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ILLUMINATION DESIGN

Submitted to

Electrical Engineering Department,

Eastern Mediterranean University

For EE 400 ----- Special Project

by

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1.1) INTRODUCTION

One cannot expect to illuminate a room by just hanging a lamp in the middle of the room. Each area to be illuminated poses a uniqe problem that needs to be solved. In solving an illumination problem, one has to take into account architectural and economical conditions as well as physical and technical limitations.

The advantages of a well illuminated area are various. Above all it does not disturb the eye and helps to elliminate occupational accidents. Thus, it increases the productivity and procures the expansion of business. Besides, order and security in a well illuminated area are always ensured.

The thought that possessing good illumination techniques will be a credit for me as an electrical engineer has led me to do my project on illumination design.

1.2) ACKNOWLEDGEMENT

My most heartfelt thanks go to Prof. Haldun Gürman who supervised me during the realization of this project.

1.3) ABSTRACT

Object of this project is to describe the steps in designing a plan to illuminate a furniture factory in a most efficient way. Taking into account all the related physical, technical and economical problems.

2.1) Calculation of surface indoor illumination:

The method for determining surface indoor illumination can be summarised as follows:

I) The dimensions of the room are obtained;

a= Width , b= Length

II) Values are picked for;

1) Efficiency (η = m).

2) Appropriate illuminance level E from table 3.

3) Type of lighting colour (C=84) and Efficacy (E_{ff} = 96 lm/W) from table 4.

III) The following are calculated;

1) Area of the room (A= a x b).

2) Source flux ($\Phi_s = \frac{A \times E}{m}$).

3) Total power ($P_T = \frac{\Phi_s}{E_{ff}}$).

4) The number of lamps ($n = \frac{P_T}{P_1}$)

where; P_1 = 40 is the estimated power.

5) The flux of one lamp ($\Phi_1 = \frac{\Phi_s}{n}$).

6) Normalised source flux ($\Phi_{On} = n \times \Phi_{1n}$)
where; Φ_{1n} is the flux value from table 5 closest to Φ_1.

7) Illuminance level corresponding to normalised source flux $E_{On} = (\frac{\Phi_{On} \times m}{A})$.

8) Normalised total lamp power ($P_{On} = n \times P_{1n}$)
where; P_{1n} is the power value from table 5 closest to Φ_1.

NOTE: All values are shown on the table 1.

Store Part:

I) The dimensions of the room are obtained;

a= 16.6 m , b= 25 m

II) Values are picked for;

1) m= 0.75

2) E= 150 lx

3) C= 84, E_{ff} = 96 lm/W

III) The following are calculated;

1) $A = 16.6 \times 25 = 456\ m^2$

2) $\Phi_s = \frac{456 \times 150}{0.75} = 83000$ lm

3) $P_T = \frac{83000}{96} = 864.58$ W

4) $n = \frac{864.58}{40} = 21.66$ = (10,(2 x 40 W) fluorescent)

5) $\Phi_1 = \frac{83000}{22} = 3772$ lm

6) $\Phi_{On} = 22 \times 3450 = 75900$ lm, where $\Phi_{1n} = 3450$ lm

7) $E_{On} = \frac{75900 \times 0.75}{456} = 137.2$ lx

8) $P_{On} = 22 \times 36 = 792$ W, where $P_{1n} = 36$ W

Finish Part:

I) The dimensions of the room are obtained;

a= 16.6 m , b= 21 m

II) Values are picked for;

1) m= 0.75

2) E= 500 lx

3) C= 84, E_{ff} = 96 lm/W

III) The following are calculated;

1) $A = 16.6 \times 21 = 348.6\ m^2$

2) $\Phi_s = \frac{348.6 \times 500}{0.75} = 232400$ lm

3) $P_T = \frac{232400}{96} = 2420$ W

4) $n = \frac{2420}{40} = 60.5 = 60 =$ (30,(2 x 40 W) fluorescent)

5) $\Phi_1 = \frac{232400}{60} = 3873$ lm

6) $\Phi_{On} = 60 \times 3450 = 207000$ lm, where $\Phi_{1n} = 3450$ lm

7) $E_{On} = \frac{207000 \times 0.75}{348.6} = 445$ lx

8) $P_{On} = 60 \times 36 = 2160$ W, where $P_{1n} = 36$ W

Mounting Part:

I) The dimensions of the room are obtained;

a= 16.6 , b= 21 m

II) Values are picked for;

1) m= 0.75

2) E= 300 lx

3) C= 84, E_{ff} = 96 lm/W

III) The following are calculated;

1) A = 16.6 x 21 = 348.6 m^2

2) $\Phi_s = \frac{348.6 \times 300}{0.75} = 139440$ lm

3) $P_T = \frac{139440}{96} = 1452$ W

4) $n = \frac{1452}{40} = 36$ = (18,(2 x 40 W) fluorescent)

5) $\Phi_1 = \frac{139440}{36} = 3873$ lm

6) Φ_{On} = 36 x 3456 = 124416 lm, where Φ_{1n} = 3456 lm

7) $E_{On} = \frac{124416 \times 0.75}{348.6} = 267.6$ lx

8) P_{On} = 36 x 36 = 1296 W, where P_{1n} = 36 W

Cutting Part:

I) The dimensions of the room are obtained;

a= 16.6 m , b= 29.2 m

II) Values are picked for;

1) m= 0.75

2) E= 300 lx

3) C= 84, E_{ff} = 96 lm/W

III) The following are calculated;

1) $A = 16.6 \times 29.2 = 484.72\ m^2$

2) $\Phi_s = \frac{484.72 \times 300}{0.75} = 193888$ lm

3) $P_T = \frac{193888}{96} = 2019$ W

4) $n = \frac{2019}{40} = 50$ (24,(2 x 40 W) fluorescent)

5) $\Phi_1 = \frac{193888}{50} = 3877$ lm

6) $\Phi_{On} = 50 \times 3450 = 172500$ lm, where $\Phi_{1n} = 3450$ lm

7) $E_{On} = \frac{172500 \times 0.75}{484.72} = 266.9$ lx

8) $P_{On} = 50 \times 36 = 1800$ W, where $P_{1n} = 36$ W

CALCULATION OF SURFACE INDOOR ILLUMINATION

Illuminated Area	Known Values		Picked Values							Calculated Values							
	a m	b m	Illumination System	m	E lx	C	E_{ff} lm/W	Φ_{1n} lm	P_{1n} W	A m^2	Φ_s lm	P_T W	n	Φ_1 lm	Φ_{On} lm	E_{On} lx	P_{On} W
Store Part	16.6	25	Direct	0.75	150	84	96	3450	36	456	83000	864.58	22	3772	75900	137.2	792
Finish Part	16.6	21	Direct	0.75	500	84	96	3450	36	348.6	232400	2420	60	3873	207000	445	2160
Cutting Part	16.6	29.2	Direct	0.75	300	84	96	3450	36	484.72	193888	2019	50	3877	172500	266.9	1800
Mounting Part	16.6	21	Direct	0.75	300	84	96	3450	36	348.6	139440	1452	36	3873	124416	267.6	1296

Table 1

2.3) Calculation of recessed indoor illumination:

The method for determining recessed indoor illumination can be summarised as follows:

I) The dimensions of the room are obtained;

a= Width , b= Length , H= Height

II) Values are picked for;

1) Efficiencies of ceiling (E_c) and wall (E_w).

2) Appropriate illuminance level E from table 3.

3) Type of lighting colour (C=84) and Efficacy (E_{ff} = 96 lm/W) from table 4.

III) The following are calculated;

1) Area of the room (A= axb).

2) Distance from the work point to the ceiling (h=H-0.8).

3) The factor ($k = \frac{0.8 \times a + 0.2 \times b}{h}$).

4) The efficiency value is found from the table 6 according to the k value (m).

5) Source flux ($\Phi_s = \frac{A \times E}{m}$).

6) Total power ($P_T = \frac{\Phi_s}{E_{ff}}$).

7) The number of lamps ($n = \frac{P_T}{P_1}$)

where; P_1 = 40 W is the estimated power.

8) The flux of one lamp ($\Phi_1 = \frac{\Phi_s}{n}$).

9) Normalised source flux ($\Phi_{On} = n \times \Phi_{1n}$)
where; Φ_{1n} is the flux value from table 5 closest to Φ_1.

10) Illuminance level corresponding to normalised source flux ($E_{On} = \frac{\Phi_{On} \times m}{A}$).

11) Normalised total lamp power $P_{On} = n \times P_{1n}$
where; P_{1n} is the power value from table 5 closest to Φ_1.

<u>NOTE</u>: All values are shown on table 2.

Manager Room:

I) The dimensions of the room are obtained;

a= 3.6 m , b= 4 m , H= 2.73 m

II) Values are picked for;

1) $E_c = 0.7$, $E_w = 0.5$

2) E = 500 lx

3) C = 84, E_{ff} = 96 lm/W

III) The following are calculated;

1) $A = 3.6 \times 4 = 14.4\ m^2$

2) h = 2.73 - 0.8 = 1.93 m

3) $k = \dfrac{0.8 \times 3.6 + 0.2 \times 4}{1.93} = 1.90$

4) m = 0.42

5) $\Phi_s = \dfrac{14.4 \times 500}{0.42} = 17142$ lm

6) $P_T = \dfrac{17142}{96} = 178.56$ W

7) $n = \dfrac{178.56}{40} = 4.46 = 4$ (2,(2 x 40 W) fluorescent)

8) $\Phi_1 = \dfrac{17142}{4} = 4285$ lm

9) $\Phi_{On} = 4 \times 3450 = 13800$ lm, where $\Phi_{1n} = 3450$ lm

10) $E_{On} = \dfrac{13800 \times 0.42}{14.4} = 402.5$ lx

11) $P_{On} = 4 \times 36 = 144$ W, where $P_{1n} = 36$ W

Entrance Room:

I) The dimensions of the room are obtained;

a= 3.6 m , b= 4 m , H= 2.73 m

II) Values are picked for;

1) $E_c = 0.7$, $E_w = 0.5$

2) E= 200 lx

3) C= 84, E_{ff} = 96 lm/W

III) The following are calculated;

1) $A = 3.6 \times 4 = 14.4\ m^2$

2) $h = 2.73 - 0.8 = 1.93$ m

3) $k = \frac{0.8 \times 3.6 + 0.2 \times 4}{1.93} = 1.90$

4) $m = 0.42$

5) $\Phi_s = \frac{14.4 \times 200}{0.42} = 6857$ lm

6) $P_T = \frac{6857}{96} = 71.42$ W

7) $n = \frac{71.42}{40} = 1.78 = 2$ (1,(2 x 40 W) fluorescent)

8) $\Phi_1 = \frac{6857}{2} = 3428$ lm

9) $\Phi_{On} = 2 \times 3450 = 6900$ lm, where $\Phi_{1n} = 3450$ lm

10) $E_{On} = \frac{3450 \times 0.42}{14.4} = 201$ lx

11) $P_{On} = 2 \times 36 = 72$ W, where $P_{1n} = 36$ W

Personnel Waiting Room:

This room is divided into two parts:

PART 1:

I) The dimensions of the room are obtained;

a= 4.1 m , b= 7.6 m , H= 2.73 m

II) Values are picked for;

1) $E_c = 0.7$, $E_w = 0.5$

2) $E = 500$ lx

3) $C = 84$, $E_{ff} = 96$ lm/W

III) The following are calculated;

1) $A = 4.1 \times 7.6 = 31.16\ m^2$

2) $h = 2.73 - 0.8 = 1.93$ m

3) $k = \dfrac{0.8 \times 4.1 + 0.2 \times 7.6}{1.93} = 2.48$

4) $m = 0.47$

5) $\Phi_s = \dfrac{31.16 \times 500}{0.47} = 33149$ lm

6) $P_T = \dfrac{33149}{96} = 345$ W

7) $n = \dfrac{345}{40} = 8.62 = 8$(4,(2 x 40 W) fluorescent)

8) $\Phi_1 = \dfrac{33149}{8} = 4143$ lm

9) $\Phi_{On} = 8 \times 3450 = 27600$ lm, where $\Phi_{1n} = 3450$ lm

10) $E_{On} = \dfrac{27600 \times 0.47}{31.16} = 416$ lx

11) $P_{On} = 8 \times 36 = 288$ W, where $P_{1n} = 36$ W

PART 2:

I) The dimensions of the room are obtained;

a= 4 m , b= 4 m , H= 2.73 m

II) Values are picked for;

1) $E_c = 0.7$, $E_w = 0.5$

2) $E = 500$ lx

3) $C = 84$, $E_{ff} = 96$ lm/W

III) The following are calculated;

1) $A = 4 \times 4 = 16\ m^2$

2) $h = 2.73 - 0.8 = 1.93$ m

3) $k = \frac{0.8 \times 4 + 0.2 \times 4}{1.93} = 2.07$

4) $m = 0.42$

5) $\Phi_s = \frac{16 \times 500}{0.42} = 19047$ lm

6) $P_T = \frac{19047}{96} = 199$ W

7) $n = \frac{199}{40} = 4$(2,(2 x 40 W) fluorescent)

8) $\Phi_1 = \frac{19047}{4} = 4761$ lm

9) $\Phi_{On} = 4 \times 3450 = 13800$ lm, where $\Phi_{1n} = 3450$ lm

10) $E_{On} = \frac{13800 \times 0.42}{16} = 362$ lx

11) $P_{On} = 4 \times 36 = 144$ W, where $P_{1n} = 36$ W

Canteen Room:

I) The dimensions of the room are obtained;

a= 1.9 m , b= 2.4 m , H=2.73 m

II) Values are picked for;

1) $E_c = 0.7$, $E_w = 0.5$

2) $E = 500$ lx

3) $C = 84$, $E_{ff} = 96$ lm/W

III) The following are calculated;

1) $A = 1.9 \times 2.4 = 4.56\ m^2$

2) $h = 2.73 - 0.8 = 1.93$ m

3) $k = \frac{0.8 \times 1.9 + 0.2 \times 2.4}{1.93} = 1.03$

4) $m = 0.26$

5) $\Phi_s = \frac{4.56 \times 500}{0.26} = 8769$ lm

6) $P_T = \frac{8769}{96} = 91$ W

7) $n = \frac{91}{40} = 2.27 = 2(1,(2 \times 40\ W)$ fluorescent)

8) $\Phi_1 = \frac{8769}{2} = 4384$ lm

9) $\Phi_{On} = 2 \times 3450 = 6900$ lm, where $\Phi_{1n} = 3450$ lm

10) $E_{On} = \frac{6900 \times 0.26}{4.56} = 393$ lx

11) $P_{On} = 2 \times 36 = 72$ W, where $P_{1n} = 36$ W

Waiting Room:

I) The dimensions of the room are obtained;

a= 3.6 m , b= 4 m , H= 2.73 m

II) Values are picked for;

1) $E_c = 0.7$, $E_w = 0.5$

2) E = 500 lx

3) C = 84, E_{ff} = 96 lm/W

III) The following are calculated;

1) $A = 3.6 \times 4 = 14.4\ m^2$

2) h = 2.73 - 0.8 = 1.93 m

3) $k = \frac{0.8 \times 3.6 + 0.2 \times 4}{1.93} = 1.90$

4) m = 0.42

5) $\Phi_s = \frac{14.4 \times 500}{0.42} = 17142$ lm

6) $P_T = \frac{17142}{96} = 178.56$ W

7) $n = \frac{178.56}{40} = 4.46 = 4$ (2,(2 x 40 W) fluorescent)

8) $\Phi_1 = \frac{17142}{4} = 4285$ lm

9) $\Phi_{On} = 4 \times 3450 = 13800$ lm, where $\Phi_{1n} = 3450$ lm

10) $E_{On} = \frac{13800 \times 0.42}{14.4} = 402.5$ lx

11) $P_{On} = 4 \times 36 = 144$ W, where $P_{1n} = 36$ W

Accountancy and Technique Room:

This room is divided into three parts:

PART 1:

I) The dimensions of the room are obtained;

a= 4.1 m , b= 7.6 m , H= 2.73 m

II) Values are picked for;

1) $E_c = 0.7$, $E_w = 0.5$

2) $E = 500$ lx

3) $C = 84$, $E_{ff} = 96$ lm/W

III) The following are calculated;

1) $A = 4.1 \times 7.6 = 31.16\ m^2$

2) $h = 2.73 - 0.8 = 1.93$ m

3) $k = \dfrac{0.8 \times 4.1 + 0.2 \times 7.6}{1.93} = 2.48$

4) $m = 0.47$

5) $\Phi_s = \dfrac{31.16 \times 500}{0.47} = 33149$ lm

6) $P_T = \dfrac{33149}{96} = 345$ W

7) $n = \dfrac{345}{40} = 8.62 = 8(4,(2 \times 40\ W)$ fluorescent)

8) $\Phi_1 = \dfrac{33149}{8} = 4143$ lm

9) $\Phi_{On} = 8 \times 3450 = 27600$ lm, where $\Phi_{1n} = 3450$ lm

10) $E_{On} = \dfrac{27600 \times 0.47}{31.16} = 416$ lx

11) $P_{On} = 8 \times 36 = 288$ W, where $P_{1n} = 36$ W

PART 2:

I) The dimensions of the room are obtained;

a= 3.6 m , b= 4.1 m , H= 2.73 m

II) Values are picked for;

1) $E_c = 0.7$, $E_w = 0.5$

2) $E = 500$ lx

3) $C = 84$, $E_{ff} = 96$ lm/W

III) The following are calculated;

1) $A = 3.6 \times 4.1 = 14.76\ m^2$

2) $h = 2.73 - 0.8 = 1.93$ m

3) $k = \dfrac{0.8 \times 3.6 + 0.2 \times 4.1}{1.93} = 1.91$

4) $m = 0.42$

5) $\Phi_s = \dfrac{500 \times 14.76}{0.42} = 17571$ lm

6) $P_T = \dfrac{17571}{96} = 183$ W

7) $n = \dfrac{183}{40} = 4.57 = 4(2,(2 \times 40\ W)$ fluorescent)

8) $\Phi_1 = \dfrac{17571}{4} = 4392$ lm

9) $\Phi_{On} = 4 \times 3450 = 13800$, where $\Phi_{1n} = 3450$ lm

10) $E_{On} = \dfrac{13800 \times 0.42}{14.76} = 392$ lx

11) $P_{On} = 4 \times 36 = 144$ W, where $P_{1n} = 36$ W

PART 3:

I) The dimensions of the room are obtained;

a= 2.4 m , b= 4 m , H= 2.73 m

II) Values are picked for;

1) $E_c = 0.7$, $E_w = 0.5$

2) $E = 500$ lx

3) $C = 84$, $E_{ff} = 96$ lm/W

III) The following are calculated;

1) $A = 2.4 \times 4 = 9.6\ m^2$

2) $h = 2.73 - 0.8 = 1.93$ m

3) $k = \dfrac{0.8 \times 2.4 + 0.2 \times 4}{1.93} = 1.41$

4) $m = 0.36$

5) $\Phi_s = \dfrac{9.6 \times 500}{0.36} = 13333$ lm

6) $P_T = \dfrac{13333}{96} = 138$ W

7) $n = \dfrac{138}{40} = 3$(1,(2 x 40 W) fluorescent)

8) $\Phi_1 = \dfrac{13333}{3} = 4444$ lm

9) $\Phi_{On} = 3 \times 3450 = 10350$ lm, where $\Phi_{1n} = 3450$ lm

10) $E_{On} = \dfrac{10350 \times 0.36}{9.6} = 388$ lx

11) $P_{On} = 3 \times 36 = 108$ W, where $P_{1n} = 36$ W

Secretary Room:

I) The dimensions of the room are obtained;

a= 3.6 m , b= 4 m , H= 2.73 m

II) Values are picked for;

1) $E_c = 0.7$, $E_w = 0.5$

2) E = 500 lx

3) C = 84, E_{ff} = 96 lm/W

III) The following are calculated;

1) $A = 3.6 \times 4 = 14.4\ m^2$

2) h = 2.73 - 0.8 = 1.93 m

3) $k = \frac{0.8 \times 3.6 + 0.2 \times 4}{1.93} = 1.90$

4) m = 0.42

5) $\Phi_s = \frac{14.4 \times 500}{0.42} = 17142$ lm

6) $P_T = \frac{17142}{96} = 178.56$ W

7) $n = \frac{178.56}{40} = 4.46 = 4$ (2,(2 x 40 W) fluorescent)

8) $\Phi_1 = \frac{17142}{4} = 4285$ lm

9) $\Phi_{On} = 4 \times 3450 = 13800$ lm, where $\Phi_{1n} = 3450$ lm

10) $E_{On} = \frac{13800 \times 0.42}{14.4} = 402.5$ lx

11) $P_{On} = 4 \times 36 = 144$ W, where $P_{1n} = 36$ W

CALCULATION OF RECESSED INDOOR ILLUMINATION

Illuminated Area	Know Values			Picked Values								Calculated Values										
	a m	b m	H m	Illumination System	E_c	E_w	E lx	C	E_{ff} lm/W	Φ_{1n} lm	P_{1n} W	A m^2	h m	k	m	Φ_s lm	P_T W	n	Φ_1 lm	Φ_{On} lm	E_{On} lx	P_{On} W
Manager Room	3.6	4	2.73	Direct	0.7	0.5	500	84	96	3450	36	14.4	1.93	1.90	0.42	17142	178.56	4	4285	13800	402.5	144
Entrance Room	3.6	4	2.73	Direct	0.7	0.5	200	84	96	3450	36	14.4	1.93	1.90	0.42	6857	71.42	2	3428	6900	201	72
Personnel Waiting Room																						
Part 1	4.1	7.6	2.73	Direct	0.7	0.5	500	84	96	3450	36	31.16	1.93	2.48	0.47	33149	345	8	4143	27600	416	288
Part 2	4	4	2.73	Direct	0.7	0.5	500	84	96	3450	36	16	1.93	2.07	0.42	19047	199	4	4761	13800	362	144
Canteen Room	1.9	2.4	2.73	Direct	0.7	0.5	500	84	96	3450	36	4.56	1.93	1.03	0.26	8769	91	2	4384	6900	393	72
Waiting Room	3.6	4	2.73	Direct	0.7	0.5	500	84	96	3450	36	14.4	1.93	1.90	0.42	17142	178.56	4	4285	13800	402.5	144
Accountancy and Tech. Room																						
Part 1	4.1	7.6	2.73	Direct	0.7	0.5	500	84	96	3450	36	31.16	1.93	2.48	0.47	33149	345	8	4143	27600	416	288
Part 2	3.6	4.1	2.73	Direct	0.7	0.5	500	84	96	3450	36	14.76	1.93	1.91	0.42	17571	183	4	4392	13800	392	144
Part 3	2.4	4	2.73	Direct	0.7	0.5	500	84	96	3450	36	9.6	1.93	1.41	0.36	13333	138	3	4444	10350	388	108
Secretary Room	3.6	4	2.73	Direct	0.7	0.5	500	84	96	3450	36	14.4	1.93	1.90	0.42	17142	178.56	4	4285	13800	402.5	144

Table 2

3.1) Voltage drop in one phase circuit:

Fig 1 represents an alternative current circuit with two cables. Alternative current is affected by resistance of the line as well as inductance and capacitance. In the following calculations only the effect of the resistance and inductance will be considered.

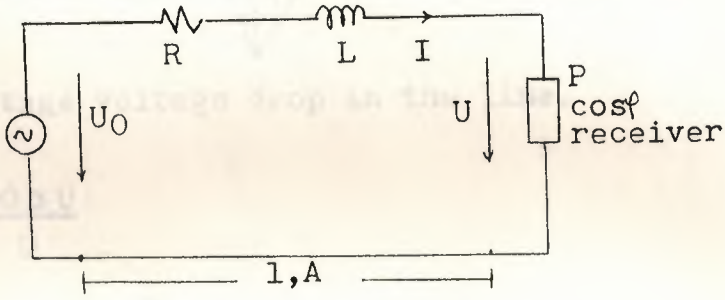

fig 1

If P denotes the real power and cosφ denotes the power factor of the receiver at the end of the line, fig 2 shows the vector diagram for fig 1.

One of the voltage components is the voltage drop $U_R = RI$ which is in the same phase as the current I. The other components is the inductance voltage drop which leads the current by 90°. The resultant of these two voltage drops is the total voltage drop in the line.

$$\Delta U = \sqrt{R^2 + w^2L^2}\, I = ZI \quad .....(1)$$

where U is the voltage drop in the line, Z is the impedance of the line.

In practice the voltage drop which is equal to the difference of the voltages at the beginning and end of the line $\Delta U = U_O - U$ is taken instead of eq(1).

$$\Delta U = (R \cos\varphi + wL \sin\varphi)\, I$$

and

$$U = (R + wL \tan\varphi)\, I \cos\varphi$$

Since the angle between U and U_o is quite small, in practice U can be taken to be equal to U_o.

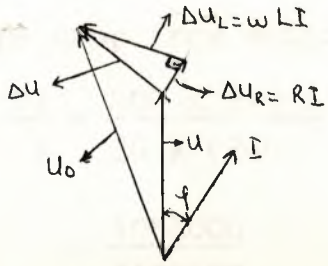

fig 2

The percentage voltage drop in the line.

$$\epsilon = \frac{100\,\Delta U}{U}$$

$$\epsilon = \frac{100\ I\ \cos\varphi}{U} \quad (R + wL\ \tan\varphi\ )$$

where $P = UI\ \cos\varphi$

$$I\ \cos\varphi = \frac{P}{U}$$

Therefore $\epsilon = \dfrac{100\ P}{U^2} \quad (R + wL\ \tan\varphi\ )$

If the inductance of the line is assumed to be very small,

$$\epsilon = \frac{100\ PR}{U^2} = \frac{100\ Pl}{x\ A\ U^2}$$

where $R = \dfrac{2l}{xA}$

Therefore $\epsilon = \dfrac{200\ Pl}{x\ A\ U^2}$

Here, P(W), l(m), x(m/Ωmm^2), A(mm^2) and U(V).

3.2) Calculation of one phase voltage drop:

For finish and dispatch part on the line L_{10}.

The voltage drop from switch to the load is:

$$\epsilon_1\% = \frac{200\ Pl}{56\ U^2 A} = \frac{200 \times 240 \times 22}{56 \times (240)^2 \times 1}$$

$$= \frac{1056000}{3225600}$$

$$= 0.327$$

From switch to the distribution box:

$$\epsilon_2\% = \frac{200 \times 240 \times 18}{56 \times (240)^2 \times 1} = \frac{864000}{3225600} = 0.267$$

From distribution box to the main distribution box:

$$\epsilon_3\% = \frac{200 \times 2400 \times 37}{56 \times (240)^2 \times 4}$$

$$= \frac{17760000}{193536000}$$

$$= 1.376$$

Total voltage drop:

$$\epsilon\% = (\epsilon_1 + \epsilon_2 + \epsilon_3)\%$$

$$= 0.327 + 0.267 + 1.376$$

$$= 1.97$$

Maximum permissible volt drop = 2.5 %

$$1.97 < 2.5$$

Therefore the chosen cables fit the local regulations.

3.3) Voltage drop in three phase circuit:

Here we assume that the three phase current is loaded symmetrically. Hence three phase line can be assumed to be composed of three equal parts.

Therefore each part carries one third of the power of the receiver connected between the phase and neutral cable.

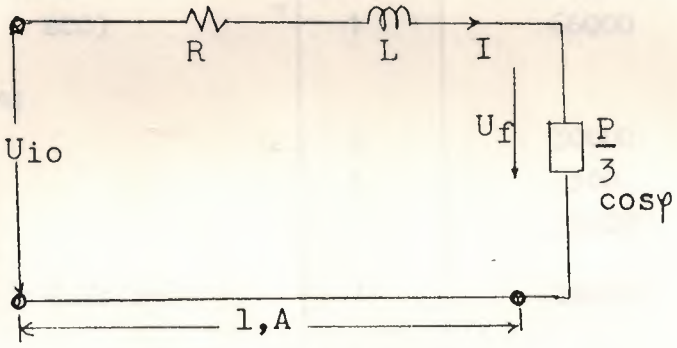

fig 3

Fig 3 One phase plan of three phase circuit when symmetrically loaded.

When finding R and L, the length l is taken instead of 2l because in case of symmetric loading no current flows in the neutral cable.

$$U_f = RI \cos\varphi$$

$$\epsilon = \frac{100\ U_f}{U_f} = \frac{100\ RI \cos\varphi}{U_f}$$

$$P = 3\ UI \cos\varphi,\ I \cos\varphi = \frac{P}{3\ U}$$

where $R = \frac{l}{xA}$, $U_f = \frac{U}{3}$

Therefore $\epsilon = \frac{100\ Pl}{x\ A\ U^2}$

Feasibility Report:

Name	Number	Per Unit Cost (₺)	Total Cost (₺)
Automatic (3 x 60A)	1	95000	95000
Complete distribution box (3x4)	1	250000	250000
Complete distribution box (1x4)	2	40000	80000
Complete distribution box (1x6)	2	50000	100000
Complete distribution box (1x10)	1	100000	100000
Surfaces cables;			
(100 x 1 mm^2 + ECC)	10	40000	400000
(100 x 2.5 mm^2 + ECC)	1	66000	66000
Recessed cables;			
(100 x 4 mm^2)	5	30000	150000
(40 x 6 mm^2)	1	25000	25000
(30 x 16 mm^2)	1	33000	33000
Cable 100 x (2 x 0.75 mm)	1	28000	28000
Four way round junction box	32	500	16000
Fluorescent (2 x 40 W)	108	28000	3024000
Ceiling globes	11	6700	73700
One gang one way	39	1600	62400
Three gang one way	1	4500	4500
Two gang one way	1	3000	3000
One gang two way	1	2100	2100
Socket	15	3500	52500
Junction box	77	750	57750
Pipe 5/8"	80	550	44000
Pipe 1"	50	1100	+ 55000
			4721950 ₺

Range	Recommended* illuminance (lx)	Examples of area or activity
General lighting for rooms and areas used either infrequently and/or for casual or simple visual tasks	20	Minimum service illuminance in exterior circulation areas
	30	Outdoor stores, stockyards
	50	Exterior walkways and platforms; indoor car parks
	75	Docks and quays
	100	Theatres and concert halls; hotel bedrooms, bath rooms
	150	Circulation areas in industry, stores and stock rooms
General lighting for working interiors	200	Minimum service illuminance on the task
	300	Rough bench and machine work; general processes in chemical and food industries; casual reading and filing activities
	500	Medium bench and machine work; motor vehicle assembly; printing machine rooms; general offices, shops and stores
	750	Proof reading; general drawing offices; offices with business machines
	1000	Fine bench and machine work; office machine assembly; colour work; critical drawing tasks
	1500**	Very fine bench and machine work; instrument and small precision mechanism assembly, electronic components, gauging and inspection of small intricate parts.
Additional localized lighting for visually exacting tasks	≥ 2000	Minutely detailed and precise work, e.g. very small parts of instruments, watch making and engraving; operating area in operating theatres

* If minimum values are recommended, one step lower in illuminance can be taken.
** Can be done by local lighting. Optical aids should be considered.

Fig. 1-7. Scale of recommended service illuminances.

should be recommended for for use when formulating lighting specifications for particular purposes. They are:

- 20 - 200 lux for general lighting in infrequently used rooms.
- 200 - 2000 lux for general lighting in working interiors, and
- 2000 - 20 000 lux for additional, localized, lighting.

Table 3

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'TL' FLUORESCENT LAMPS

'TL' COLOUR CHOICE GUIDE

The 'TL' fluorescent lamp range offers a very wide choice of light colour the unique advantage that lighting characteristics can be closely match particular applications. In the following pages, an extensive range of applications is listed, with recommended 'TL' light colours in each case. many instances, several colours are indicated; the ultimate choice will d upon the specific requirement. True colour-rendering? Warm, relaxing li High light output? Compatibility with daylight, or with other forms of artifi light? Careful choice ensures the best results.
'TL' light colours fall into three main categories, determined by colour temperature.

Warm colours / 82, /83, /93, /29
Colour temperatures around 3000 K. Essentially comfortable and relaxir colours, generally blend well with incandescent light, but not with dayligh

White colours /84,/94,/33,/25,/37
Colour temperatures around 4000 K. Bright white light colours which con well with daylight. Generally for installations which supplement daylight c where a cool or businesslike atmosphere is required.

Daylight colours /86,/54,/47,/57
Colour temperatures around 6500 K. Very similar to daylight. Generally used for colour comparison or to create particularly cool lighting effects in warm areas.
The new generation 'TL'D 80 and 90 series offer superb colour appearance with a high colour rendering index and a higher light output than any othe light colour. In the case of the other light colours, the choice depends on the relative importance of colour rendering and light output, the one being obtained at the expense of the other.

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'TL' LIGHT COLOUR CHARACTERISTICS

Colour	Efficacy (lm/W)	Colour Rendering Index	Colour temperature (approx.) K	Features
/82	90	85	2700	Best mixer with incandescent light
/83	96	85	3000	Superb quality warm light
/93	65	93	3000	Superb colour rendering and high efficacy
/29	86	52	2900	For outdoor lighting
/84	96	85	4000	Superb quality white light
/94	65	93	3800	Superb colour rendering and high efficacy
/33	86	66	4100	High economy, reasonable colour
/25	69	75	4000	Well balanced colour and light output
/37	45	96	4100	Superb colour
/47	46	98	5000	Ideal for colour slides and prints[2])
/86	90	85	6500	Superb quality daylight colour
/54	69	77	6200	High output for a daylight tube
/57	47	94	7500	For colour appraisal and warm areas

[1]) Based on 'TL'D 36 W lamps, but colours /37, /47 and /57 based on 'TL' 40 W lamps.
[2]) Meets international recommendations.

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Table 4

/80 RANGE 'TL'D AND 'TL' LAMPS

High light output and good colour rendering in one and the same lamp. This ideal combination makes these lamps extremely suitable for energy-effective lighting schemes and for fully universal application in the indoor lighting sector.
The 'TL'D types are available for switch-start, the 'TL'M RS types for rapid-start, whilst the 'TL'RS is applicable for rapid-start (ANSI) and switch-start operation. The 'TL'D 18, 36 and 58 W versions, operating on 20, 40 and 65 W circuits, provide an immediate saving of energy.

Ø 38

Ø 26

5

Type	Length	Dia.	Weight	Colour [1]	Nominal luminous flux[2] lm	Ordering number
'TL'D 18W	600	26	97	/82[4]	1300	9280 480 082..
				/83	1450	9280 480 083..
				/84	1450	9280 480 084..
				/86	1300	9280 480 086..
'TL'D 36W	1200	26	186	/82[4]	3250	9280 485 082..
				/83	3450	9280 485 083..
				/84	3450	9280 485 084..
				/86	3250	9280 485 086..
'TL'D 58W	1500	26	229	/82[4]	5200	9280 490 082..
				/83	5400	9280 490 083..
				/84	5400	9280 490 084..
				/86	5200	9280 490 086..
'TL'D 23W	970	26	161	/83	2050	9280 455 083..
				/84	2050	9280 455 084..
'TL'D 36W-1	970	26	161	/83	3000	9280 456 083..
				/84	3000	9280 456 084..
'TL'D 38W	1050	26	162	/83	3200	9280 457 083..
				/84	3200	9280 457 084..
'TL'M 20W RS	600	38	156	/82[4]	1200	9280 300 082..
				/83	1250	9280 300 083..
				/84	1250	9280 300 084..
'TL'M 40W RS	1200	38	292	/82[4]	3000	9280 305 082..
				/83	3200	9280 305 083..
				/84	3200	9280 305 084..
'TL' 40W RS[3]	1200	38	292	/83	3250	9280 113 083..
				/84	3250	9280 113 084..
'TL'M 65W RS	1500	38	360	/82[4]	4900	9280 310 082..
				/83	5200	9280 310 083..
				/84	5200	9280 310 084..

[1]) For 'TL'D lamps in standard colours, see page 161.
[2]) After 100 burning hours.
[3]) For RS lamps in standard colours, see page 165
[4]) For details, see page 184 (TL*).

Table 5

Efficiency Value Of Direct System

Fluorescent Lamp	E_c %	70			50			30		
	E_w %	50	30	10	50	30	10	50	30	10
Illumination System	k	Efficiency (η)								
Direct	1.0	0.26	0.21	0.17	0.26	0.21	0.17	0.25	0.20	0.17
	1.2	0.31	0.25	0.21	0.30	0.25	0.21	0.29	0.25	0.21
	1.5	0.36	0.30	0.27	0.35	0.30	0.27	0.34	0.30	0.27
	2.0	0.42	0.37	0.33	0.42	0.37	0.33	0.41	0.37	0.33
	2.5	0.47	0.42	0.39	0.46	0.42	0.38	0.45	0.41	0.38
	3.0	0.51	0.46	0.42	0.50	0.46	0.42	0.49	0.45	0.42
	4.0	0.56	0.52	0.49	0.55	0.52	0.49	0.55	0.52	0.49
	5.0	0.60	0.57	0.54	0.59	0.59	0.54	0.58	0.56	0.53
	6.0	0.62	0.59	0.57	0.61	0.64	0.56	0.61	0.58	0.56

Table 6