When the appropriate table has been drawn up, the room index k can be determined from the room geometry. The utilance can then be read off the table from the column showing the corresponding room index and line showing the appropriate combination of reflectance factors or, for greater accuracy, calculated through interpolation. The average horizontal illuminance is the result of the total luminous flux produced by all the lamps installed per room surface in the space, corrected by the light output ratio (which is provided by the lighting manufacturer), by the calculated utilance and light loss factor V, which takes into account the ageing of the lighting installation and is usually taken to be 0.8. Should a lighting installation consist of several types of luminaire of varying classification, e.g. wide-beam lighting provided by louvred luminaires and a narrow-beam component provided by downlights for incandescent lamps, then the illuminance has to be calculated separately for each component and then added.

There are computer software programs available for calculating the utilisation factor. They not only calculate the illuminance, but also locate the appropriate tables and and can handle the complex interpolation between the individual tables or values contained in the tables, if required.

3.3.6.2 Planning based on specific connected load

Another method of providing the rough dimensioning of a lighting installation derived from the utilisation factor method is based on the specific connected load available. This method allows the calculation of the required connected load for an average illuminance provided by a given luminaire and light source, or vice versa, the average illuminance that can be obtained given a specific connected load and a light source.

Planning a lighting installation based on a specified connected load relies on the fact that every type light source has a specific luminous efficacy practically irrespective of the power consumption. When using the utilisation factor method it is possible to substitute the overall luminous flux by the connected load corrected by the respective luminous efficacy. Taking this as a basis it is possible to calculate the connected load per m² which is required for a given combination of luminaire and light source to obtain an average illuminance of 100 lx in a space with standardised room geometry and reflectance factors. Values obtained in this way only apply with accuracy to the particular standard room. A correction factor must be included in the calculations to take account of conditions that deviate from the standard.

$$n = \frac{1}{f} \cdot \frac{P^* \cdot E_N \cdot a \cdot b}{100 \cdot P_L}$$

$$E_N = f \cdot \frac{100 \cdot n \cdot P_L}{P^* \cdot a \cdot b}$$

Lighting calculations based on a specific connected load of lamps (P^*). Formulae for calculating the nominal illuminance E_N for a given number of luminaires, or the number of luminaires required n for a given illuminance.

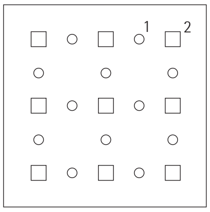
E_N (lx)	Nominal illuminance
n	Number of luminaires
P_L (W)	Connected power for one luminaire incl. control gear
P^* (W/m² · 100 lx)	Specific connected load
f	Correction factor
a (m)	Length of room
b (m)	Width of room

Lamp	P^* (W/m² · 100 lx)
A	12
QT	10
T	3
TC	4
HME	5
HIT	4

Standard values for specific connected load P^* for different lamp types in direct luminaires.

f					
		ρ_C	0.70	0.50	0.00
		ρ_W	0.50	0.20	0.00
		ρ_F	0.20	0.10	0.00
A (m²)	h (m)				
20	≤ 3		0.75	0.65	0.60
50			0.90	0.80	0.75
≥ 100			1.00	0.90	0.85
20	3–5		0.55	0.45	0.40
50			0.75	0.65	0.60
≥ 100			0.90	0.80	0.75
50	≥ 5		0.55	0.45	0.40
≥ 100			0.75	0.60	0.60

Correction factor f takes into account the effect of the room geometry and the reflectance factors on the illuminance or number of luminaires. The appropriate value is calculated from the basic area A, the room height h and the reflectance factor of the ceiling (ρ_C), walls (ρ_W) and floor (ρ_F).



Room data

Length a = 10 m
Width b = 10 m
Height h = 3 m
ρ = 0.5/0.2/0.1
f = 0.9

Example of a rough calculation of the illuminance for a room with a combination of two different luminaire types.

Luminaire type 1 (A)

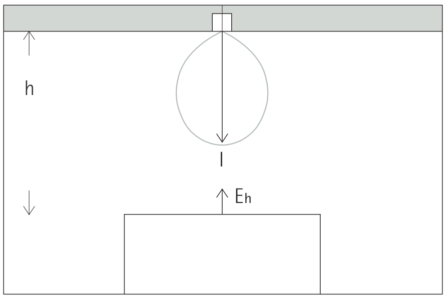
n = 12
P_L = 100 W
$P^* = 12 \cdot \frac{W}{m^2 \cdot 100\ lx}$

Luminaire type 2 (TC)

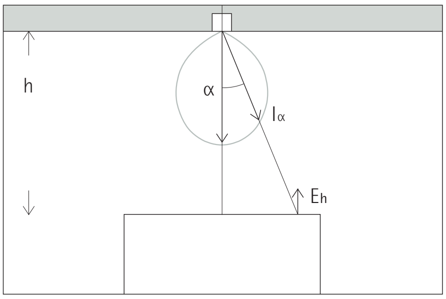
n = 9
P_L = 46 W
(2 · 18 W + ballast)
$P^* = 4 \cdot \frac{W}{m^2 \cdot 100\ lx}$

E_{N1} = 90 lx
E_{N2} = 93.2 lx
E_{com} = 183.2 lx

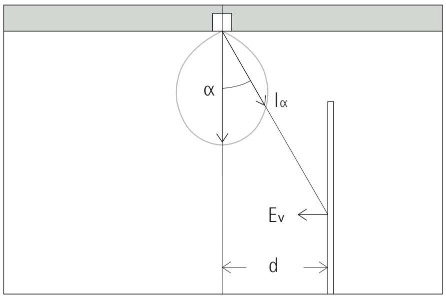
Calculating illuminance at specific points. The relation between illuminance E at a specific point and the luminous intensity I of one luminaire (from the top downwards): horizontal illuminance E_h directly below a luminaire. Horizontal illuminance E_h at an angle α to the luminaire. Vertical illuminance E_v at an angle α to the luminaire.



$$E_h = \frac{I}{h^2}$$



$$E_h = \frac{I_\alpha}{h^2} \cdot \cos^3 \alpha$$



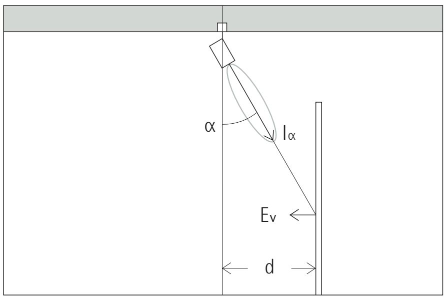
$$E_v = \frac{I_\alpha}{d^2} \cdot \cos^3 (90 - \alpha)$$

$[E] = lx$

$[I] = cd$

$[h] = m$

$[d] = m$



Formula for the rough calculation of the indirect illuminance components (E_{ind}). Using the overall luminous flux produced by all the luminaires installed in the space Φ_{Le}, the average reflectance ρ_M and the sum A_{com} of all room surfaces.

$$E_{ind} = \frac{\Phi_{Le}}{A_{ges}} \cdot \frac{\rho_M}{1-\rho_M}$$

A by-product of this method of calculation is that for each lamp type a typical value can be defined for the specific connected load. This means, for example, that a luminous flux of around 20000 lm can be obtained from conventional incandescent lamps with a connected load of 1500 W, without strict regard for whether ten 150 W lamps, fifteen 100 W lamps or twenty 75 W lamps are used. The connected power required for specific lamp types can be used for rough planning and, above all, to enable a quick comparison to be made of different light sources.

3.3.6.3 Point illuminance

In contrast to the utilisation factor method, which only allows average illuminances for an entire space to be calculated, using the inverse square law illuminance levels can be calculated for specific points in the space. The results in this case are very exact, errors only arise if light sources are incorrectly presumed to be point sources. Indirect components are not included in the calculation, but can be included through an additional calculation. The calculation of illuminance at specific points can be carried out for the lighting provided by one single luminaire or for situations where the contribution of several luminaires is to be taken into account.

The manual calculation of point illuminance at specific points can be applied for the lighting design of confined spaces illuminated by individual luminaires; calculations for numerous points within the space and a large number of luminaires take too much effort and are not justified. Computer software is generally used for calculating the illuminances for an entire space.

The basic function provided by these programs is the calculation of illuminances for all room surfaces, working planes or clearly defined zones, in which indirect lighting components are included in these calculations. Using this basic data it is possible to derive further values, such as the luminance of the illuminated areas, shadow formation or contrast rendition factors at specific points in the rooms.

Programs of this kind usually offer a variety of possibilities for the graphic presentation of the results, ranging from isolux diagrams and isoluminance diagrams for individual room surfaces or zones to three-dimensional renderings.