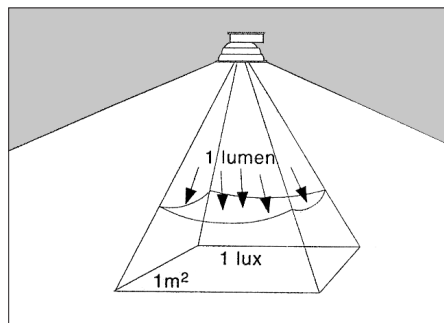
Luminance (Fig. 4-1)



Luminance (Fig. 4-2)

INDICATIVE LUMINANCE VALUES

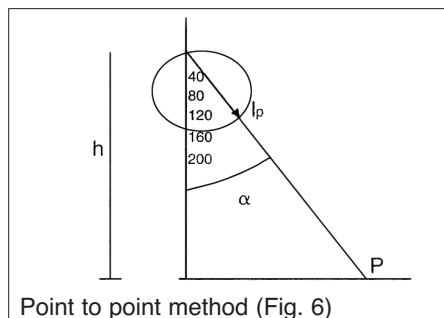
SOURCE	LUMINANCE cd/m ²		
Sun at noon	16x10 ⁹	Stearic candle	5000
Sun at sunset	6x10 ⁶	INC 60W clear bulb	5x10 ⁶
Clear sky	8000	INC 60W opal bulb	5x10 ⁴
Cloudy sky	2000	FL 18W	4000
Lawn land	800	JM 70W	1,5x10 ⁷
Snow cover	3,2x10 ⁴		



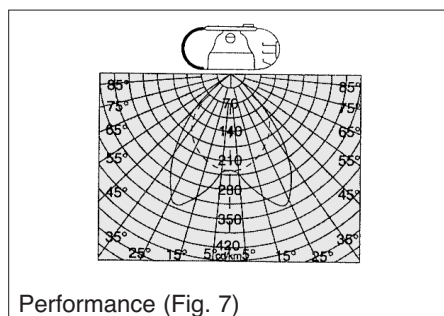
illuminance (Fig. 5)

LIGHTING LEVELS ON A SURFACE

ENVIRONMENT	ILLUMINANCE lx
Full sun, clear sky	100.000
Cloudy sky	10.000
Full moon	0.2
Starry sky with no moon	10-4
Average street lighting	5-30
Minimum required for pedestrians to avoid obstacles	0.2-1
Home environment well lit.	100-200
Commercial exercises	200-3000
Offices and schools	300-2000



Point to point method (Fig. 6)



Performance (Fig. 7)

Lighting design elements

Light emitted from a light fixture can be represented by a graphic system called "distribution curves". These are the union of points joining the various luminous intensities emitted by a light source in every direction in space and making up the "photometric solid".

"Distribution curves" are obtained by intersecting this solid with a number of planes.

When these planes are described through polar coordinates whose centre correspond to the centre of the fixture, "polar

distribution curves" are obtained. These planes can also be made to rotate around an axis so as to explore the photometric solid from all angles.

According to the axis used for rotation, there are different systems of planes determined by CIE standards. An alternative method of representing distribution curves is to substitute the polar description with a description using the Cartesian coordinates.

With this system, narrow beam curves are more readable

and this system is generally used in representing the luminous intensity of floodlights.

In this diagram, the values of the angles are positioned along the x-coordinate, with zero in the middle of the graph, while the values of intensity are positioned along the y-axis. The two planes normally represented are the transversal and longitudinal ones, which in the CIE system correspond respectively to the C0-C180 (continuous line) plane and the C90-C270 (dotted line) plane.

"PHOTOMETRIC CURVES" ceiling lamp (Fig.8)

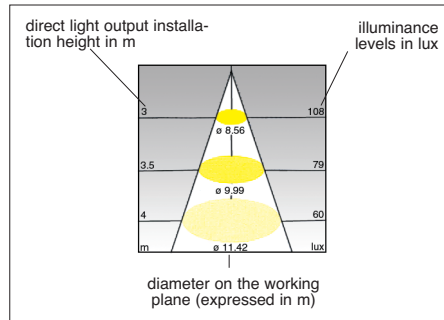
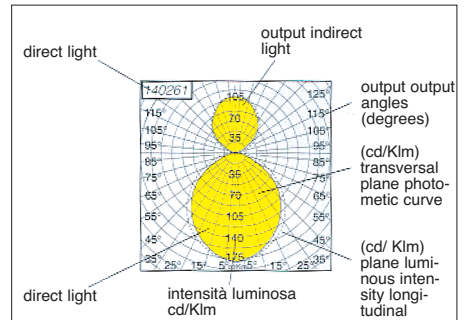
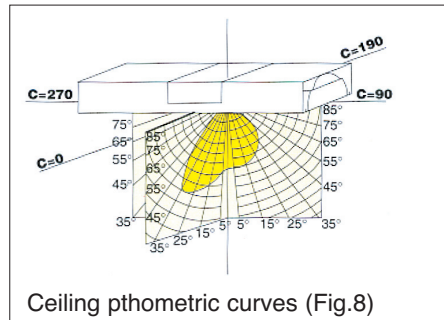
All measurements of the luminous intensity emitted by a fixture in any direction produce the "photometric solid".

Normally, information on the photometric solid is only given with reference to two vertical orthogonal planes crossing the optical centre of the fixture.

The values of the luminous intensity (referred to 1000 lm) that are plotted on a plane are called "distribution curves".

For indoor and street lighting fixtures, these distribution curves are represented with polar coordinates.

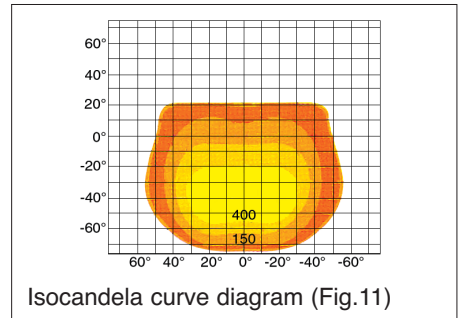
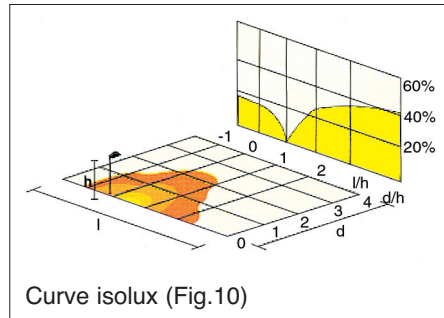
Photometric data for indoor fixtures according to the applicable UTE and DIN 5040 classification is available on request.



ISOLUX CURVE DIAGRAM (Fig.10)

This represents the point on a surface at which illuminance is the same.

The lighting fixture is assumed to be mounted at a height of 1 m for a 1 klm reference lamp. The coordinates d/h and l/h express the relationship between the road width (l), the distance between two poles (d) and the height of the poles (h).



ISOCANDELA CURVE DIAGRAM (Fig.11)

The projection on a plane of candela intensities of a given photometric solid with the same value create the isocandela curve diagram.

The curves are, therefore, the connection points of a plane which have the same candela rating.

ILLUMINANCE CURVE DIAGRAM (Fig.12)

The illuminance curve diagram is studied to facilitate the choice of the fixture for street furniture, i.e. to illuminate underpasses, open areas: gardens and especially roads.

Illuminance values in lux are shown on the Y axis while the distance from the light source is shown on the X axis.

Unlike other diagrams, which are presented with relative reference values (i.e. normalised installation height and luminous flux values), this diagram shows absolute values, i.e. the height of the fixture is the real installation height and the flux is the one that is actually emitted by the lamp. In this way, data shown are ready to be used.

