OFFICE LIGHTING DESIGN: THE LUMEN METHOD

The lumen method, or zonal cavity method, is an initial calculation for office lighting design, to determine the number of fixtures required (**N**). In its simplest form the method equates to the total required lux level (**E**) multiplied by the area of the space (**A**), divided by the lumens provided by an individual fixture (**F**).

$$N = \frac{E \times A}{F \times UF \times MF}$$

However, the utilisation factor (**UF**) and maintenance factor (**MF**) must also be considered.

ELEMENTS OF EQUATION

E - Total required lux (lx) level: Determine the required illumination in lux to the relevant Australian Standard. For office lighting, AS/NZS 1680.2.2 (2008) Table E1 provides recommended lux levels. A typical recommendation for an office space is 320 lx.

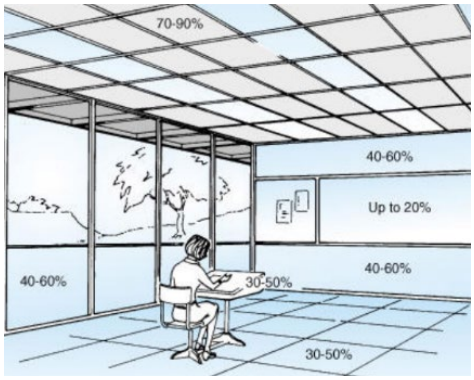
F - Lumens (lm) of individual fixture: Obtain this figure from manufacturer's data. A traditional office light troffer (T8) provides 3000 to 3500 lm at 72 watts (2 x 36 watts). A typical LED panel luminaire provides 2500 to 4000 lm. The LED panel typically has reduced wattage and is typically therefore more energy efficient.

UF - Utilisation factor: The UF indicates the proportion of luminous flux reaching the working plane (typically desk height for an office) / floor cavity. Lighting manufacturers typically provide a table (example provided overleaf), derived from laboratory tests, which is used to determine the UF. To use the table the room index (**K**) and the reflectance (%) for ceiling, wall and working plane / floor cavity must first be determined.

K - Room index: The room length (**L**), room width (**W**) and height from working plane to ceiling, or light source, ($\mathbf{H_m}$) is required to calculate K. H_m is typically 2 m for an office.

$$K = \frac{L \times W}{H_m \times (L + W)}$$

Reflectance (%): Determined to BS 8493, for ceiling, wall and working plane / floor cavity. Manufacturers may also provide values for use. The image below provides typical ranges. Typical values for an office space may be 0.70, 0.50, 0.30 respectively. The working plane / floor cavity reflectance is calculated based on direct downward-light-spreading ceiling-based luminaires, with light reflecting from both the desk surface and the floor. Together they create a total horizontal plane of reflectance referred to as the working plane or the floor cavity.



Source: IESNA Lighting Handbook (9th Ed.)

MF - Maintenance factor: Determined using AS/NZS 1680.4. This allows for depreciation of light over time due to soiling and use. MF for an office space would usually be in the range of 0.7-0.9. A calculation to determine MF is shown overleaf.

WORKED EXAMPLE

Question: *How many (N) light fixtures required for a 16.5 m x 10.0 m office space?*

E = 320 **L** = 16.5 **W** = 10 $\mathbf{H_m}$ = 2 **A** = 165 **F** = 3000 **MF** = 0.67

Therefore: K = (16.5 x 10) / (2 x (16.5 + 10)) = 3.11

Using table overleaf, assuming reflectance of 0.70, 0.50, 0.30: **UF** = 0.71

Therefore: N = (320 x 165) / (3000 x 0.71 x 0.67) = 37.00

Total number of light fixtures required = 37

THE LUMEN METHOD ASSUMPTIONS

- Uniform luminaire layout.
- Space is rectangular. Divide non-rectangular spaces into two or more rectangles and calculate individually.
- Ratio of length to width:
  - Minimum: 1.6:1
  - Maximum: 4:1
- The cavity of space to be lit is largely empty of walls and barriers.
- Uniform reflectance and distribution of luminous flux.

LED panel lights feature a flat panel giving even illumination across their surface. They typically have greater energy efficiency compared to fluorescent tube lighting (such as T8) within grid ceilings.

DEFINITION OF LUMEN VERSUS LUX

- Luminous flux is the light emitted by a source of light, having the unit of lumens (lm).
- Lux (lx) is the measure of how much light shines on a surface.
- A high lux value equates to a brightly lit surface.
- Lumens = Lux x Area.

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OTHER FACTORS TO CONSIDER WITH OFFICE LIGHTING DESIGN

- **CCT** - Correlated colour temperature: Neutral to cool temperature luminaires, with a CCT range of 3000-4000K (Kelvin) are typical for office spaces.
- **Vertical illumination**: Typically used for visual effect or to light specific features such as a notice board or sign.
- **Dimmable lighting**: Not typically a requirement of office spaces, however with many luminaires being non-dimmable, determine requirements prior to tender.
- **Glare:** Strong or dazzling light. The positioning of luminaires must be considered so that reflected dazzling light from shiny and smooth surfaces is not created.
- **Luminance contrast**: The amount of light reflected from one surface compared to another surface. A design consideration with respect to items such as signage, doorways and nosing strips. Illuminating vertical surfaces can also provide higher background luminance, reducing the contrast of items such as computer screens.

FURTHER DETAILS – EXPANDED CALCULATIONS

Determining the Utilisation Factor (UF)

With the room index (**K**) and reflectance values determined, tables as per the example below can be used to determine the utilisation factor (**UF**) required for the calculation.

Room Index k	Reflectances (%) for ceiling, walls and working plane (CIE)															
	0.80	0.80	0.70	0.70	0.70	0.70	0.50	0.50	0.30	0.30	0.00
	0.50	0.50	0.50	0.50	0.50	0.30	0.30	0.10	0.30	0.10	0.00
	0.30	0.10	0.30	0.20	0.10	0.10	0.10	0.10	0.10	0.10	0.00
0.60	0.37	0.35	0.36	0.36	0.35	0.30	0.30	0.27	0.30	0.27	0.26
0.80	0.44	0.42	0.44	0.43	0.41	0.37	0.37	0.34	0.36	0.33	0.32
1.00	0.51	0.47	0.50	0.48	0.46	0.42	0.42	0.39	0.41	0.39	0.37
1.25	0.56	0.52	0.55	0.53	0.51	0.47	0.47	0.44	0.46	0.43	0.42
1.50	0.60	0.55	0.59	0.57	0.54	0.51	0.50	0.47	0.49	0.47	0.46
2.00	0.67	0.59	0.65	0.62	0.59	0.56	0.55	0.53	0.54	0.52	0.51
2.50	0.71	0.62	0.69	0.65	0.62	0.59	0.58	0.56	0.57	0.56	0.54
3.00	0.73	0.64	0.71	0.67	0.64	0.61	0.60	0.59	0.60	0.58	0.57
4.00	0.77	0.66	0.74	0.70	0.66	0.64	0.63	0.62	0.62	0.61	0.59
5.00	0.79	0.68	0.76	0.71	0.67	0.66	0.64	0.63	0.63	0.62	0.61

Calculating the Maintenance Factor (MF)

The maintenance factor (MF) is calculated using the following formula:

$$MF = LMF \times LLMF \times LSF \times RSMF$$

The data required for the above formula is provided directly from the lighting manufacturer or can be determined using AS/NZS 1680.4, as follows:

- **LMF** - Luminaire maintenance factor: Sourced from AS/NZS 1680.4 (2017) Table B1. The IP rating of the luminaire is used to determine LMF. IP stands for Ingress Protection and is a way of rating how well a device is protected from materials and liquids such as dust and water. For example: IP65 is dust-tight and protected from water projected from a nozzle and IP20 is protected from object finger size or larger and has no protection from water. The IP rating for the luminaire is provided by the lighting manufacturer. An office light troffer would typically be IP20 to IP40. The LMF for an IP20 luminaire in a normal environment where the fitting is cleaned every 3 years would be 0.73. Noting that it is more likely that luminaires would be replaced rather than cleaned in an office environment (see note below). Cleaning more likely to occur in a hospital environment.
- **LLMF** - Lamp lumen maintenance factor: This is the reduction of luminous flux due to the lamp aging. Again, this data would be available from the manufacturer for their product but using AS/NZS 1680.4 (2017) Table B2 for an LED luminaire having operated for 10000 hours, the LLMF would be 0.97.
- **LSF** - Lamp survival factor: This relates the anticipated number of lamps in a system that will continue to operate after a certain period of time. Again, this can be obtained from the manufacturer, but for an LED luminaire, using AS/NZS 1680.4 (2017) Table B2, this would typically be 1.0.
- **RSMF** - Room service maintenance factor: Determined from AS/NZS 1680.4 (2017) Table B3 using the calculated room index. For a room index of 3.11, assuming a direct luminance flux distribution in a normal environment where the fitting is cleaned every 3 years, the RSMF would be 0.95. As above, it is more likely that luminaires would be replaced rather than cleaned in an office environment, but AS/NZS 1680.4 does not provide for cleaning periods longer than 3 years.

So, for the calculation overleaf, **MF** = 0.73 x 0.97 x 1.0 x 0.95. Therefore **MF** = 0.67

RELEVANT STANDARDS

The AS/NZS 1680 *Interior and workplace lighting* series. Particularly:

- Part 1: *General principles and recommendations*.
- Part 2.2: *Specific applications - Office and screen-based tasks*.
- Part 4: *Maintenance of electrical lighting systems*.

BS 8493: *Light reflectance value (LRV) of a surface. Method of test.*