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SMART CITIES

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LIGHTING SYSTEMS - CEM REFRESHER

ONLINE TRAINING COURSE

KRISHNAJI PAWAR, LEED AP BD+C, GSAS CGP, ISO 14001:2015, GCP

ENERGY SPECIALIST CURRICULUM

LIGHTING SIMULATION SPECIALIST

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PROCEDURE FOR ASSESSMENT OF

LIGHTING SYSTEMS

FOR ENERGY PROFESSIONALS

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WHAT SHOULD YOU LEARN

Procedure for Assessment of
Lighting Systems

PROCEDURE FOR ASSESSMENT OF LIGHTING SYSTEMS

To Determine the Minimum Number and Positions of Measurement Points

Calculate the Room Index:

$$RI = L \times W / Hm(L + W)$$

Where L = length of interior; W = width of interior; Hm = the mounting height, which is the height of the lighting fittings above the horizontal working plane. The working plane is usually assumed to be 0.75m above the floor in offices and at 0.85m above floor level in manufacturing areas.

PROCEDURE FOR ASSESSMENT OF LIGHTING SYSTEMS +

It does not matter whether these dimensions are in metres, yards or feet as long as the same unit is used throughout. Ascertain the minimum number of measurement points from Table 13.1.

TABLE 13.1 DETERMINATION OF MEASUREMENT POINTS

Room Index	Minimum number of measurement points
Below 1	9
1 and below 2	16
2 and below 3	25
3 and above	36

To obtain an approximately "square array", i.e. the spacing between the points on each axis to be approximately the same, it may be necessary to increase the number of points.

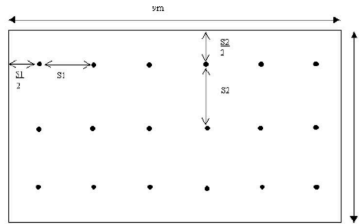
PROCEDURE FOR ASSESSMENT OF LIGHTING SYSTEMS

For example, the dimensions of an interior are: Length = 9m, Width = 5m, Height of luminaires above working plane (Hm) = 2m

Calculate $RI = 9 \times 5 / 2(9 + 5) = 1.607$

From Table 13.1 the minimum number of measurement points is 16. As it is not possible to approximate a "square array" of 16 points within such a rectangle it is necessary to increase the number of points to say 18, i.e. 6 x 3. These should be spaced as shown below:

PROCEDURE FOR ASSESSMENT OF LIGHTING SYSTEMS +



Therefore in this example the spacing between points along rows along the length of the interior = $9 \div 6 = 1.5\text{m}$ and the distance of the 'end' points from the wall = $1.5 \div 2 = 0.75\text{m}$. Similarly the distance between points across the width of the interior = $5 \div 3 = 1.67\text{m}$ with half this value, 0.83m, between the 'end' points and the walls.

If the grid of the measurement points coincides with that of the lighting fittings, large errors are possible and the number of measurement points should be increased to avoid such an occurrence.

CALCULATION OF THE INSTALLED LOAD EFFICACY AND INSTALLED LOAD EFFICACY RATIO OF A GENERAL LIGHTING INSTALLATION IN AN INTERIOR

STEP 1	Measure the floor area of the interior.	Area = m^2
STEP 2	Calculate the Room Index	RI =
STEP 3	Determine the total circuit watts of the installation by a power meter if a separate meter for lighting is available. If the actual value is not known a reasonable approximation can be obtained by reading up the lamp wattages including the ballasts.	Total circuit watts =
STEP 4	Calculate Watts per square metre. Value of step 3 ÷ value of step 1	Watt/m ² =
STEP 5	Ascertain the average maintained illuminance by using lux meter. Use: Maintained	E _{av} (lx) =
STEP 6	Divide 5 by 4 to calculate lux per watt per square Metre	Lux/Watt/m ² =
STEP 7	Obtain target Lux/Watt/m ² for the type of the type of installation/application and RI (2)	Target Lux/Watt/m ² =
STEP 8	Calculate Installed Load Efficacy Ratio (÷ 7)	ILER =

TABLE 13.2 Target lux/W/m² (W/m²/100lux) Values for maintained illuminance on horizontal plane for all room indices and applications:

Room Index	Target lux/W/m ² (W/m ² /100lux) for very clean industrial applications, standard or good colour rendering, Ra > 80	Target lux/W/m ² (W/m ² /100lux) for clean industrial applications, standard or good colour rendering, Ra > 80	Target lux/W/m ² (W/m ² /100lux) for clean industrial applications, standard or good colour rendering, Ra > 80
1	11 (1.09)	10 (1.06)	17 (1.69)
2	11 (1.09)	10 (1.06)	17 (1.69)
3	11 (1.09)	10 (1.06)	17 (1.69)
4	11 (1.09)	10 (1.06)	17 (1.69)
5	11 (1.09)	10 (1.06)	17 (1.69)
6	11 (1.09)	10 (1.06)	17 (1.69)
7	11 (1.09)	10 (1.06)	17 (1.69)
8	11 (1.09)	10 (1.06)	17 (1.69)
9	11 (1.09)	10 (1.06)	17 (1.69)
10	11 (1.09)	10 (1.06)	17 (1.69)
11	11 (1.09)	10 (1.06)	17 (1.69)
12	11 (1.09)	10 (1.06)	17 (1.69)
13	11 (1.09)	10 (1.06)	17 (1.69)
14	11 (1.09)	10 (1.06)	17 (1.69)
15	11 (1.09)	10 (1.06)	17 (1.69)
16	11 (1.09)	10 (1.06)	17 (1.69)
17	11 (1.09)	10 (1.06)	17 (1.69)
18	11 (1.09)	10 (1.06)	17 (1.69)
19	11 (1.09)	10 (1.06)	17 (1.69)
20	11 (1.09)	10 (1.06)	17 (1.69)
21	11 (1.09)	10 (1.06)	17 (1.69)
22	11 (1.09)	10 (1.06)	17 (1.69)
23	11 (1.09)	10 (1.06)	17 (1.69)
24	11 (1.09)	10 (1.06)	17 (1.69)
25	11 (1.09)	10 (1.06)	17 (1.69)
26	11 (1.09)	10 (1.06)	17 (1.69)
27	11 (1.09)	10 (1.06)	17 (1.69)
28	11 (1.09)	10 (1.06)	17 (1.69)
29	11 (1.09)	10 (1.06)	17 (1.69)
30	11 (1.09)	10 (1.06)	17 (1.69)
31	11 (1.09)	10 (1.06)	17 (1.69)
32	11 (1.09)	10 (1.06)	17 (1.69)
33	11 (1.09)	10 (1.06)	17 (1.69)
34	11 (1.09)	10 (1.06)	17 (1.69)
35	11 (1.09)	10 (1.06)	17 (1.69)
36	11 (1.09)	10 (1.06)	17 (1.69)
37	11 (1.09)	10 (1.06)	17 (1.69)
38	11 (1.09)	10 (1.06)	17 (1.69)
39	11 (1.09)	10 (1.06)	17 (1.69)
40	11 (1.09)	10 (1.06)	17 (1.69)
41	11 (1.09)	10 (1.06)	17 (1.69)
42	11 (1.09)	10 (1.06)	17 (1.69)
43	11 (1.09)	10 (1.06)	17 (1.69)
44	11 (1.09)	10 (1.06)	17 (1.69)
45	11 (1.09)	10 (1.06)	17 (1.69)
46	11 (1.09)	10 (1.06)	17 (1.69)
47	11 (1.09)	10 (1.06)	17 (1.69)
48	11 (1.09)	10 (1.06)	17 (1.69)
49	11 (1.09)	10 (1.06)	17 (1.69)
50	11 (1.09)	10 (1.06)	17 (1.69)
51	11 (1.09)	10 (1.06)	17 (1.69)
52	11 (1.09)	10 (1.06)	17 (1.69)
53	11 (1.09)	10 (1.06)	17 (1.69)
54	11 (1.09)	10 (1.06)	17 (1.69)
55	11 (1.09)	10 (1.06)	17 (1.69)
56	11 (1.09)	10 (1.06)	17 (1.69)
57	11 (1.09)	10 (1.06)	17 (1.69)
58	11 (1.09)	10 (1.06)	17 (1.69)
59	11 (1.09)	10 (1.06)	17 (1.69)
60	11 (1.09)	10 (1.06)	17 (1.69)
61	11 (1.09)	10 (1.06)	17 (1.69)
62	11 (1.09)	10 (1.06)	17 (1.69)
63	11 (1.09)	10 (1.06)	17 (1.69)
64	11 (1.09)	10 (1.06)	17 (1.69)
65	11 (1.09)	10 (1.06)	17 (1.69)
66	11 (1.09)	10 (1.06)	17 (1.69)
67	11 (1.09)	10 (1.06)	17 (1.69)
68	11 (1.09)	10 (1.06)	17 (1.69)
69	11 (1.09)	10 (1.06)	17 (1.69)
70	11 (1.09)	10 (1.06)	17 (1.69)
71	11 (1.09)	10 (1.06)	17 (1.69)
72	11 (1.09)	10 (1.06)	17 (1.69)
73	11 (1.09)	10 (1.06)	17 (1.69)
74	11 (1.09)	10 (1.06)	17 (1.69)
75	11 (1.09)	10 (1.06)	17 (1.69)
76	11 (1.09)	10 (1.06)	17 (1.69)
77	11 (1.09)	10 (1.06)	17 (1.69)
78	11 (1.09)	10 (1.06)	17 (1.69)
79	11 (1.09)	10 (1.06)	17 (1.69)
80	11 (1.09)	10 (1.06)	17 (1.69)
81	11 (1.09)	10 (1.06)	17 (1.69)
82	11 (1.09)	10 (1.06)	17 (1.69)
83	11 (1.09)	10 (1.06)	17 (1.69)
84	11 (1.09)	10 (1.06)	17 (1.69)
85	11 (1.09)	10 (1.06)	17 (1.69)
86	11 (1.09)	10 (1.06)	17 (1.69)
87	11 (1.09)	10 (1.06)	17 (1.69)
88	11 (1.09)	10 (1.06)	17 (1.69)
89	11 (1.09)	10 (1.06)	17 (1.69)
90	11 (1.09)	10 (1.06)	17 (1.69)
91	11 (1.09)	10 (1.06)	17 (1.69)
92	11 (1.09)	10 (1.06)	17 (1.69)
93	11 (1.09)	10 (1.06)	17 (1.69)
94	11 (1.09)	10 (1.06)	17 (1.69)
95	11 (1.09)	10 (1.06)	17 (1.69)
96	11 (1.09)	10 (1.06)	17 (1.69)
97	11 (1.09)	10 (1.06)	17 (1.69)
98	11 (1.09)	10 (1.06)	17 (1.69)
99	11 (1.09)	10 (1.06)	17 (1.69)
100	11 (1.09)	10 (1.06)	17 (1.69)

RI: Colour rendering index

The principal difference between the targets for Commercial and Industrial Ra: 40-85 (Cols.2 & 3) of Table 10.2 is the provision for a slightly lower maintenance factor for the lat- ter. The targets for very clean industrial applications, with Ra: of 40 -85, are as column 2.

ILER ASSESSMENT

ILER	Assessment
0.75 or over	Satisfactory to Good
0.51 – 0.74	Review suggested
0.5 or less	Urgent action required

Compare the calculated ILER with the information in Table 13.3.

ILER Ratios of 0.75 or more may be considered to be satisfactory. Existing installations with ratios of 0.51 - 0.74 certainly merit investigation to see if improvements are possible. Of course there can be good reasons for a low ratio, such as having to use lower efficacy lamps or less efficient luminaires in order to achieve the required lighting result -but it is essential to check whether there is a scope for a more efficient alternative. Existing installations with an ILER of 0.5 or less certainly justify close inspection to identify options for converting the installation to use more efficient lighting equipment.

ILER ASSESSMENT +



Having derived the ILER for an existing lighting installation, then the difference between the actual ILER and the best possible (1.0) can be used to estimate the energy wastage. For a given installation:

Annual energy wastage (in kWh) = $(1.0 - \text{ILER}) \times \text{Total load (kW)} \times \text{annual operating hours (h)}$

This process of comparing the installed load efficacy (ILE) with the target value for the Room Index and type of application can also be used to assess the efficiency of designs for new or replacement general lighting installations. If, when doing so, the calculated ILE (lux/W/m²) is less than the target value then it is advisable to ascertain the reasons. It may be that the requirements dictate a type of luminaire that is not as efficient as the best, or the surface reflectances are less than the normal maxima, or the environment is dirty, etc.,. Whatever the reasons, they should be checked to see if a more efficient solution is possible.

EXAMPLE OF ILER CALCULATION



STEP 1	Measure the floor area of the interior:	Area = 45 m ²
STEP 2	Calculate the Room Index	RI = 1.93
STEP 3	Determine the total circuit watts of the installation by a power meter if a separate feeder for lighting is available. If the actual value is not known a reasonable approximation can be obtained by totaling up the lamp wattages including the ballasts:	Total circuit watts = 990 W
STEP 4	Calculate Watts per square metre, 3 ÷ 1 :	W/m ² = 22
STEP 5	Ascertain the average maintained illuminance, Eav. Maintained (average lux levels measured at 18 points)	Eav.maint. = 700
STEP 6	Divide 5 by 4 to calculate the actual lux per watt per square Metre	Lux/W/m ² = 31.8
STEP 7	Obtain target Lux/W/m ² lux for type of the type of interior/ application and RI (2):(Refer Table 10.2)	Target Lux/W/m ² = 46
STEP 8	Calculate Installed Load Efficacy Ratio (6 ÷ 7).	ILER = 0.7

Referring to table 3, ILER of 0.7 means that there is scope for review of the lighting system.
Annual energy wastage = $(1 - \text{ILER}) \times \text{watts} \times \text{no. of operating hours}$
= $(1 - 0.7) \times 990 \times 8 \text{ hrs/day} \times 300 \text{ days}$
= 712 kWh/annum

AREAS FOR IMPROVEMENT



- ✓ Look for natural lighting opportunities through windows and other openings
- ✓ In the case of industrial lighting, explore the scope for introducing translucent sheets
- ✓ Assess scope for more energy efficient lamps and luminaries
- ✓ Assess the scope for rearrangement of lighting fixtures