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Research Article

Optimum Utilization of Electric Bulbs

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Abstract

Centuries back all work was done during daytime and night was utilized mainly for rest. In modern times with the development of electric gadgets little difference is left between day and night. Nevertheless, in developing countries and more so in rural areas still electric filament bulbs are the commonest source of illumination. Even in daytime electric bulbs are needed for indoor work. However, the use of these bulbs has been mainly empirical by common sense as knowledge about illumination is rather primitive even in cities and in educated persons also.

Continued use of improper illumination is a very common cause of eye strain which may lead to great discomfort and even organic disease. Students who form a large bulk of population suffer the most as they have to read for long hours. In the present work an effort has been made to measure the illumination emitted by different type of bulbs by a luxmeter at different distances. Theoretical requirement of illumination is available from books but hardly anyone knows how to get that illumination by electric bulbs. Even an approximate required illumination for different types of work has been worked out. If this guideline is followed many persons suffering from eye strain can be relieved without any medicine. The efficiency of work will also increase.

Keywords: Electric Bulbs; Illumination; Eye Strain

Introduction

For all human activities illumination is of vital importance. Sun light is the best and natural source of illumination since eternity. In primitive times day was meant for work and night for sleep. Since light was provided by sun during day and during night light was not needed, there was no problem. However, with the evolution of human race more and more activities started creeping up and it was found that day time is not enough to carry out all activities during the day and illumination is needed even for the night time. Initially fire was commonly used to carry out gross activities in the night. With further evolution fire was found insufficient to carry out finer work like reading. The quality of illumination has a direct bearing on the incidence of eye strain (Duke-Elder) [1]. Modern times involves protracted use of eyes at a close range (Weston) [2].

Thomas Alva Edison was first to introduce incandescent lamps for use in night time (Boast) [3]. Since then filament bulbs became very popular source of illumination all over the world because of low cost and convenience (Gimson) [4]. Later, though in many Western countries tube lights came in use for softer illumination but in most of the Eastern and African countries electric bulb was the commonest source of illumination. They come in different power (25 to 200 watts) expressing different power of illumination for different kinds of work. However these bulbs are used empirically by common sense without any specific knowledge of the degree of illumination at different distances. With these ideas in mind a project was taken to measure the degree of illumination of different power of bulbs at different distances. As a corollary to that an effort was also made to form some guide lines for optimum degree of illumination for some common types of occupations. The work was mainly carried out at the physics department of a local Engineering College.

Materials and Methods

A luxmeter was the important instrument for measuring the degree of illumination in lux (Figure 1). It has two ranges of illumination shown in two curves. The upper curve showed illumination from 0 to 300 lux whereas the lower curve showed illumination from 0 to 3000 lux. Above the two curves there was a rectangular photosensitive plate to absorb the illumination and show it below in the two curves. Electrical connections were made to ensure constant supply of 230 voltage to the bulbs tested (Figure 2). The

luxmeter with a stand was mounted on the optical bench where distances were marked in cms. The luxmeter could be freely moved forwards and backwards on the optical bench (Figure 3). The test bulb was fixed in a socket at one end of the optical bench which was provided with 230 volts current constantly. The bulbs of 15, 25, 40,60, 100 and 150 watts were used in this study. The illumination of some color bulbs of 15 wt. cc. was also tested after noting their wavelengths by constant deviation spectrophotometer (Figure 4). The bulbs were of red , orange, yellow, green, blue and white color. The effect of variation of voltage of from 150 to 250 volts was also studied at 25 and 50 centimeter distances.

Figure 1: Luxmeter showing two ranges from 0-300 and 0-3000. Above is the rectangular photosensitive plate.

Figure 2: Diagram showing electrical connections to get a constant voltage of 230 v.

Figure 3: Luxmeter mounted on optical bench. The bulb with socket is at one end.

Figure 4: Recording of wavelength for color bulbs by constant deviation spectrometer.

An effort was made to determine the optimum illumination of some common occupations by varying the light at the exact place of work for a number of persons in that occupation and calculating the average figure.

Observations

The illumination was recorded in steps of 5, 10, 20 and 50 centimeters for distances up to 50, 100, 200 andn500 centimeters. Similarly, the distances in centimeters were recorded to get illumination from 10 to 500 lux by a particular bulb. The results were recorded in a tabular form for all the bulbs. Table 1 shows the readings for a 100 wt. bulb. From these tables three types of curves (A, B and C) have been derived. "A" curve denotes variation of illumination with distance by a given bulb (Figure 5). "B" curve shows the variation of bulbs and distances to get a particular degree of illumination and "C" curve shows the illumination by different bulbs at a given distance. Typical curve for a 100 wt bulb (A curve), 100 lux (B curve) and 100 centimeters (C curve) are shown in figure 5 and figure 6. Similar curves are derived for other bulbs, illuminations and distances.

Figure 5: "A" type curve for 100watt cc. bulb at 230 v.

Distance	Illumination (Lux)	Illumination (Lux)	Distance
10 cm	3000 l.	10 l.	380 cm
20 cm	2200 I.	20 I.	260 cm
30 cm	1200 I.	30 I.	210 cm
40 cm	700 I.	40 I.	185 cm
50 cm	450 I.	50 I.	163 cm
60 cm	300 I.	60 I.	147 cm
70 cm	240 I.	70 I.	134 cm
80 cm	170 I.	80 I.	123 cm
90 cm	120 I.	90 I.	116 cm
100 cm	108 I.	100 I.	109 cm
120 cm	80 I.	120 I.	98 cm
140 cm	65 I.	140 I.	90 cm
160 cm	52 I.	160 I.	82 cm
180 cm	42 I.	180 I.	77 cm
200 cm	32 I.	200 I.	73 cm
300 cm	16 I.	300 I.	61 cm
400 cm	08 I.	400 I.	51 cm
500 cm	05 I.	500 I.	46 cm

Table 1 : 100 watt coiled coil bulb, 230 volts.

*1000 lux illumination can be obtained by keeping the bulb at a distance of 33 centimeters.

Figure 6: "B" and "C" type curves for 100 lux and 100 cm. respectively 15, 25, 40, 60, 100 and 150 watt bulbs have been used.

Illumination by a 15 watt color bulbs was similarly recorded up to 50 centimeters and 50 lux. A and B types of curve were derived from the data. Table 2 shows the figures from a 15 wt. red colored bulb. These bulbs do not give a pure spectrum. Table 3 shows their wave lengths and their intensity of illumination in descending order. White bulb has the maximum and the blue bulb has the minimum intensity of illumination.

Distance	Illumination	Illumination	Distance
10 cm	100 I.	10 I.	32.0 cm
15 cm	50 I.	15 I.	27.0 cm
20 cm	28 I.	20 I.	25.0 cm
25 cm	18 I.	25 I.	20.5 cm
30 cm	13 I.	30 I.	18.5 cm
35 cm	10 I.	35 I.	17.5 cm
40 cm	07 I.	40 I.	16.5 cm
45 cm	05 I.	45 I.	15.5 cm

Table 2: 15 Watt Coiled bulb, 230 volts, Red 5250-6910 A0.

Colour	Wave Length	Illumination (lux)
White	4640 – 6650 A^0	700 I.
Yellow	5320 – 6620 A^0	650 I.
Orange	5790 – 6780 A^0	220 I.
Red	6250 – 6910 A^0	100 I.
Green	5210 – 5230 A^0	50 I.
Blue	4840 – 4860 A^0	25 I.

Table 3: 15 watt coiled coil color bulbs at 10 cm distance 230 volts.

A0 – Angstrom Units.

25 watt single coil bulb	Illumination at 25 cm	Illumination at 50 cm
150 volts	100 lux	20 lux
160 volts	125 lux	30 lux
170 volts	160 lux	40 lux
180 volts	200 lux	50 lux
190 volts	250 lux	60 lux
200 volts	300 lux	70 lux
220 volts	400 lux	100 lux
240 volts	5550 lux	140 lux

Table 4: (A): Effect of variation of voltage on illumination by 25 watt bulb.

The effect of variation of voltage on 25 and 60 watt bulbs at 25 and 50 centimeter distances is shown in table 4. The effect on 60 watt bulb at 25 centimeters is graphically shown in figure 7. The illumination increases proportionately with the increase in voltage. Table 5 shows the illumination by plain, milky and day light bulbs of 40 watts. The illumination required for some common occupations in India are recorded in table 6.

60 watt coiled coil bulb (voltage)	Illumination at 25 cm	Illumination at 50 cm
150 v.	250 l.	60 l.
160 v.	300 l.	75 l.
170 v.	350 l.	95 l.
180 v.	450 l.	125 l.
190 v.	550 l.	145 l.
200 v.	700 l.	170 l.
220 v.	900 l.	230 l.
240 v.	1200 l.	325 l.

Table 4: (B).

Distance	Plane	Milky	Day Light
10 cm	2400 l.	2400 l.	1225 l.
15 cm	1400 l.	1400 l.	850 l.
20 cm	800 l.	800 l.	525 l.
25 cm	600 l.	600 l.	350 l.
30 cm	400 l.	400 l.	250 l.
35 cm	300 l.	300 l.	180 l.
40 cm	200 l.	200 l.	120 l.
45 cm	160 l.	160 l.	100 l.
50 cm	135 l.	130 l.	80 l.
60 cm	92 l.	100 l.	58 l.
70 cm	70 l.	75 l.	44 l.
80 cm	55 l.	58 l.	34 l.
90 cm	44 l.	46 l.	28 l.
100 cm	36 l.	37 l.	22 l.
120 cm	27 l.	27 l.	17 l.
140 cm	20 l.	20 l.	14 l.
160 cm	16 l.	17 l.	10 l.
180 cm	13 l.	14 l.	7 l.
200 cm	8 l.	8 l.	5 l.
250 cm	5 l.	6 l.	3 l.
300 cm	3 l.	4 l.	2 l.
350 cm	2 l.	3 l.	1 l.
400 cm	1 l.	2 l.	0 l.
450 cm	0 l.	1 l.	0 l.
500 cm	0 l.	0 l.	0 l.

Table 5: Illumination by different types of 40 watt bulbs. 230 volts.

Figure 7: Effect of variation of voltage on 60watt cc. bulb at 25 cm. distance.

Occupation	Illumination (lux)
Students	65 l.
Clerks	50 l.
Typists	55 l.
Tailors	170 l.
Upholstery Workers	80 l.
Watch Makers	460 l.
Cloth Merchants	360 l.
Cooks	60 l.
Barbers	60 l.
Electricians	75 l.
Washermen	45 l.
Carpenters	60 l.
Goldsmiths	75 l.
Lawyers	60 l.
Painters	80 l.
Press workers	120 l.
Physicians	60 l.
Surgeons	2500 l.

Table 6: Optimum Illumination for some common occupation.

Note: The light requirement for various types of workers in cotton, rayon, biscuit, leather and machine making factories has also been determined.

Discussion and Conclusion

The illumination by any light source is governed by inverse square law. It rapidly falls as the distance is increased and the change is more marked at closer distance. The subject of illumination is very complex as visual efficiency depends on many factors apart from intensity of illumination. These include the quality of light, glare, size, shape, motility of the object and the time required

for observation apart from the visual capacity of the individual (Barrow) [5]. However the intensity of illumination is the most important factor. By the three curves (A,B and C) an individual can easily adjust optimum illumination for his work by altering the distance and the power of electrical bulbs. Defective illumination is a very important cause of eye strain particularly in students which has been largely neglected. So far the emphasis is only in correcting the vision by providing them appropriate glasses. Little attention has been given to illumination.

The colored lamps are mainly used for decorative purpose and have hardly any role in visual function. The effect of voltage is also marked and the illumination can flicker due to changing voltage (Figure 7). Sharp [6] has observed that 1% overvoltage increases the light output by 3% and 1% under voltage decreases it by 3%. Further 1% overvoltage reduces the lamp life by 12.5% and 1% under voltage increases it by 11.4%. The illumination for some common occupations was studied by visiting them at work place and optimum light requirement was approximately calculated as shown in Table 6. It was observed that most of the people working under defective illumination and were thus straining their eyes. Not only under illumination but over illumination is also equally harmful to the eyes.

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