ELECTRICAL SERVICE DESIGN FOR A PROPOSED OFFICE BUILDING HAVING A CONFERENCE HALL

BY

KASALI OLAWALE TAOFIQ

(2006/25777EE)

AND

USMAN LUKMAN OLAREWAJU

(2006/24384EE)

A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, FEDDERAL UNIVERSITY OF TECHNOLOGY MINNA.

NOVEMBER, 2010

DEDICATION

We cheerfully dedicate this work to Almighty God with thanksgiving. Also dedicate it to our parent for their constant and silent prayer for us.

DECLARATION

This is to declare that this project work was done by Kasali Olawale Taofiq and Usman Lukman Olarewaju and has never been presented elsewhere for the award of a degree.

We also hereby relinquish the copy to Federal University of Technology, Minna

3/11/2010

Kasali Olawale Taofiq

Mr. Ambafi J. G.

03/11/2010
....

1/12/10
....

Signature and Date

Signature and Date

Engr. Dr. G. I. Igbeka

Usman Lukman Olarewaju

External Examiner

03/11/2010
....

Signature and Date

Engr.A.G.RAJI

Head of Department

(Jan-11, 2011)
....

Signature and Date

ACKNOWLEDGMENT

Those who live in expectation of a large experience and support must expect to have to toe the profound gratitude line. In view of this, it becomes necessary for us to appreciate people who have either individually or collectively made this course of study a successful one.

We thank Almighty God who has given us the strength during our course of study.

We are also indebted to Mr. Ambafi J.G. and Mr. Bukola O. whose support and inspiration have made this project a successful one.

Our heartfelt regards to our mentor, benefactor and wonderful caring and loving people which we hold high esteem and profound gratitude for the unshaken confidence and unmistakable terms, these loving people cannot be easily wished away among them are; Kasali Kayode Rafiu, Abolarinwa Bukola, Bolanle Muhydeen,Usman Saheed and others. We are deeply touched by your kind gestures and proud of you all.

We are also grateful to the HOD Engr. A.G Raji and all the Lecturers in the department for the priceless knowledge they impacted on us.

ABSTRACT

This project presents design criteria of electrical services design of an office building based on cost effectiveness and safety. The use of AutoCAD to achieve the electrical services design is implemented in the design. The power requirement analysis was carried out based on the calculation of the installed equipment in the building in other to choose for the actual rating of the generator plant and number of distribution boards required.

TABLE OF CONTENT

CHAPTER FOUR

CHAPTER ONE

GENERAL INTRODUCTION

1.1 BACKGROUND

A building structure is just a carcass; it is the infrastructure that breathes life into the buildings to make it not only habitable but also comfortable. Most of the works in provision and maintenance of infrastructure are engineering based, hence the engineering infrastructure or engineering service. Building service experience is principally concerned with the provision of utility and environmental comfort for the occupant of the building.

The scope of building service engineering includes all aspects of design, installation, security and fire prevention, solar collectors, and water supply. This project write up is mainly concerned with electrical installation and unit (utility and environmental comfort).

The electrical utility services include the design and installation of power distribution system, communication distribution and fire protection system. The electrical comfort services have to do with visual comfort, that is lighting design installation. Lighting is necessary for task illumination, display and ambience, safety and security. This study is necessary for the provision of lighting to meet various requirements and also to provide an understanding of the various lighting tools available at ones disposal which is capable of efficient and effective visual environment. The electrical service design for a proposed office building is targeting a comfort and to reduce the consumption of electric energy and also to minimize wastage and unnecessary contrast in the building.

Thus, it is necessary to provide adequate utility services to a proposed office building such as:

1. Electrical distribution system.

2. Smoke detector and fire protection

3. CCTV. Camera and monitor

Electricity is a form of energy on modern building to provide utility services and environmental comfort requirement, its use in a building makes modest demand on space layout and structural planning of the building.

Since the main source of total energy requirement in building is electricity, this necessitates its effective utilization and safe installation. Though electricity is for comfort and also exists in a form that is convenient to harness, however, it could be a great source of danger to building, user and often the cause of domestic accident (fire outbreak in building, shock) where safety precaution are not adequately incorporated; use of substandard material in the electrical installation. It will also be important to install electricity as economically as optimized and design of the power distribution system should be convenient so as to minimize power losses.

The electrical installation and unit of the apartment is different in terms of illumination level, number of socket outlets, accessories and electrical appliances. The illumination level of each portion is different depending on the purpose it is really meant for.

The design was based strictly on the provision of the institution of electrical engineers (IEE) regulations while adequate provisions was made for flexibility so as to enable any necessary extension and alteration. Conduit system is chosen for durability so that the design can last for the life time of the installation. Many factors were put into consideration during the design. Some of these include safety, flexibility of installation, durability and cost of installation.

An office building contains conference hall, mailroom, library, lobby, staff room, kitchen, security office, waiting room, entry way, balcony, rest room, changing room/locker room, server room, workshop, bathroom/toilet, recreation room, and cafeteria.

1.2 AIMS AND OBJECTIVES

1. The aim of our project is to do the electrical service design of an office building so as to be safe, convenient, economical and environmentally friendly.

2. To promote the works or other activities carried out within the building

3. To create aesthetics in conjunction with the structure and decoration of the building.

4. To learn the electrical wiring information conveyed to the electrician/technician.

5. To develop familiarity with working specifications, electrical symbols and standard drawing notation used in electrical service design

6. To be aware of the needs for building permits and inspections.

1.3 MOTIVATION

The large extent of fire outbreaks in building due to substandard materials being used in electrical installation contracts motivated us to carry out this project work. In this regard, the design of electrical installation and unit for an office building was designed based on the provision of IEE regulations while adequate consideration was given to safety, use of standard material and comfort throughout the appliances, the accessories, the cable rating and the equipment, diligent consideration was given to safety in order to make a shock free and fire-free installation. Also maintainability and durability of the installation were put into consideration before designing.

1.4 METHODOLOGY

1. The whole installation distribution network is studied as a complete system. A selection guide is proposed for determination of the most suitable architecture of the building.

2. Neutral Earthing arrangement are chosen according to local regulations, constraints related to the power supply and to the type of loads.

3. The distribution equipment (Panel boards, switchgears, circuit connections) are determined from building plans, from the locations and grouping of the loads.

4.Each circuit is then studied in details from the rated current of the loads, the level of short-circuit current and the type of protective devices, the cross-sectional area of the circuit conductor can be determined, taking into account the nature of cable ways and their influence on the current rating of the conductor.

5. AutoCAD was used to implement the design of the lightings, distribution boards as well as other electrical outlet.

6. Measurement and Design of each of the office rooms was carried out so as to know the number of lamps in each room and to know the overall total number of lamps in the building. Also to calculate the number of distribution boards needed.

In the design, the under listed formulas were used:

$$\text{Total lumen} = \frac{luminance\ x\ Area\ of\ working\ plane}{Maintenance\ factor\ x\ Utilization\ factor}$$

$$F = \frac{E\ X\ A}{MF\ X\ UF}$$

$$\text{Number of Lamps, N} = \frac{Total\ Luminance}{Luminance/Lamp} = F / \varphi$$

LINE CURRENT (I_L) = $\frac{P_T}{\sqrt{3}\,x\cos\varphi\times V}$

P_T-total power on the distribution board

I_L-line current

V_L-Line Voltage

Ø-cos p.f where p.f is the power factor

$I_T = \frac{In}{CaCgCiCC}$

Where In=nominal current

Ca=Ambient Temperature Factor (Using 35^0c)

Cg= Group Factor

Ci=Insulation Factor

Cc=Correction Factor

CHAPTER TWO

2.0 THEORETICAL BACKGROUND/ LITERATURE REVIEW

2.1 HISTORY OF ELECTRICAL SERVICE DESIGN

Electrical service design was propounded by a strong of motivated team of qualified engineers with basic infrastructure to take on challenging assignments, provide innovative solutions to make stringent time commitment in the domestic and international market; given the right working environment of self-development. [10].The group stated the provisions of a broad range of convenient and superior service to the client; selecting recherché colours, furnishing and carefully considered the desire to balance traditional and contemporary element to generate extraordinary interiors that have high-end visual appeal, using the unique ability to bring together the mirage cultures and the impeccable beauty of the world. [11].

2.2 THE LITERATURE REVIEW

The following literatures were consulted in the course of this project work:

The federal Ministry of works and Housing (June, 1991) regulation for Standard specification for Electrical Installation in Government Buildings and Institutions.[1]

The Institution of Electrical Engineers Regulation for Electrical Equipment of Building Published 1981 with amendment in January 1983 covers prevention of fire risk arising from industrial and electrical installation work of a building.[6]

Factories,1961,memorandum by senior electrical inspector of factories deals with regulations that relates principally to design, selections, erections, inspection and testing of electrical installation, whether permanent or temporary, in and about building generally.[7]

Explanation note on electricity supply regulation, 1937, indicate the requirements to lay supply cables to a suitable point inside the building, from which point the installation commences.[8]

Electrical service design of a five star hotel by Osinowo olusegun Immanuel (1995/1996)

2.3 LIMITATIONS/SHORTCOMINGS

(1) Difficulties in obtaining approved equipment for use in designing electrical systems for hazardous locations.

(2) One of the problems encountered was that we have to go extra mile to familiarize ourselves with AutoCAD for a proper implementation of the design on a hard copy.

(3) Because of the diversity of our project, many literatures have to be reviewed before we could come out with our own design.

CHAPTER THREE

3.0 INTRODUCTION

3.1 BASIC DESIGN DATA

The design of a lighting installation entails the knowledge of the following basic design data;

(a) Plan and sectional drawings of a plan.

(b) Details of the ceiling construction

(c) Colours of walls and floors

(d) Usage of the room

(e) The furnishing or arrangement of machinery

(f) Operating conditions such as the temperature, humidity, dust etc.

3.2 <u>QUALITY OF LIGHT</u>

The quality of light in an interior illumination depends generally on the followings:

(a) Intensity of illumination (illuminance)

(b) Shadow effect and incidence of light

(c) Local uniformity

(d) Constant intensity (no flickering)

(e) No glaring

(f) Colour of light and colour rendering

The purpose of lighting design with which this chapter is mainly concerned is to enable people see clearly and comfortably. To design a lighting scheme, the quality depends on the comfort to eye (glare), space height ratio, and utilization factor, light loss factor (Maintenance) and colour of light. However, preventions of unnecessary strain and defective vision in the task of seeing is the utmost aim of the designer.

Lighting device requires more thought than the strategic placing of 60 watts bulb and the operation of a switch. Therefore, a great need to be creative in one's ability to display and reveal the visual scene, such must also have competent in his calculation and understanding of the lighting tools at his disposal. Thus, to say lighting is purely of human sensation is not overemphasing which is similar to electromagnetic radiation falling on retina.

The basic requirement for artificial lighting is to permit defective vision and unnecessary strain in the task of seeing; hence the visual task involved must be well planned while minimizing energy consumption.

Good lighting is necessary to the purpose of an office building and residential building and has three chief aims: these aims are;

(a) Careful planning of the brightness and colour patterns within both the working area and the surroundings so that attention is drawn naturally to the important area, details is seen quickly and accurately and room is free from any sense of gloom.

(b) Using directional lighting installation, minimizing flickering from certain types of lamp and paying attention to the colour rendering properties of light.

(c) Installing emergency lighting system where necessary.

3.3 COMMON LIGHTING TERMS

(a) LUMINOUS FLUX (φ):

This is the flow of light energy radiated from a source per second in the form of luminous light waves. It is a sort of power unit. The unit is lumen (7m).It is called flux contained per unit solid angle of a source or standard candela. The symbol is represented by (φ) .Therefore 1 lumen = 0.006 watt (approx.)

(b) **CANDELA**:`

It is the unit of luminous intensity of a source. It is defined as $1/60^{th}$ of the luminous intensity per cm^2 of a blackbody radiator at the temperature of solidification of platinum (2045^{0C}). A source of one candela (cd) emits one lumen per steradian. The unit of solid angle is steradian (sq). The total flux emitted by it is 4п x 1 = 4 п lumen

(c) **ILLUMINANCE**

This is the amount of light falling on an area A of a surface. it is denoted by E. it is called the intensity of illumination, the unit is " lux".

(i) Illuminance, E is directly proportional to the luminous intensity (I) of the source is [E α]

(ii) The illuminance of a surface is inversely proportional to the square of the distance of the surface from source.

I.e. $E = 1/d^2$

(d) **LUMINOUS INTENSITY [I] CANDLE POWER**

This is the power of source of light energy. In other words, it is solid angular flux density of a source of light in a given direction.

Luminous flux, [φ= 4пl] lumen.

(e) **LUMINANCE:** It is a measure of the brightness of a surface. It also a measure of the light which is reflected from a surface. The objects we see vary in appearance according to the light which they emit towards the eye.

(f) **COEFFICIENT OF UTILISATION**

This is a factor in illumination engineering taking care of the utilized flux reaching the working plane, since source of the emitted flux cannot get to the working plane. The effect of the above is to reduce the illumination on a working plane or contrarily to increase the power of the light source in order to achieve a given illumination level. Therefore, coefficient of utilization is the ratio of the utilized flux to the luminous flux emitted by the lamps.

(g) **MAINTENANCE FACTOR**

Lighting output from lamps could be reduced reasonably by dust and dirt on fittings. The ageing of lamps contributes to poor output illumination. In fact, maintenance factor is the ratio of the average illumination on the working plane after a specified period of use of a lighting installation to the average illumination obtained under the same conditions for a new installation. The figure could be between 0.7 – 0.8. Sometimes a depreciation factor is given instead of the maintenance factor. This is merely the inverse of the maintenance factor and for maintenance factor of 0.8 would be 1 / 0.8 = 1.25

(i) **SPACE TO MOUNTING HIGHT RATIO**

The correct mounting height of luminance is important since glare may result if fittings are placed on the line of vision. Excessive height will result in a rapid reduction of illuminance and make lamp replacement and maintenance difficult .The correct spacing of luminance is important since large spaces between them would be allowed to fall below 70% of the value directly below the fitting. For electrical services design of an office building, a spacing to mounting height ration 1 :1,1:2 and 1:1.5 above the working surface is considered adequate for different location.

(j) **MOUNTING HEIGHT**

The mounting height of light fitting is defined as their height above the working plane. In this design a suitable mounting height of 2.2m was used for all the ceiling mounted fittings.

(k) **ROOM INDEX (K) :**The room index relates the dimension of the room; height I, width w, with luminance height above working plane Hm,

Room index, k = $\frac{L \times W}{(L+W)Hm}$

Where L = Room length

W = Room width

Hm = Mounting height

3.4.0 DESIGN OF LIGHTING POINTS

There are two basic method for calculating size, number, and possible spacing of luminaires to provide a given level (foot candle) of illumination on a given plane or surface. These methods are called the point – by – point method and the lumen method.

3.4.1 THE POINT – BY POINT METHOD

It will utilize the inverse square law for a point source of light to determine what is needed to produce a given level of illumination on a given area. The method is somewhat laborious, since it involves computing the contribution from each luminaire in a system to the illumination of a given area. This method is useful in determining illumination levels produced by single or multiple fixtures for spot lighting and flood lighting. One of the disadvantages of this method is that it does not generally account for inter – inter reflections from room surfaces, when sued for determining illumination levels for general lighting. In order to be able to consider non-perpendicular surfaces, the point method is based on the addition of the cosine factor to the inverse square law to account for other surface orientations.

$$E = \frac{I \cos B}{d2}$$

Where E = illuminance at the receiving surface (lux)

I = the luminous intensity (cd) at the source when field from the direction to the receiving surface.

β = the angle between a line from the source to the surface and a vector normal to the receiving surface.

d = distance from the source to the surface

3.4.2 THE LUMEN METHOD

The design of a general lighting system is determined by room dimensions, structural features, reflection characteristics of walls and ceiling; and mounting height, intensity distribution, and maintenance characteristics of the luminaires. The basic goal of general lighting design is to deliver goal of general lighting design is to deliver a specified average lux level of illumination to a working pane or other plane of reference in a room.

However, the light emitted by the sources is variously affected and reduced by the reflection, diffusion, and absorption of the parts of the luminaire and the walls, ceiling, floor and objects in the room. The lumen method takes into account many of these variables in determining the final average illumination level.

Total number of luminaires required to provide a chosen level of illumination at a surface.

Lumen required (φ_{tot}) = $\frac{E \times A}{Uf \times Mf}$

Where E = the illuminance level is chosen after consideration of the I.E.E regulation

uf = the utilization factor

mf= maintenance factor

A=Area

In this project the lumen method was used to calculate the lighting point needed in each apartment.

3.5 FACTORS AFFECTING ILLUMINATION

The inverse square law calculations are only really applicable to point sources or where there are no reflecting surfaces such as that of outdoor lightening. For interior lighting, illuminations are produced on the working plane or on illuminated surfaces, by light fittings or by additional secondary source of light.

The secondary lights are produced by reflections from fitting themselves, walls and ceilings practical method of lighting calculations are based on using the lumen method, which considers various aspect of light distribution such as coefficient of utilization, maintenance factor and spacing height ratio. The lumen method gives a general illumination which may be supplemental by local lighting. The modern method is to provide for good overall illumination, and reduce the cost of providing for localized lighting.

The steps in the design can be summarized as:

(i) Choose the illumination (E) required

(ii) Select a suitable lighting fitting.

(iii)Decide on the mounting height.

(iv)Find the room index.

(v) Read off the calculated utilization factor.

(vi)Calculate the total lamp required.

3.6.0 **TYPICAL LAMP DATA**

Lamp wattage	Lumen	Output
	(Initial)	(Maintained)
7	400	320
9	600	480
13	900	720
18	1250	1000
23	1500	1200
26	1710	1368
32	2400	1920
4 2	3200	2560
52	4000	3360

Table 3.0

3.7 **DISCHARGE LAMPS**

Discharge lamps are depending upon electric discharge in gasses and metallic vapours. They usually have much higher luminous efficiencies than filament lamps, up to 1001m/w. the colour of the light produced depends upon the type of gas or metallic vapour contained within the tube. Some examples are given below:

Gases	Neon	Red
	Argon	Green/Blue
	Hydrogen	Pink
	Helium	Ivory
	Mercury	Blue
	Sodium	Yellow
	Magnesium	Grass Green

Table 3.10 shows gases and metallic vapour with colour produced within discharge lamps.

The table below shows typical values for utilization factors of interior and industrial luminaires under defined conditions.

	Type of illumination (Light	Illumination efficiency (η) or

	distribution)	utilization factor
A	Direct	0.70 – 0.45
b.	Mainly direct (semi – direct)	0.65 – 0.45
C	Uniform (General diffusing)	0.65 – 0.35
D	Mainly indirect (semi – indirect)	0.45 – 0.35
E	Indirect	0.35 – 0.25
F	Indirect (cornice lighting)	0.20 – 0.15

Table 3.2

3.8 <u>CALCULATION (DESIGN) OF LIGHTHING FOR EACH ROOM</u>

$$\text{Total lumen} = \frac{luminance\ x\ Area\ of\ working\ plane}{Maintenance\ factor\ x\ Utilization\ factor}$$

$$F = \frac{E\ X\ A}{MF\ X\ UF} =$$

$$\text{Number of Lamps, N} = \frac{Total\ Luminance}{Luminance/Lamp} = F / \varphi$$

(1) Conference Hall (210.60 sq.m)

$$\text{Total lumens} = \frac{300\ x\ 210.60}{0.8\ x\ 0.65} = 121500\ \text{lumen}$$

Number of lamps = $\frac{121500}{4000}$ = 30.375

= **30 lamps**.

(2) Meeting Room(946.978sq)

Total lumens = $\frac{250 \times 46.978}{0.8 \times 0.35}$ = 41944.6 lumen

Number of lamps = $\frac{41944.6}{3200}$

=13.107687

13 lamps

(3) Waiting Room (68.271 sq.m)

Total lumen = $\frac{250 \times 68.271}{0.8 \times 0.65}$ = 32,822.5961

Number of lamps= $\frac{32822.5961}{3200} = 10\ lamps$

(4) Staff Room (46.977sqm)

Total lumen = $\frac{250 \times 46.977}{0.8 \times 0.65}$ = 22, 585.09615 lumen

Number of lamps = $\frac{22,585.09615}{4000}$ = 5.64637

6 lamps

(5) Workshop (22.8927m^2)

Total lumen = $\frac{250 \times 22.8927}{0.8 \times 0.65}$ = 11,006.10577 lumens

Number of lamps = $\frac{11,006.10577}{3200}$ = 3.4394

$= \quad$ 4 lamps

(6) Rest Room (17.154 sq.m)

$$\text{Total lumen} = \frac{8247.1153}{3200} = 8{,}247.1153 \text{ lumens}$$

$$\text{Number of lamps} = \frac{8247.1153}{3200} = 2.57722$$

$= \quad$ **2 lamps**

(7) Kitchen (17.154sq.m)

$$\text{Total lumen} = \frac{250 \times 17.154}{0.8 \times 0.65} = 8\ 247.1153 \text{ lumens}$$

$$\text{Number of lamps} = \frac{8{,}247.1153}{3200} = 2.57722$$

$= \quad$ **2 lamps**

(8) Lobby (25.104sq.m)

$$\text{Total lumen} = \frac{300 \times 25.104}{0.8 \times 0.65} = 14{,}\ 483\ .07692 \text{ lumen}$$

$$\text{Number of lamps} = \frac{14483.07692}{4000} = 3.620769231$$

$=$ **4 lamps.**

(9) Toilet/Bathroom (6.574)

$$\text{Total lumen} = \frac{250 \times 6.574}{0.8 \times 0.65} = 1643.5 \text{ lumens}$$

Number of lamps $= \frac{1643.5}{3200} = 0.51359$

$=$**<u>1 lamp</u>**

The summary of the lighting calculations is in appendix 1

Calculation of Room Index

The following mounting height (Hm) for various building are suggested by BZ (British Zonal) system,

For general office, (BZ 1 and BZ 2) = 2.15m,

For small reception (BZ 3 and BZ 4) =1.85m

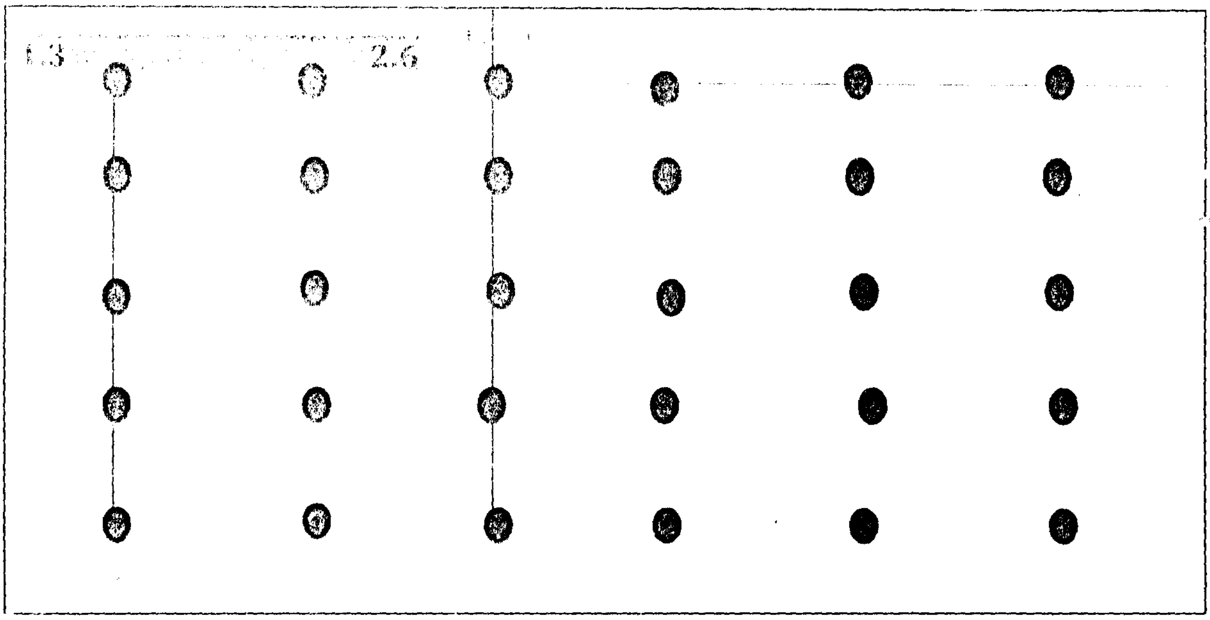
Room index, $k = \frac{L\ X\ W}{(L+W)Hm}$

Where L = Room length

W = Room width

Hm = Mounting height

For Conference Hall: $\frac{15.60 \times 13.50}{2.15(15.60+13.50)} = 3.36$



ARRANGEMENT OF LUMINIERS USING CONFERENCE ROOM AS AN EXAMPLE

POSSIBLE WAYS OF ARRANGEMENT

(i) 30x1= 15.60/30 = 0.52

(ii) 15X2= 15.60/15 = 1.04

(iii) 6X5 =15.60/6 = 2.6

Final arrangement (iii) was chosen due to its flexibility and suitable

Other apartment lighting is as shown in Appendix 1

POWER DESIGN

3.9.0 INTRODUCTION

In any design for power supply to a building, It is practical to start with the final sub circuits design. A final sub circuit according to the IEE regulation is defined as an outgoing circuit connected to a distribution board and intended to supply electrical energy to current using apparatus either directly to socket outlets or fused spurs boxes.

A final sub circuits make up the greater part of electrical installation it varies from a pair of 1mm cables feeding one lamp to a heavy three core paper insulated lead copper cable feeding large industrial motors from circuits breakers.

Five general groups of final subscripts are –

(a) Rating not exceeding 15A

(b) Rating exceeding 15A

(c) Rated for 13A fused plugs

(d) Rated for feeding fluorescent and other discharge – lamp circuits.

(e) Rated for feeding a motor

3.9.1 DIVERSITY FACTOR

Diversity factor is very important in an electrical installation design and final costing of materials. The factor is based on the assumption that the whole connected load wouldn't be ON at the same time. Diversity factor is applied to sub – mains and mains cables and associated switch gear. The provision of an allowance or a value for a diversity factor is a matter of special knowledge and experience. As it was indicated on appendix (1) of the IEE regulation, it is just a guide and can be increased or decreased by the engineer based on his experience.

3.9.2 POWER FACTOR

The power factor of an electrical power system is defined as the ratio of the real power flowing to the load to the apparent power. It is usually expressed as a dimensionless number between 0 and 1; specifically the cosine of the phase angle between the voltage and the current

3.9.3 FACTORS INVOLVED IN THE CHOICE OF FINAL SUB-CIRCUIT

The following factors are that determine the loading of a final sub – circuit.

(a) CIRCUIT RATED NOT EXCEEDING 15A

Circuits rated under 15A may feed unlimited number of points provided the arithmetic sum of the total currents demand is not greater than 15A. The points under this category are 15A, 13A, 5A, 2A socket outlets, lighting sockets, stationary appliances and other negligence loads. No diversity factor is applied on final sub –circuit (except for that of lighting points of an office building which has the diversity factor of 75%).

Current rating of cables must not be exceeded where there is need to increase cable size to compensate for excessive voltage drop, fuse rating must not be increased, lighting circuits in domestic installation are rated at 5A while industrial lighting are rated at 15A.

(b) CIRCUIT RATED AT 13A

There are two types – radial and ring circuit, these types of circuit is said to be feed stationary appliances. The regulation states that all stationary appliances should be connected permanently to a radial or ring final subscript and should be protected with a fuse rating not exceeding 13A and controlled by a switch.

(c) **CIRCUIT RATED OVER 15A**

These categories should not serve more than a point except where it is used to feed 13A switch plug and in cooker control units.

(d) **CIRCUIT FEEDING MOTORS**

Cables carrying the starting, accelerating and load currents of a motor must be rated at least to the full load current rating of the motor. If motor is function of frequent starting and stopping cable size should be increased to allow for increase in conductor temperature. More than one motor may be connected to 15A final sub-circuits provided the aggregate full load current is not more than 15A.

(e) **FINAL SUB-CIRCUIT PROTECTED**

Final sub – circuit protection is by means of fuses and miniatures circuit breakers located at switches boards and distribution boards. The protection is for over current caused by short circuit between conductor and earth, or over load. The protective gear should operate without danger of fire risks or damage to equipment. In large installation like the proposed office building having a conference hall in question, where there are main circuits, sub-main circuits and final sub-circuits, discriminating factor in providing protective circuits breakers are used by setting sub-circuit breaker to operate at a lower over current value and a shorter time lag than the mains circuit breakers. For instance, if a fault occurs on a final sub – circuit, the final sub – circuit gear will operate while the main breaker remains closed. If however, the fault persists and circuit breaker falls to operate within its specified time, then the main breaker may trip off, in one or two seconds later. Discrimination can only be achieved where the sub-circuit rating is less than 50% of the main circuit rating.

(f) **RING CIRCUITS**: The ring circuits were used for both the 13A single and double switch socket outlet and they were reasonably shared in the circuit, while radial circuits were used for 15A unit and water heaters.

3.9.4 **DISTRIBUTION BOARD DESIGN**

The distribution board is the assembly of fuses on circuit breakers arranged for the control and distribution of electrical energy to final sub-circuit within a dwelling. Although it can be applied to the distribution board from a main to sub-mains or other distribution board.

The methods used in designing distribution board and choice of cables sizes for an office building is clearly shown in below calculation

An office building was grouped and distributed according to the plan. Whereby if there is problem, the entire building shall not be affected or be out of power supply. Also, if there is main power failure, the generator would be able to supply power to the desired part of the building.

From the table in appendix 2

TOTAL POWER OUTPUT (P_T) = 11363.60 + 11349.10 + 11198.40

= **33911.10W**

LINE VOLTAGE (V_L) = 415V

POWER FACTOR (P.F) = COS φ = 0.8

LINE CURRENT (I_L) = $\frac{P_T}{\sqrt{3}\ x \cos\varphi \times V}$

$$= \frac{33911.10}{1.732\ x\ 415\ x 0.8}$$

$$= \underline{\mathbf{58.97A}}$$

DISTRIBUTION FUSE CHOSEN FOR DB A = 100A, 10WAYS TPN & N

From the table in appendix 3

Total power output (P_T) = 10424.50 + 10578.70 + 10581.70

$$= \underline{\mathbf{31584.90}}$$

LINE VOLTAGE (V_L) = 415V

POWER FACTOR (P.F) = COS φ = 0.8

LINE CURRENT (I_L) = $\frac{P_T}{\sqrt{3}x\ V_L\ x \cos\varphi} = \frac{31584.90}{1.732\ x\ 415\ x\ 0.8}$

$$= \underline{\mathbf{54.93A}}$$

DISTRIBUTION FUSE CHOSEN FOR DB B = 100A, 10WAYS TPN.

From the table in appendix 4

TOTAL POWER OUTPUT (PT) = 14746.80 + 14887.80 + 15059.60

= **44694.20**

LINE VOLTASGE (V_L) = 415

POWER FACTOR (PF) = COS φ = 0.8

LINE CURRENT (I_L) = $\frac{PT}{\sqrt{3}x\,V_L\;x\cos\varphi} = \frac{44694.20}{1.732\,X\,415\,X\,0.8}$

= **77.72A**

DISTRIBUTION FUSE CHOSEN FOR DB C = 100A, 12WAYS TP&N

3.9.4.1 **SUMMARY OF DISTRIBUTION BOARD DESIGN**

S/N	DESCRIOPTION OF DISTRIBUTION BOARD	CALCULATED LOAD CURRENT (A)	CABLE SIZE (MM^2)	DB FUSE RATING (A)
1	DBA	58.97	25	100,10WAT TPN
2.	DBB	54.93	25	100A, 10 WAT TPN
3	DBC	77.72	35	100A, 12 WAT TPN

TOTAL LOAD CURRENT = 191.62A

MAXIMUM DEMAND ON THE MAIN MV PANEL BOARD

= 33911.70 + 31584.90 + 44694.20 = 110.190.2

$$I = \frac{P}{\sqrt{3} x\ V_L\ x \cos\varphi}$$

COS $\varphi = 0.8$

$$\frac{110190.2}{1.732\ X\ 415\ 0.8}$$

= **191.63A**

DISTRIBUTION FUSE CHOSEN FOR THE MV PANEL IS 200A

3.9.5 **TRANSROMER RATING**

Total load current computed = 191.63 A

Where line voltage = 415 v

Power factor = cos φ = 0.8

Total power in kw, $P_T = \sqrt{3}$ X VL X IL

= $\sqrt{3}$ x 415 x 191.63

= 137743.85 W

Total rating of load in VA = $\frac{KW}{P.F}$

$= \frac{137743.85}{0.8}$

= 172180VA

Using Diversity Factor of 0.6

$172180 \times 0.6 = 103,308VA$

Considering 20% of total for planned and unplanned load

$20\% \times 103,308VA$

$= 20661.6VA$

Total VA=20661.6+103,308=123969.6VA

$\frac{123969.6VA}{1000} = 123.97KVA$

Based on the value above, 150KVA,/415VOLT,3-phase, 50HZ transformer is chosen

3.9.6 CALCULATIONS OF CABLES TO FEED THE DISTRIBUTION BOARDS FROM THE MV PANEL AND THE MV PANEL FROM THE TRANSFORMER

DITRIBUTION BOARD A

$$It = \frac{In}{Ca \times Cg \times Cc \times Ci}$$

Where In=nominal current

C_a=Ambient Temperature Factor (Using 35^0c)

C_g= Group Factor

C_i=Insulation Factor

Cc=Correction Factor

$$=\frac{100}{0.94}=106.38$$

From page 117(Appendix 8) of IEE Regulations 15th Edition.4x35mm^2 Multicore Armoured PVC Insulated Cable (copper conductor) is chosen.

DITRIBUTION BOARD B

$$It=\frac{In}{Ca\times Cg\times Cc\times Ci}$$

$$=\frac{100}{0.94}=106.38$$

From page 117(Appendix 8) of IEE Regulations 15th Edition.4x35mm^2 Multicore Armored PVC Insulated Cable (copper conductor) is chosen

DITRIBUTION BOARD C

$$It=\frac{In}{Ca\times Cg\times Cc\times Ci}$$

$$=\frac{100}{0.94}=106.38$$

From page 117(Appendix 8) of IEE Regulations 15th Edition.4x35mm^2 Multicore Armored PVC Insulated Cable (copper conductor) is chosen

MV PANEL

$$It=\frac{In}{Ca\times Cg\times Cc\times Ci}$$

$$=\frac{200}{0.94}=212.765$$

From page 117(Appendix 8) of IEE Regulations 15th Edition.4x95mm^2 Multicore Armored PVC Insulated Cable (copper conductor) is chosen

3.9.7 STAND-BY GENERATOR

Based on the total connected load 150KVA, 415V, 50Hz Generator is recommended. However, before any generator has to be installed, the following conditions must be met;

The terminal voltage (effective) of the incoming alternator must be the same as the bus-bar voltage.

The speed of the incoming machine must be such that its frequency equals bus-bar frequency.

The phase of the alternator voltage must be identical with the phase of the bus-bar frequency.

This means that such must be closed at or very near the instant of two voltages have correct phase relationship.

The following are the reasons why 150KVA, 415V, 50Hz Generator is chosen, these are;

(a) FOR CONTINUITY OF SERVICE

Continuity of service is one of the most important requirements of any electrical apparatus. This would be impossible if power plant consist of a single unity because in event of breakdown of such a unity the whole premises will be in darkness which supposes not to occur in an office building. In recent years, the requirement of uninterrupted service has become so important especially in offices and building.

(b) FOR EFFECTIVE MAINTENANCE AND REPAIR

It is considered a good practice to inspect generators carefully and periodically to forestall and possibility of failure or breakdown. This is possible only when the generator is at rest (i.e. "off position").

(C) 150KVA Generator was chosen because of future extension of the existing load and is the nearest available rating in the market

CHAPTER FOUR

4.0 TESTING AND MEASUREMENT

Tests and measurements are carried out in an electrical installation for these main reasons are:

(i) To locate the exact position of the breakdown.

(ii) To find solution to the cause of the failure.

(iii) To ensure (by means of regular tests and measurement) that an installation remains in a sound working condition throughout its life (The IEE regulation attaches considerable importance to periodic inspection-routing maintenance).

4.1 TEST OF NEW INSTALLATION

Before connecting a new electrical installation to supply some test are required to indicate the quality of the work. These tests include;

A. **INSTALLATION RESISTANCE**

This is the resistance between the following parts of an installation.

i. A phase line and the consumer's earth terminal measured with 500V D.C across the line conductor and the earth terminal

ii. A phase line and neutral measured with 500V D.C across the line conductor and the neutral conductor with the neutral link removed.

iii. One phase line and another measured with 500V D.C across the line conductor.

iv. Live part and metal frame of an appliance or equipment with 500V D.C across the live conductor and the metal frame.

For each sub-circuit, the test is made with lamps and all other appliances and loads disconnected and fuses and switches closed. Where the removal of an appliance is not practical, all the associated local switches should be open. The insulation resistance in (i-iii) not less than 1n as measured with a mugger, in IV, it is to be less than 0.5n.

(B) EARTH CONTINUITY CONDUCTOR (ECC) RESISTANCE

This is the resistance between the earthed pant in the socket outlet and the consumer's earthing terminal, measured for each sub-circuit. It should not exceed 0.5n where the ECC is partly of cable or wholly of cable sheath, steel conduct or metal pipe and 1n where it is a separate copper or aluminum conductor.

(C) EARTH LOOP IMPEDANCE

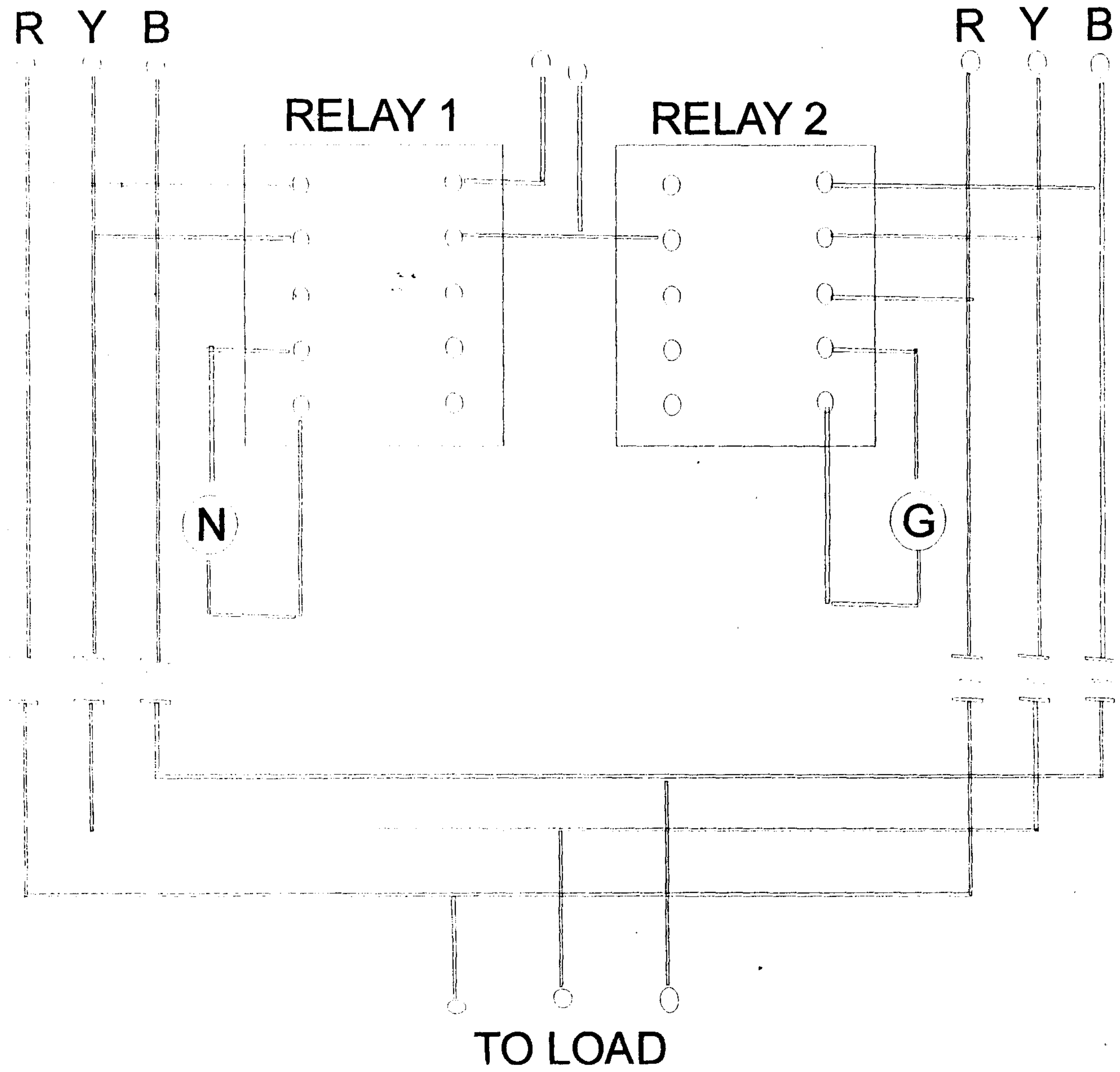
This is the resistance of the part of fault current from the live conductor connection of the equipment or appliance to the metal conductor parts along the EEC to the to the consumer's earthing lead and hence to the consumer's earth electrode. From here to the part continues to the general mass and to the PHCN earth electrode connected to the neutral of the supply transformer through the transformer winding and along the supply line through the consumer's wiring back to the fault. This path is the line neutral loop.

(D) EARTH TESTING INSTRUMENTS

These instruments are used for testing the resistance of the earth electrode resistance area. The principle involved in testing is passed through the electrode under tests and the earth to a distance auxiliary electrode. The potential is measured between the electrodes under test and a center potential electrode. The resistance is obtained by dividing the voltage reading thus obtained the current flowing in the circuit.

4.2 AUTOMATIC POWER CHANGE OVER

If the main power supply service fails, equipment must be provided to start the engine of the stand-by generator and transfer the supply connections from the regular source (PHCN) to the generator. These operations can be accomplished by a control panel as shown in Fig below:



AUTOMATIC POWER CHANGE OVER EQUIPMENT

RELAY 1: voltage sensitive

RELAY 2: Voltage and frequency sensitive

Coil: Powered from Regular Source

Coil: Powered from Emergency Source

A Voltage sensitive relay is connected to the main power source. This relay (transfer switch) activates the control cycle when the correct speed, a set of contactors is energized to the correct speed, a set of contactors is energized to disconnect the load from its normal supply and connect it to the generator output.

4.3 EARTHING

Earthing is connecting to the earth through on earth electrode to provide a reference voltage point. The ultimate purpose of earthing is to achieve equi-potential bonding where by all exposed metal conductive parts are at the same potential as the earth continuity conductor, it is therefore essential that through as installation the whole length of metal conduit, including couplers, fittings, boxes and all exposed metal work must be effectively connected to the general mass of the earth as near as possible to the consumer's terminal

In this design (Design of electrical installation) and units for a proposed office building the consumer's earthing terminal is connected by the earthing lead to an effective earth electrode using copper strip, buried in the ground near to the consumer's earthing terminal

4.3.1 FUNCTION OF EARTHING

For all that the earth is an in efficient conductor, it is widely used in electrical work, and there are three main function of earthing

1. To maintain the potential of any part of a system at a definite value with respect to earth
2. To allow current to flow to earth in the events of a faults, so that the protective gear will operate to isolate the fault circuit.
3. To make sure that, in the event of a fault, apparatus normally "dead" cannot reach a dangerous potential with respect to earth,(earth is normally takes as OV, no Volt)

4.3.2 EARTH ELECTRODE RESISTANCE

The resistance to earth of an electrode will depends upon its shape, size and resistance of the soil. A copper rod about 1m long is used as an earth electrode (fig) It is sunk into the ground at a continent position and then connected securely to the earth- continuity conductor (protective earth conductor or circuit protective conductor) through the earth head, the connection to the earth electrode should be from and secure in a "trap" which can be opened for inspection A warning sign to prevent disconnection of the earth should be displayed.

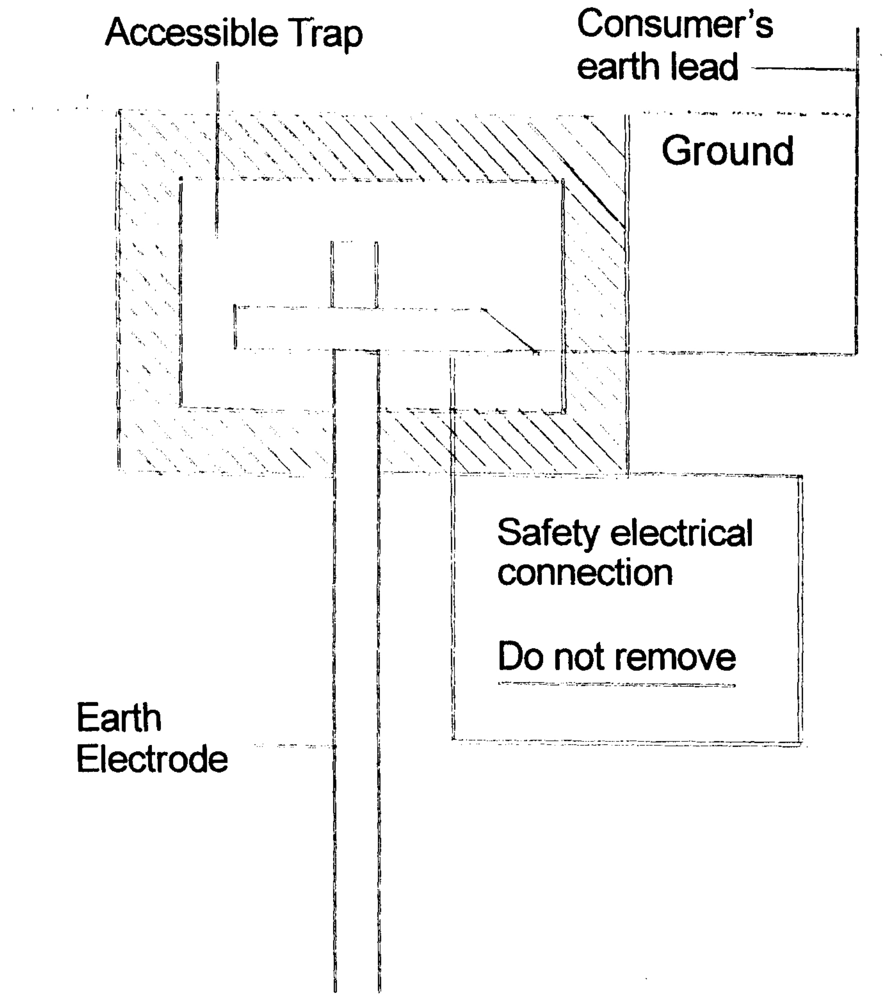


Fig. Earth electrodes sunk in the ground.

In addition to the earth, the following are used as earth continuity conductors (protective earth or circuit protection conductors).

1. Metallic reinforcement of concrete structures
2. Metal Pipe
3. Metal Conduits
4. Metallic sheath

These will have resistance in parallel with the earth electrode resistance

4.4 LIGHTNING CONDUCTOR

This is a protective device consisting of a pointed metallic rod set up on an exposed elevation of a structure and connected to carry the current of lighting discharge to the ground, Tall structures require a lighting conductor also known as arrestor to protect the installation from lighting discharge

A thunder – Cloud striking a building structure can result is a transient disturbance of several thousand volt with respect to the earth, unless the transient current discharge is safely conducted to the earth, it may damage the electrical installations where there is no light timing conductor which may cause the ELC13 to trip; even then some sensitive electronic gadgets can get damage.

A lightening conductor should be provided with its own earth electrode, which must not be connected to any conductor. This is because the discharge current may be so high as to cause a voltage between the earth and any conductor connected to it.

4.5.0 FIRE ALARM SYSTEM

They say fire could be regarded as a good servant but a bad master; the ruin action of fire to lives and properties cannot be over-emphases in an electrical installation design of buildings be it domestic building or commercial building it is on the basis of this that fire alarm system is essential in all modern buildings.

Fire alarm circuits are therefore defined as the arrangement of cells points, detectors and sounder. In any commercial building, a case with proposed office building premises adequate provision must be made for giving warning in case of fire and should be clearly audible throughout the building. A fire alarm circuit as its name implies sounds an alarm in the event of fire outbreak.

4.5.1 FIRE DETECTORS

The function of a fire detector is to detect one or more changes in the protected environment that would indicate the development of fire condition detectors are usually mounted at ceiling level or in air dusts.

Four stages in the development of fire can be produced.

1. After ignition, when visible product of combustion are being produced.
2. When visible smoke is produced.
3. Where there is significant rise in temperature produced by the fire.
4. When flame and heat are being produced.

4.5.2 SMOKE DETECTOR

A well –planned smoke detector system should be put into critical areas and in numbers sufficient to assume full coverage of the office complex the smoke detector used for design of proposal prototype customary court of appeal is smoke sensitive equipment that are sent signal within its environs .Basically, there are two types of smoke detector, which works on either Photo electric detectors or ionization detectors. Photo electric detectors are more sensitive to smoke from taste flames

4.5.3 ALARM INDICATORS

Alarm- Indicator device that actually signal fire condition, include audible device such as bell (vibrating and single – stroke types) horns Chinese, speaker, visual indicator.

4.5.4 HEAT DECTECTOR

The function of heat detector is to give a signal whenever there is a risk in temperature within the building to be taken to prevent any disaster.

4.5.5 ALARM STATION

A fire alarm station is a normal alarm indicating device and is also referred to as "Pull box" or "Fire box" a person must physically activate the station to turn into alarm

4.6.0 RESULT

Upon the calculations carried out on the lighting and power design, the following results were tabulated below:

S/N	DESCRIPTION	TOTAL NUMBER
1	Lighting (Lamps)	220
2	Distribution board (D.B)	3
3	Air Condition (A.C)	31
4	13Amperes Socket outlet	128
5	15 Amperes	8
6	20 Amperes	31

7	Switches	178
8	Fans	149
9	Hand drier	8
10	150KVA Generator	1

Table 4.0

4.6.1 DISCUSSION OF RESULT

(1) From the design (calculation) it shown that the total number of loads in a building determine the rating and the number of distribution boards required .

(2) Based on the calculated load in KVA, 150KVA,/415Volt 3-phase,50HZ, generator is recommended.

4.7 LIMITATIONS/ PROBLEM ENCOUTERED

(1) Difficulties in obtaining approved equipment for use in designing electrical systems for hazardous locations..

(4) One of the problems encountered was that we have to go extra mile to familiarize ourselves with AutoCAD for a proper implementation of the design on a hard copy.

(5) Because of the diversity of our project, many literatures have to be reviewed before we could come out with our own design.

4.8 COST ANALYSIS OF THE DESIGN

TABLE 4.1: CABLE COST

S/N	DESCRIPTION	UNIT COST (₦)	QUANTITY	TOTAL COST (₦)
1	1.5mm^2	55	300	16,500.00
2	2.5mm^2	90	150	13,500.00
3	4mm^2	230	200	46,000.00
4	35mm^2	1050	180	189,000.00
5	95mm	2500	60	150,000.00
TOTAL				415,000.00

DISTRIBUTION BOARD

S/N	DESCRIPTION	UNIT COST (₦)	QUANTITY	TOTAL COST (₦)
1	100A,10 WAYS,TP&N DB	9000	2	18,000.00
2	100A,12 WAYS, TP&N DB	9500	1	9,500.00

TOTAL				27,500.00

SOCKET OUTLET

S/N	DESCRIPTION	UNIT COST (₦)	QUANTITY	TOTAL COST (₦)
1	13A	160	128	20,480.00
2	15A	200	8	1,600.00
3	20A	300	35	10,500.00
TOTAL				32,580.00

SWITCHES

S/N	DESCRIPTION	UNIT COST (₦)	QUANTITY	TOTAL COST (₦)
1	1 Gang	100	86	8,600.00
2	2 Gang	150	62	9,300.00
3	3 Gang	250	30	7,500.00
TOTAL				25,400.00

LAMPS

S/N	DESCRIPTION	UNIT COST (₦)	QUANTITY	TOTAL COST (₦)
1	52 watts	800	105	84,000.00
2	42 watts	740	74	54,760.00
3	40 watts	700	35	24,500.00
4	180 watts	1650	6	9,900.00
TOTAL				173,160.00

ACCESSORIES

S/N	DESCRIPTION	UNIT COST (₦)	QUANTITY	TOTAL COST (₦)
1	Lamp Holder	55	220	12,100.00
TOTAL				12,100.00

OTHERS

S/N	DESCRIPTION	UNIT COST (₦)	QUANTITY	TOTAL COST (₦)
1	A.C (Air	30,000.00	31	930,000.00

	Condition)			
2	Ceiling Fan	3,500	149	521,500.00
3	150KVA Generator Plant	850,000.00	1	850,000.00
TOTAL				2,301,500.00

GRAND TOTAL=2,301,500+12,100+173,160+25,400+32,580+27,500+415,000 =

₦2.987,240.00

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.0 CONCLUSION

The design of electrical Installation of a proposed office building was carried out bearing in mind the economy of the design

Various salient points are involved in a proposed office building such as the size of the object to be illuminated. A big object does not need a too high illumination level while glare must be prevented.

With this electrical service design write-up, we sincerely believe that the implementation aspect can be carried out with little or no other paper work. In carrying out this aspect, those charged with the responsibility of purchasing the materials should do so from the recommended company and the electrical wiring information is conveyed to the technician in order to carry out a safe installation.

With this design, it is evidence that the building is safe from electric fire outbreak. All cables presented to be used were calculated to the specified standard in accordance to IEE regulations

5.1 RECOMMENDATION

No additional, temporary or permanent electrical installation should be made to the authorized load of an existing installation unless it has been ascertain that current rating and the condition of any existing conductor which will have to carry the additional load is adequate for the increased loading. Moreover, any one intending to interpret this design to consult the legend fitting accessory or aspect of the design should be read in this project report. Those charged with the responsibility of electrical installation should strictly abide by the material specified. On no condition, should any substandard material be used during the electrical installation of any aspect of this work.

On completion of the work, all the installations must be tested and measured to ensure that the electrical installation is free from fault and conforms to IEE regulation.

We sincerely welcome advice, criticism and suggestion on the design implementation of electrical installation and unit of the proposed office building and consultancy service in general for the promotion of electrical engineering in Nigeria.

REFERENCES

[1] Standard specification for Electrical installation in government building and institutions, federal ministry of works in all states of federation and Abuja, June 1991

[2] Whitney, William J; Electrical Wiring Residential, United States; John Wiley and Son Incorporated Press 1979

[3] Electrical networks design and installation in buildings, 2nd Edition, by Prof. Oria Osifo.

[4] G. Seip (1979) - Electrical installation Handbook volume I and 11 Hayden & Son Ltd, first edition, London.

[5] Chambers Encyclopedia Volume 5: International Learning Systems Corporation Press, 1973.[6] The institution of electrical engineers regulation for electrical equipment of building published 1981 with amendments in January 1983 covers prevention of fire risk arising from industrial and electrical installation of a building.

[7] Factories 1961, Memorandum by senior electrical inspector of factories deal with regulations that relates principally to design, selections, elections, inspection and testing of electrical installation whether permanent or temporary in and out of the building.

[8] Explanation note on electricity supply regulation, 1937, indicate the requirements to lay supply cables to a suitable point inside the building, from which point the installation commences.

[9] http://www.dfxsystem.org 2010

[10] http://www.contructiondir.com/lighting-service.html

[11] Electrical service design of a five star hotel by osinowo olusegun Immanuel (1995/1996)

APPENDIX 1

SUMMARY OF LIGHTING DESIGN FOR EACH ROOM

NO	APARTMENT	LENGTH (M)	WIDTH (M)	AREA (M^2)	MOUNT HEIGHT	CEILING	WALL	ROOM INDEX	UTILIZATION FACTOR	ILLUM. FACT.	MAINT FACT.	LUMEN FACT.	N
1	CONFERENCE HALL	15.60	13.50	210.60	2.15	0.7	0.5	3.36	0.65	300	0.8	400	30
2	MEETING ROOM	6.740	6.970	46.978	2.15	0.7	0.5	1.59	0.35	250	0.8	3200	13
3	WAITING ROOM	5.77	11.832	68.271	2.15	0.7	0.5	1.52	0.65	250	0.8	3200	10
4	STAFF ROOM	2.8199	16.659	46.977	2.15	0.7	0.5	1.12	0.65	250	0.8	4000	6
5	WORK SHOP	5.570	4.11	22.8927	2.55	0.7	0.5	0.93	0.65	250	0.8	3200	4
6	REST ROOM	5.23	3.28	17.154	2.15	0.7	0.5	0.94	0.65	250	0.8	3200	2
7	KICTHEN	5.23	3.28	17.154	2.15	0.7	0.5	0.94	0.65	250	0.8	3200	2
8	LOBBY	5.871	4.276	25.104	2.15	0.7	0.5	1.16	0.75	300	0.8	4000	1
9	TOILET/BATHROOM	2	4.574	6.574	2.15	0.7	0.5	0.47	0.65	250	0.8	3200	1
10	BALCONY	5.570	4.11	22.8922	2.15	0.7	0.5	1.10	0.65	250	0.8	3200	4
11	TOILET/BATHROOM	2	4.574	6.574	2.15	0.7	0.5	0.39	0.65	250	0.8	3200	1
12	RECREATION OFFICE	15.00	5.00	45.00	2.15	0.7	0.5	0.90	0.48	250	0.8	3200	8

13	PARKING LOT	11.610	7.01	81.397	2.15	0.7	0.5	0.48	0.36	60	0.8	6200	3
14	CHANGING ROOM	3.60	2.50	9.00	2.15	0.7	0.5	0.69	0.26	250	0.8	3200	2
15	LIBRARY	7.562	6.411	48.374	2.55	0.7	0.5	1.36	0.65	0.65	0.8	3200	6
16	MAIL ROOM	5.467	3.482	19.036	2.15	0.7	0.5	0.99	0.65	250	0.8	3200	2
17	ENTRY WAY	5.570	4.110	22.8927	2.15	0.7	0.5	1.10	0.65	250	0.8	3200	4
18	CAFETERIA	5.871	4.276	25.104	2.55	0.7	0.5	0.97	0.65	250	0.8	3200	4
19	SECRUITY OFFICE	6.6906	3.345	10.055	2.15	0.7	0.5	0.47	0.36	250	0.8	3200	2
20	STORE	5.23	3.28	17.154	2.15	0.7	0.5	0.94	0.65	250	0.8	3200	2
21	CENTRAL OFFICE	12.775	6.387	19.163	2.15	0.7	0.5	0.47	0.65	300	0.8	3200	3
22	SECURITY OFFICE	59.50	30.90	90	2.15	0.7	0.5	0.47	0.48	250	0.8	3200	18
23	OUTSIDE LIGHT	10.89	15.60	170	9.0	0.7	0.5	0.11	0.48	250	0.8	3200	26

APPENDIX 2

Lighting and distribution schedule for distribution board "A" (DBA)

Circuit number	description	Number of point per circuit	Point load (W)	Total load (w)	Fuse rating (a)	Diversity factor	Load estimate (w)	Cable size (mm^2)	Power distribution phase in each phase		
									RED	YELLOW	BLUE
L1	LIGHTING	21	1 X52	1115	10	0.9	1003.5	1.5			1003.5
L2	LIGHTING	28	1 X 52	4499	10	0.9	1003.5	1.5		1349.1	
L3	FAN	28	1 X 42	1176	10	0.9	1349.1	1.5	1044.9		
F1	LIGHTING	48	1 X 40	1904	10	0.9	1044.9	1.5			1713.6
L5	13AS.S.0	8	1 X 180	1300	10	1.0	1713.6	1.5		1300	
PS1	13AS.S.O	14	1 X 200	2750	30	0.9	1300	2.5			1650
PS2	13AS.S.0	14	1 X 200	2750	30	0.6	1650	2.5		1650	
PS3	13AS.S.0	11	1 X 200	2250	30	0.6	1650	2.5		1350	
PS4	BASSO	13	1 X 200	2500	30	0.6	1350	2.5			1500
PS5	15ASSO	1	1000	1000	20	1.0	1500	4.0	1000		
HD1	HAND DRYER	1	1 X 1000	1000	20	1.0	1000	4.0			
AC1	AIR CONDITIONER	1	1 X 1900	1900	20	1.0	1000	4.0	1900		1500
AC3	AIR CONDITIONER	1	1 X 1900	1900	20	1.0	1900	4.0			

AC3	AIR CONDITIONER	1	1 X 1900	1900	20	1.0	1900	4.0			1000
AC4	AIR CONDITIONER	2	1 X 1900	1200	20	1.0	1900	4.0			1900
AC5	AIRCONDITIONER	1	1 X 1900	1900	20	1.0	1200	4.0			1900
AC6	AIR CONDITIONER	1	1 X 1900	1900	20	1.0	1900	4.0	1900	1900	1200
AC7	AIR CONDITIONER	1	1 X 1900	1900	2020	1.0	1900	4.0			
AC8	AIR CONDITIONER1900	1	1 1900	1900	20	1.0	1900	4.0			
AC9	AIR CONDITIONER	1	1 X1900	1300	10	1.0	1900	4.0	1300	1900	1900
F2	FAN	13	1 X 40	2750	30		1300	1.5	1650		
PS6	13ASSO	14	1 X 200		10		1650	2.5	1300		
SPARE					10				1650		
SPARE					10						
SPARE					20						
SPARE					20						
SPARE					20						
SPARE					30						
SPARE					30						
SPARE											
TOTAL									11363.60	11349.10	11198.40

APPENNDIX 3

Lighting and distribution schedule for distribution board "B" (DBB)

Circuit number	description	Number of point per circuit	Point load (W)	Total load (w)	Fuse rating (a)	Diversity factor	Load estimate (w)	Cable size (mm^2)	Power distribution phase in each phase		
									RED	YELLOW	BLUE
L1	LIGHTING	6	1 X180	1098	10	0.9	988.2	1.5			988.2
L2	LIGHTING	22	1 X 52	1143	10	0.9	1028.7	1.5		1028.7	
L3	LIGHTING	17	1 X 42	723	10	0.9	650.7	1.5	650.7		
F1	FAN	30	1 X 40	1215	10	0.9	1093.5	1.5			1093.5
F2	FAN	27	1 X 40	1085	10	1.0	973.8	1.5	973.8		
PS1	13A S.S.O	13	1 X 200	2500	30	0.9	1500	2.5		1800	1500
PS2	13A S.S.O	15	1 X 200	3000	30	0.6	1800	2.5		1350	
PS3	13A S.S.O	11	1 X 200	2250	30	0.6	1350	2.5			
PS4	13A S.S.O	15	1 X 200	3000	30	0.6	1800	2.5	1800		
PS5	15A S.S.O	1	1 X 1000	1000	20	1.0	1000	4.0		1000	1000
PS6	15A S.S.O	1	1 X 1000	1000	20	1.0	1000	4.0			

PS7	15A S.S.O	1	1 X 1000	1000	20	1.0	1000	4.0	1000		
HD1	HAND PRAYER	1	1 X 1000	1000	20	1.0	1000	4.0	1000		
HD2	HAND PRAYER	1	1 X 1000	1000	20	1.0	1900	4.0			1000
AC1	AIR CONDITIONER	1	1 X 1900	1900	20	1.0	1900	4.0	1900		
AC2	AIR CONDITIONER	1	1 X 1900	1900	20	1.0	1900	4.0			1900
AC3	AIR CONDITIONER	1	1 X 1900	1900	20	1.0	1900	4.0	1900	1200	
AC4	AIR CONDITIONER	1	1 X 1900	1900	20	1.0	1200	4.0		1200	1900
AC5	AIR CONDITIONER	2	1 X 750	1200	20	1.0	1200	4.0			
AC6	AIR CONDITIONER	2	1 X750	1200	20	1.0	1200	4.0	1200	3000	
AC7	AIR CONDITIONER	2	1 X750	1200	30	1.0	1200	4.0			

AC8	AIR CONDITIONER	2	1 X 750	1200	20	1.0	1200	4.0			1200
CC111	COOKER CONTROL UNIT	2	1 X300	6000	45	0.5	3000	6.0			
SPARE					10						
SPARE					10						
SPARE					20						
SPARE					20						
SPARE					20						
SPARE					30						
SPARE					30						
TOTAL									104245	10578.70	10581.70

APPENDIX 4

Lighting and distribution schedule for distribution board "C" (DBC)

Circuit number	description	Number of point per circuit	Point load (W)	Toal load (w)	Fuserating (a)	Diversity fatcor	Load estimate (w)	Cable size (mm²)	Power distribution phase in each phase		
									RED	YELLOW	BLUE
L1	LIGHTING	28	1 X52	1459	10	0.9	1313.1	1.5			1313.1
L2	LIGHTING	28	1 X 42	1185	10	0.9	1066.5	1.5			1066.5
L3	LIGHTING	31	1 X 42	1324	10	0.9	1191.6	1.5	1191.6		
L4	LIGHTING	41	1 X 42	1728	10	0.9	1555.2	1.5		1555.2	
L5	LIGHTING	42	1 X 42	1728	10	0.9	1555.2	1.5	1555.2		
F1	FAN	33	1 X 40	1310	10	0.9	1182.2	1.5			118 2.6
F2	FAN	18	1 X 40	700	10	0.9	630	1.5			630
PS1	13AS.S.0	10	1 X 200	2000	30	0.6	1200	2.5	1200		
PS2	13A S.S.O	14	1 X 200	2750	30	0.6	1650	2.5			1650
PS3	13A S.S.O	12	1 X 200	2500	30	0.6	1500	2.5			1500
PS4	13A S.S.O	11	1 X 200	2250	30	0.6	1350	2.5		1350	
HD1	HANDDRYE	1	1 X 1000	1000	20	1.0	1000	4.0		1000	

	R										
HD2	HANDPRAYE R	1	1 X 1000	1000	20	1.0	1000	4.0			1000
AC1	AIR CONDITIONE R	1	1 X 1900	1900	20	1.0	1900	4.0	1900		
AC2	AIR CONDITIONE R	1	1 X 1900	1900	20	1.0	1900	4.0		1900	
AC3	AIR CONDITIONE R	1	1 X 1900	1900	20	1.0	1900	4.0			1900
AC4	AIR CONDITIONE R	1	1 X 1900	1900	20	1.0	1900	4.0	1900		
AC5	AIR CONDITIONE R	1	1 X 1200	1200	20	1.0	1200	4.0		1200	
AC6	AIR	1	1 X 1200	1200	20	1.0	1200	4.0			1200

	CONDITIONE										
AC7	AIR CONDITIONE R	1	1 X 1900	1900	20	1.0	1900	4.0		1900	
AC8	AIR CONDITIONE R	1	1 X 1200	1200	20	1.0	1200	4.0	1200		
AC9	AIR CONDITIONE R	1	1 X 2400	2400	20	1.0	2400	4.0	2400		
AC10	AIR CONDITIONE R	1	1 X 2400	2400	20	1.0	2400	4.0		2400	
AC11	AIR CONDITIONE R	1	1 X 2400	2400	20	1.0	2400	4.0			2400
AC12	AIR CONDITIONE R	1	1 X 2400	2400	20	1.0	2400	4.0	2400		

AC13	AIR CONDITIONER	1	1 X 2400	2400	20	1.0	2400	4.0		2400	
AC14	AIR CONDITIONER	1	1 X 2400	2400	20	1.0	2400	4.0			2400
PSS	15A.S.S.O	1	1 X 1000	1000	20	1.0	1000	4.0	1000		
SPARE						1.0					
SPARE						1.0					
SPARE						20					
SPARE						20					
SPARE						20					
SPARE						20					
SPARE						30					
SPARE						30					
TOTAL									14746.80	14887.80	15059.60

Minimum requirements for lighting in offices, schools, large shops and stores and in trade and industry[1]) as laid down in DIN 5035 sheet 2, 1972 edition.

Room purpose or work involved		Rated illuminance lux	fluorescent lamp colour designation	fluorescent lamp colour rendering index	Glare limitation class	Planning notes
General rooms	Dressing rooms	120	nw or ww	1 or 2	2	extra light over mirror, de-luxe warm white
	Washrooms, toilets					
	Entrance halls, staircases, landings					for stairs avoid shadows and glare
admin. rooms, offices	office work (no severe task involved)	250	nw or ww	1 or 2	1	
	bank counters and cash points					extra light for bank counters
	conference room					
	office work (more severe tasks involved) e.g., bookkeeping, shorthand, data processing	500	nw or ww	1 or 2	1	Avoid reflected glare by suitably directed light
	drawing offices	1000	nw	1 or 2	1	Provide adequate light/shade effect
	open-plan offices					
School-rooms, lecture rooms	general classrooms, conference rooms, libraries, assembly rooms, music rooms	250	nw or ww	1 or 2	1	Extra light for blackboard. For shelves give adequate vertical lighting.
	Indoor games rooms, gymnasia, beginner's swimming pools					
	kitchens					
	chemistry and physics laboratories, large classrooms, large libraries, reading rooms, handicraft rooms, sewing rooms, art rooms, rooms in special schools for the visually handicapped, first aid rooms	500	nw or ww	1 or 2	1	Provide blackboard lighting with high vertical illuminance. For screen-projected lectures provide 10 lx general lighting for note taking.
Exhibition rooms	museums, art galleries	250	nw, ww	1	1	Provide adequate vertical illuminance. Avoid reflected glare. Extra light for exhibits.
	exhibition halls and trade fair halls	500	nw, ww	1,2		
Large shops and stores	storerooms	120	nw, ww	3	2	
	despatch rooms	250	nw, ww	3		
	salesrooms	250	nw, ww	1,2	1	Higher illuminance often required for sale-promoting effect.
	multiple stores	500	nw, ww	1,2		
	supermarkets	750	nw, ww	1,2		
	shop windows	1000 +	–	–		In butchers shops, greengrocers and flower shops provide "natural" lamps.
Hotels and restaurants	hotel rooms, restaurants, cafes	120	ww	1	–	Extra light over mirrors, beds, writing desks.
	refreshment rooms, self-service, hotel kitchens	250	nw, ww	1,2	1	Extra light for show-cases.
Theatres and concert halls	cinemas, foyers, theatres	60	ww	1	–	Co-ordinate the lighting system to the architecture of the room.
	concert halls	120	nw, ww	1		
	banquetting halls, conference rooms	250	nw, ww	1		
Churches and places of worship	entrances	30	nw, ww	1,2	–	Co-ordinate the design of the system to the sacred character and special architecture of these edifices.
	naves	60	nw, ww	1,2		
	orchestra or choir areas	120	nw, ww	1		
Hospitals	Special rules apply: e.g. DIN 5035 sheet 3					
General rooms in industry	annexes, side rooms	30	nw or ww	3	–	Match the illuminance and light colour of neighbouring rooms in order to prevent eye adaption difficulties.
	car parking, garages, loading ramps	60				
	storerooms	120				
	packing, despatch	250			2	
	Electrical control rooms	500	nw	2	1	Avoid reflection.
Chemical industry, plastics	Distilling, mixing and drying plant	60	nw	3	–	
	Filtering, filling, granulating plant, extruders, injection moulding machines, paint spraying and plastic foil machinery	120	nw	3	–	
	vulcanising plant, presses for plastic products, works laboratories	250	nw	2	1	

[1]) High illuminance improves the visual task. Applications not listed above may be assessed by referring to similar categories in the table.

APPENDIX 6

TRILUX

ble 6 Minimum requirements for lighting

Room purpose or work involved		Rated illuminance lux	fluorescent lamp colour designation	fluorescent lamp colour rendering index	Glare limitation class	Planning notes
hemical ndustry, lastics	fine coating, prescription work, research laboratories	500	nw	1 or 2	1	
	colour testing	1000	tw or nw	1	1	Note that painted walls and coloured furniture can lead to erroneous color-identification
on and teel ndustry	Furnaces and foundries, sand blasting, drawing of large diameter wire	120	nw or ww	3 or 4	–	
	moulding, injection moulding, rolling and drawing of medium profiles	250			2	
	core shop, rolling of thin sheet steel, drawing of fine wire, sheet steel quality-control shops	500	nw	3	1	
lectrical ndustry	electro plating, simple assembly	250	nw	3	2	
	assembly shops e.g., small motors	500	nw	2	1	
	precision assembly, adjusting, setting, testing	1000				
	assembly of electronic components	1500				Special attention to correct distribution of light
anual work	average visual tasks e.g., painting, sawing, planing	250	nw	2	1	
	veneering, french polishing, enamelling, upholstering, leather work, cutting	500	nw or ww	1 or 2		Arrange luminaires so that disturbing reflections are avoided
	leather dyeing, hair dyeing	750	nw, ww	1	1	
etal rocessing	forging, large-piece assembly	120	ww	3, 4	–	
	turning, drilling, milling, welding	250	nw	3	2	
	tracing and marking, fine grinding, setting up machine tools	500	nw	3	1	
	Precision assembly	750	nw	2	1	
	toolmaking, jig manufacture	1000				
	watchmaking, engraving	2000				well-directed light recommended
ood and rink ndustry	peeling, boiling, straining, sugar and preservatives factory	120	nw or ww	1 or 2	–	
	mills, dairies, slaughter houses, sugar refineries, tobacco industry	250	nw	1 or 2	1	
	colouring inspection	1000	tw or nw	1	1	room surfaces must be neutral colour
aper ndustry and raphic arts	simple bookbinding	250	nw, ww	1 or 2	1	
	manual printing work, block and matrix making, printing machinery	500	nw or ww	1 or 2		correct light direction and avoidance of reflective glare assist recognition of the finest details
	retouching, manual and machine compositing	1000	nw, ww	1 or 2		
	Colour testing	1500	tw, nw	1	1	
extile anufacture nd rocessing	work with baths	120	nw or ww	3	–	
	carding, ironing, hemp spinning	250				
	spinning, twisting, winding, weaving light-colour fabrics	500	nw	2	1	
	sewing, knitting, printing, weaving dark-colour fabrics	750				
	inspection of wares, quilting	1000	tw or nw	1	1	special work plane lighting recommended
	fine needlework	1500				

ligh illuminance improves the visual task. Applications not listed above may be assessed by referring to similar categories in the table.

APPENDIX 1

TABLE 4B

Allowances for diversity

Purpose of final circuit fed from conductors or switchgear to which diversity applies	Type of premises+		
	Individual household installations, including individual dwellings of a block	Small shops, stores, offices and business premises	Small hotels, boarding houses, guest houses, etc.
1. Lighting	66% of total current demand	90% of total current demand	75% of total current demand
2. Heating and power (but see 3 to 8 below)	100% of total current demand up to 10 amperes + 50% of any current demand in excess of 10 amperes	100% f.l. of largest appliance + 75% f.l. of remaining appliances	100% f.l. of largest appliance + 80% f.l. of 2nd largest appliance +60% f.l. of remaining appliances
3. Cooking appliances	10 amperes + 30% f.l. of connected cooking appliances in excess of 10 amperes + 5 amperes if socket-outlet incorporated in unit	100% f.l. of largest appliance + 80% f.l. of 2nd largest appliance + 60% f.l. of remaining appliances	100% f.l. of largest appliance + 80% f.l. of 2nd largest appliance + 60% f.l. of remaining appliances
4. Motors (other than lift motors which are subject to special consideration)		100% f.l. of largest motor + 80% f.l. of 2nd largest motor + 60% f.l. of remaining motors	100% f.l. of largest motor + 50% f.l. of remaining motors
5. Water-heaters (instantaneous type)*	100% f.l. of largest appliance + 100% f.l. of 2nd largest appliance + 25% f.l. of remaining appliances	100% f.l. of largest appliance + 100% f.l. of 2nd largest appliance + 25% f.l. of remaining appliances	100% f.l. of largest appliance + 100% f.l. of 2nd largest appliance + 25% f.l. of remaining appliances
6. Water-heaters (thermostatically controlled)	no diversity allowable†		
7. Floor warming installations	no diversity allowable†		
8. Thermal storage space heating installations	no diversity allowable†		
9. Standard arrangements of final circuits in accordance with Appendix 5	100% of current demand of largest circuit + 40% of current demand of every other circuit	100% of current demand of largest circuit + 50% of current demand of every other circuit	
10. Socket outlets other than those included in 9 above and stationary equipment other than those listed above	100% of current demand of largest point of utilisation + 40% of current demand of every other point of utilisation	100% of current demand of largest point of utilisation + 75% of current demand of every other point of utilisation	100% of current demand of largest point of utilisation + 75% of current demand of every point in main rooms (dining rooms, etc) + 40% of current demand of every other point of utilisation

+ For blocks of residential dwellings, large hotels, large commercial premises, and factories, the allowances are to be assessed by a competent person.

* For the purpose of this Table an instantaneous water-heater is deemed to be a water-heater of any loading which heats water only while the tap is turned on and therefore uses electricity intermittently.

† It is important to ensure that the distribution boards are of sufficient rating to take the total load connected to them without the application of any diversity.

COPPER CONDUCTOR

TABLE 9D1

Current-carrying capacities and associated voltage drops for single-core p.v.c.-insulated cables, non-armoured, with or without sheath (copper conductors)

BS 6004
BS 6346

Conductor operating temperature; 70°C

Conductor cross-sectional area	Installation methods A to C† of Table 9A ('Enclosed')				Installation methods E to H of Table 9A ('Clipped direct')				Installation method J of Table 9A ('Defined conditions')					
	2 cables, single-phase a.c., or d.c.		3 or 4 cables, three-phase a.c.		2 cables, single-phase a.c., or d.c.		3 or 4 cables, three-phase a.c.		Flat or vertical (2 cables, single-phase a.c., or d.c., or 3 or 4 cables three-phase)				Trefoil (3 cables three-phase)	
	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre: Single-phase	d.c.	Three-phase	Current carrying capacity	Volt drop per ampere per metre
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
mm²	A	mV	A	mV	A	mV	A	mV	A	mV	mV	mV	A	mV
1.0	14	42	12	37	17	42	16	37	–	–	–	–	–	–
1.5	17	28	14	24	21	28	20	24	–	–	–	–	–	–
2.5	24	17	21	15	30	17	26	15	–	–	–	–	–	–
4	32	11	29	9.2	40	11	36	9.2	–	–	–	–	–	–
6	41	7.1	37	6.2	50	7.1	45	6.2	–	–	–	–	–	–
10	55	4.2	51	3.7	68	4.2	61	3.7	–	–	–	–	–	
16	74	2.7	66	2.3	90	2.7	81	2.3	–	–	–	–	–	–
25	97	1.7	87	1.5	118	1.7	106	1.5	–	–	–	–	–	–
35	119	1.3	106	1.1	145	1.3	130	1.1	–	–	–	–	–	–
		a.c. d.c.				a.c. d.c.								
50	145	0.97 0.91	125	0.84	175	0.93 0.91	160	0.82	195	0.95	0.91	0.85	170	0.80
70	185	0.71 0.63	160	0.62	220	0.65 0.63	200	0.59	240	0.68	0.63	0.62	210	0.59
95	230	0.56 0.45	195	0.48	270	0.48 0.45	240	0.45	300	0.52	0.45	0.49	260	0.42
120	260	0.48 0.36	220	0.42	310	0.40 0.36	280	0.38	350	0.44	0.36	0.43	300	0.34
150	–	– –	–	–	355	0.34 0.29	320	0.34	410	0.39	0.29	0.39	350	0.29
185	–	– –	–	–	405	0.29 0.24	365	0.30	470	0.35	0.24	0.36	400	0.25
240	–	– –	–	–	480	0.24 0.18	430	0.27	560	0.36	0.18	0.38	480	0.22
300	–	– –	–	–	560	0.22 0.14	500	0.25	660	0.33	0.14	0.35	570	0.19
400	–	– –	–	–	680	0.20 0.12	610	0.24	800	0.30	0.12	0.33	690	0.17
500	–	– –	–	–	800	0.18 0.086	710	0.23	910	0.28	0.086	0.31	770	0.16
630	–	– –	–	–	910	0.17 0.068	820	0.22	1040	0.26	0.068	0.30	880	0.15

† For installation method C, the tabulated values are applicable only to the range up to and including 35mm². For larger sizes in this installation method, see ERA Report 69–30. For cables in ducts in the floor of a building, the ERA ratings must be adjusted by the appropriate factor for ambient temperature. For installation method D, the current-carrying capacities for twin and multicore sheathed cables in methods A to C, up to 35mm², are applicable (see Table 9D2).

NOTES: 1 – WHERE THE CONDUCTOR IS TO BE PROTECTED BY A SEMI-ENCLOSED FUSE TO BS 3036, SEE ITEM 4(ii) OF THE PREFACE TO THIS APPENDIX.

2 – The current-carrying capacities in columns 6 and 8 are applicable to flexible cables to BS 6004 Table 1(b) when the cables are used in fixed installations.

CORRECTION FACTORS

FOR AMBIENT TEMPERATURE

Ambient temperature	25°	35°C	40°C	45°C	50°C	55°C	60°C	65°C
Correction factor	1	0.94	0.87	0.79	0.71	0.61	0.50	0.35

FOR GROUPING

See Table 9B except that the factors for 32, 36 and 3 conductors do not apply to three-phase.

APPENDIX 9

MAXIMUM DEMAND AND DIVERSITY
(See Regulation 311–2)

s Appendix gives some information on the determination of the maximum demand for an installation and, udes the current demand to be assumed for commonly used equipment. It also includes some notes on the lication of allowances for diversity.

information and values given in this Appendix are intended only for guidance because it is impossible to ify the appropriate allowances for diversity for every type of installation and such allowances call for special wledge and experience. The figures given in Table 4B, therefore, may be increased or decreased as decided he engineer responsible for the design of the installation concerned.

current demand of a final circuit is determined by summating the current demands of all points of utilisa- and equipment in the circuit and, where appropriate, making an allowance for diversity. Typical current nds to be used for this summation are given in Table 4A. For the standard circuits using BS 1363 socket ts, detailed in Appendix 5, an allowance for diversity has been taken into account and no further diversity l be applied.

urrent demand of a circuit supplying a number of final circuits may be assessed by using the allowances versity given in Table 4B which are applied to the total current demand of all the equipment supplied by ircuit and not by summating the current demands of the individual final circuits obtained as outlined . In Table 4B the allowances are expressed either as percentages of the current demand or, where followed e letters f.l., as percentages of the rated full load current of the current-using equipment. The current d for any final circuit which is a standard circuit arrangement complying with Appendix 5 is the rated t of the overcurrent protective device of that circuit.

ernative method of assessing the current demand of a circuit supplying a number of final circuits is to te the diversified current demands of the individual circuits and then apply a further allowance for y but in this method the allowances given in Table 4B are not to be used, the values to be chosen being ponsibility of the designer of the installation.

of other methods of determining maximum demand is not precluded where specified by a suital l electrical engineer.

e design currents for all the circuits have been determined, enabling the conductor sizes to be cho essary to check that the limitation on voltage drop is met.

TABLE 4A

Current demand to be assumed for points of utilisation and current-using equipment

utilisation or current-using equipment	Current demand to be assumed
utlets other than 2A socket outlets	Rated current
t outlets	at least 0.5A
outlet*	Current equivalent to the connected load, with a minimum of 100W per lampholder
lock, electric shaver supply unit g with BS 3052), shaver socket outlet g with BS 4573), bell transformer, and ing equipment of a rating not greater	May be neglected
cooking appliance	The first 10A of the rated current plus 30% of the remainder of the rated current plus 5A if a socket outlet is incorporated in the control unit
ationary equipment	British Standard rated current, or normal current.

TE – Final circuits for discharge lighting are arranged so as to be capable of carrying the total steady current, viz. that of the lamp(s) and any associated gear and also their harmonic currents. Where more exact information is not available, the demand in volt-amperes is taken as the rated lamp watts multiplied by not less than 1.8. This multiplier is based upon the assumption that the circuit is corrected to a power factor of not less than 0.85 lagging, and takes into account control gear losses and harmonic currents.

APPENDIX D

APPENDIX 5

STANDARD CIRCUIT ARRANGEMENTS

This appendix gives details of standard circuit arrangements which satisfy the requirements of Chapter 43 for overload protection and Chapter 46 for isolation and switching, together with the requirements as regards current-carrying capacities of conductors prescribed in Chapter 52 – Cables, conductors and wiring materials.

It is the responsibility of the designer and installer when adopting these circuit arrangements to take the appropriate measures to comply with the requirements of other chapters or sections which are relevant, such as Chapter 41 – Protection against electric shock, Section 434 – Protection against short circuit current, Chapter 54 – Earthing and protective conductors, and the requirements of Chapter 52 other than those concerning current-carrying capacities.

Circuit arrangements other than those detailed in this appendix are not precluded where they are specified by a suitably qualified electrical engineer, in accordance with the general requirements of Regulation 314–3.

The standard circuit arrangements are:

- – Final circuits using socket outlets complying with BS 1363
- – Final circuits using socket outlets complying with BS 196
- – Final radial circuits using socket outlets complying with BS 4343
- – Cooker final circuits in household premises.

Final circuits using socket outlets complying with BS 1363 and fused connection units

General

A ring or radial circuit, with spurs if any, feeds permanently connected equipment and an unlimited number of socket outlets.

The floor area served by the circuit is determined by the known or estimated load but does not exceed the value given in Table 5A.

For household installations a single 30A ring circuit may serve a floor area of up to 100m² but consideration should be given to the loading in kitchens which may require a separate circuit. For other types of premises, final circuits complying with Table 5A may be installed where, owing to diversity, the maximum demand of current-using equipment to be connected is estimated not to exceed the corresponding ratings of the overcurrent protective device given in that table.

The number of socket outlets is such as to ensure compliance with Regulation 553–9, each socket outlet of a twin or multiple socket outlet unit being regarded as one socket outlet.

Diversity between socket outlets and permanently connected equipment has already been taken into account in Table 5A and no further diversity should be applied.

TABLE 5A

Final circuits using BS 1363 socket outlets

Type of circuit	Overcurrent protective device		Minimum conductor size*			Maximum floor area served
			Copper conductor rubber- or p.v.c. insulated cables	Copperclad aluminium conductor p.v.c. insulated cables	Copper conductor mineral-insulated cables	
	Rating	Type				
1	2	3	4	5	6	7
	A		mm²	mm²	mm²	m²
A1 Ring	30 or 32	Any	2.5	4	1.5	100
A2 Radial	30 or 32	Cartridge fuse or circuit breaker	4	6	2.5	50
A3 Radial	20	Any	2.5	4	1.5	20

*The tabulated values of conductor size may be reduced for fused spurs.

TABLE 9D2

Current-carrying capacities and associated voltage drops for twin and multicore p.v.c.-insulated cables, non-armoured (copper conductors)

BS 6004
BS 6346

Conductor operating temperature: 70°C

Conductor cross-sectional area	Installation methods A to C† of Table 9A ('Enclosed')				Installation methods E to H of Table 9A ('Clipped direct')				Installation method K of Table 9A ('Defined conditions')			
	One twin cable, with or without protective conductor, single-phase a.c., or d.c.		One three-core cable, with or without protective conductor, or one four-core cable, three-phase		One twin cable, with or without protective conductor, single-phase a.c., or d.c.		One three-core cable, with or without protective conductor, or one four-core cable, three-phase		One twin cable, with or without protective conductor, single-phase a.c., or d.c.		One three-core cable, with or without protective conductor or one four-core cable, three-phase	
	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre
1	2	3	4	5	6	7	8	9	10	11	12	13
mm²	A	mV	A	mV	A	mV	A	mV	A	mV	A	mV
1.0	14	42	12	37	16	42	13	37	–	–	–	–
1.5	18	28	16	24	20	28	17	24	–	–	–	–
2.5	24	17	21	15	28	17	24	15	–	–	–	–
4	32	11	29	9.2	36	11	32	9.2	–	–	–	–
6	40	7.1	36	6.2	46	7.1	40	6.2	–	–	–	–
10	53	4.2	49	3.7	64	4.2	54	3.7	–	–	–	–
16	70	2.7	62	2.3	85	2.7	71	2.3	–	–	–	–
25	79	1.8	70	1.6	108	1.8	90	1.6	114	1.8	[illegible]	1.6
35	98	1.3	86	1.1	132	1.3	115	1.1	139	1.3	121	1.1
50	–	–	–	–	163	0.92	140	0.81	172	0.92	148	0.81
						a.c. d.c.				a.c. d.c.		
70	–	–	–	–	207	0.65 0.64	176	0.57	218	0.65 0.64	186	0.57
95	–	–	–	–	251	0.48 0.46	215	0.42	265	0.48 0.46	227	0.42
120	–	–	–	–	290	0.40 0.36	251	0.34	306	0.40 0.36	263	0.34
150	–	–	–	–	330	0.32 0.25	287	0.29	348	0.32 [illegible]25	302	0.29
185	–	–	–	–	380	0.29 0.23	330	0.24	400	0.29 [illegible]	348	0.24
240	–	–	–	–	450	0.25 0.18	393	0.20	474	0.25 0.16	413	0.20
300	–	–	–	–	520	0.23 0.14	450	0.18	548	0.23 0.14	474	0.18
400	–	–	–	–	600	0.22 0.11	520	0.17	632	0.22 0.11	548	0.17

†For installation method C, the tabulated values are applicable only to the range up to and including 35 mm². For larger sizes in this installation method, see ERA Report 69–30. For cables in ducts in the floor of a building, the ERA ratings must be adjusted by the appropriate factor for ambient temperature.

NOTES: 1 – WHERE THE CONDUCTOR IS TO BE PROTECTED BY A SEMI–ENCLOSED FUSE TO BS 3036, SEE ITEM 4(ii) OF THE PREFACE TO THIS APPENDIX.

2 – The current carrying capacities in columns 6 and 8 are applicable to flexible cables to BS 6004 Table 1(b) where the cables are used in fixed installations.

CORRECTION FACTORS

FOR AMBIENT TEMPERATURE

Ambient temperature	25°C	35°C	40°C	45°C	50°C	55°C	60°C	65°C
Correction factor	1.06	[illegible]	0.87	0.79	0.71	0.61	0.50	0.35

FOR GROUPING
See Table 9B.

APPENDIX 13

COPPER CONDUCTORS

TABLE 9D3

Current-carrying capacities and associated voltage drops for twin and multicore armoured p.v.c.-insulated cables (copper conductors)

BS 6346

Conductor operating temperature: 70°C

Conductor cross-sectional area	Installation methods E, F and G† of Table 9A ('Clipped direct')				Installation method K of Table 9A ('Defined conditions')			
	One twin cable, single-phase a.c., or d.c.		One three- or four-core cable, three-phase		One twin cable, single-phase a.c., or d.c.		One three- or four-core cable, three-phase	
	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre
1	2	3	4	5	6	7	8	9
mm²	A	mV	A	mV	A	mV	A	mV
1.5	20	29	18	25	—	—	—	—
2.5	29	18	24	16	—	—	—	—
4	37	12	31	9.6	—	—	—	—
6	48	7.4	41	6.3	50	7.3	42	6.3
10	66	4.3	56	3.8	69	4.3	58	3.8
16	86	2.7	73	2.3	90	2.7	77	2.3
25	115	1.8	97	1.6	121	1.8	102	1.6
35	142	1.3	119	1.1	149	1.3	125	1.1
50	168	0.92	147	0.81	180	0.92	155	0.81
		a.c. d.c.				a.c. d.c.		
70	209	0.65 0.64	180	0.57	220	0.65 0.64	190	0.57
95	257	0.48 0.46	219	0.42	270	0.48 0.46	230	0.42
120	295	0.40 0.36	257	0.34	310	0.40 0.36	270	0.34
150	337	0.32 0.25	295	0.29	355	0.32 0.25	310	0.29
185	390	0.29 0.23	333	0.24	410	0.29 0.23	350	0.24
240	461	0.25 0.18	399	0.20	485	0.25 0.18	420	0.20
300	523	0.23 0.14	451	0.18	550	0.23 0.14	475	0.18
400	589	0.22 0.11	523	0.17	620	0.22 0.11	550	0.17

†For installation method C, see ERA Report 69–30. For cables in ducts in the floor of a building, the ERA ratings must be adjusted by the appropriate factor for ambient temperature.

NOTE – WHERE THE CONDUCTOR IS TO BE PROTECTED BY A SEMI-ENCLOSED FUSE TO BS 3036, SEE ITEM 4 (ii) OF THE PREFACE TO THIS APPENDIX.

CORRECTION FACTORS

FOR AMBIENT TEMPERATURE

Ambient temperature	25°C	35°C	40°C	45°C	50°C	55°C	60°C	65°C
Correction factor	1.06	0.94	0.87	0.79	0.71	0.61	0.50	0.35

FOR GROUPING

See Table 9B.

	SPECIAL CHARACTERISTICS	APPLICATION
	Sharp edges, strong corners	Schools, offices, shops
	Sharp edges, strong corners	Schools, offices, shops
	Super elliptical shapes	Foyers, public rooms, shops, staircases, offices.
IIL	Mirror luminaire with earthed socket outlet	Cloakrooms, bathrooms, toilets, hotel rooms.
IIKL	Mirror luminaire with earthed socket outlet	Cloakrooms, bathrooms, toilets, hotel rooms.
	Methacrylate injection moulding, accurate prismatic formation, good lighting quality.	Schools, offices, shops, laboratories.
	Accurate distribution of light, low glare factor	Schools, offices, shops, laboratories.
	Two tone design, sharp edges, strong corners	Schools, offices, shops, hotels
	Two tone design, accurate light distribution, low glare factor.	Schools, offices, shops, hotels
	Slim cornice luminaires opal	Schools, offices, shops.
	Slim ceiling luminaires to match ERL	Schools, offices, shops.
	Slim cornice luminaires with reflectors, accurate light distribution.	Schools, offices, shops.
	Slim ceiling luminaires with reflectors to match ERLS	Schools, offices, shops.
	Economical, good glare protection.	Schools, offices, multiple stores, super-markets.
	Two tone design, good light distribution.	Schools, offices, shops, sports centres.
	Mirror louvre construction, excellent light distribution, high efficiency.	Laboratories, schools, offices, shops, hotels.
	Mirror louvre construction, excellent light distribution, high efficiency.	Laboratories, shops, offices, hotels, banks foyers.
	Isocon louvre, accurate mirror construction, excellent light distribution.	Foyers, shops, boutiques, hotels
	Flush with ceiling, uniform light distribution.	Offices, schools, shops.
	Flush with ceiling, good light distribution.	Offices, schools, shops.
	Uniform light distribution	Offices, schools, shops.
	Good light distribution	Offices, schools, shops.
	Shallow recessed luminaire Uniform light distribution	Offices, schools, shops.
	Shallow recessed luminaire Uniform light distribution	Offices, schools, shops.
	Good light distribution	Offices, schools, shops sport centres.
	Mirror louvre construction, excellent light distribution, high efficiency.	Laboratories, schools, offices, shops, hotels,
	Mirror louvre construction, excellent light distribution, high efficiency.	Laboratories, shops, offices, hotels, banks, foyers.
	Isocon louvre, accurate mirror construction, excellent light distribution.	Foyers, shops, boutiques, hotels.

information on all luminaires, photometric curves and full descriptions are in the „Technical Appendix to

TABLE 5.1 EFFECTIVE CEILING AND FLOOR REFLECTANCES

Per Cent Base† Reflectance: 90

Per Cent Wall Reflectance / Cavity Ratio	90	80	70	60	50	40	30	20	10	0
0.2	89	88	86	87	86	85	85	84	84	82
0.4	88	87	86	85	84	83	81	80	79	76
0.6	87	86	84	82	80	79	77	76	74	73
0.8	87	85	82	80	77	75	73	71	69	67
1.0	86	83	80	77	75	72	69	66	64	62
1.2	85	82	78	75	72	69	66	63	60	57
1.4	85	80	77	73	69	65	62	59	57	52
1.6	84	79	75	71	67	63	59	56	53	50
1.8	83	78	73	69	64	60	56	53	50	48
2.0	83	77	72	67	62	56	53	50	47	43
2.2	82	76	70	65	59	54	50	47	44	40
2.4	82	75	69	64	58	53	48	45	41	37
2.6	81	74	67	62	56	51	46	42	38	35
2.8	81	73	66	60	54	49	44	40	35	34
3.0	80	72	64	58	52	47	42	38	34	30
3.2	79	71	63	56	50	45	40	36	32	28
3.4	79	70	62	54	48	43	38	34	30	27
3.6	78	69	61	53	47	42	36	32	28	25
3.8	78	69	60	51	45	40	35	31	27	23
4.0	77	69	58	51	44	39	33	29	25	22
4.2	77	62	57	50	43	37	32	28	24	21
4.4	76	61	56	49	42	36	31	27	23	20
4.6	76	60	55	47	40	35	30	26	22	19
4.8	75	59	54	46	39	34	28	25	21	18
5.0	75	59	53	45	38	33	28	24	20	16
6.0	73	61	49	41	34	29	24	20	16	11
7.0	70	58	45	38	30	27	21	18	14	08
8.0	68	55	42	35	27	23	18	15	12	06
9.0	66	52	38	31	25	21	16	14	11	05
10.0	65	51	36	29	22	19	15	11	09	04

Per Cent Base† Reflectance: 80

Per Cent Wall Reflectance / Cavity Ratio	90	80	70	60	50	40	30	20	10	0
0.2	79	78	78	77	77	76	76	75	74	72
0.4	79	77	76	75	74	73	72	71	70	68
0.6	78	76	75	73	71	70	68	66	65	63
0.8	78	75	73	71	69	67	65	63	61	57
1.0	77	74	72	69	67	65	62	60	57	55
1.2	76	73	70	67	64	61	58	55	53	51
1.4	76	72	68	65	62	59	55	53	50	48
1.6	75	71	67	63	60	57	53	50	47	44
1.8	75	70	66	62	58	54	50	47	44	41
2.0	74	69	64	60	56	52	48	45	41	38
2.2	74	68	63	58	54	49	45	42	38	35
2.4	73	67	61	56	52	47	43	40	36	33
2.6	73	66	60	55	50	45	41	38	34	31
2.8	73	65	59	53	48	43	39	36	32	29
3.0	72	65	58	52	47	42	37	34	30	27
3.2	72	65	57	51	45	40	35	33	28	25
3.4	71	64	56	49	44	39	34	32	27	24
3.6	71	63	54	48	43	38	32	30	25	23
3.8	70	62	53	47	41	36	31	28	24	22
4.0	70	61	53	46	40	35	30	26	22	20
4.2	69	60	52	45	39	34	29	25	21	18
4.4	69	60	51	44	38	33	28	24	20	17
4.6	69	59	50	43	37	32	27	23	19	15
4.8	68	58	49	42	35	31	26	22	18	14
5.0	68	56	48	41	35	30	25	21	18	14
6.0	66	55	44	38	31	27	22	19	15	10
7.0	64	53	41	35	28	24	19	16	12	07
8.0	62	50	38	32	25	21	17	14	11	05
9.0	61	49	36	30	23	19	15	13	10	04
10.0	59	46	33	27	21	18	14	11	06	03

Per Cent Base† Reflectance: 70

Per Cent Wall Reflectance / Cavity Ratio	90	80	70	60	50	40	30	20	10	0
0.2	70	69	68	68	67	67	66	66	65	64
0.4	69	68	67	66	65	64	63	62	61	58
0.6	69	67	65	64	63	61	59	58	57	54
0.8	68	66	64	62	60	58	56	55	53	50
1.0	68	65	62	60	58	55	53	52	50	47
1.2	67	64	61	59	57	54	50	48	46	44
1.4	67	63	60	58	55	51	47	45	44	41
1.6	67	62	59	56	53	47	45	43	41	38
1.8	66	61	58	54	51	46	42	40	38	35
2.0	66	60	56	52	49	45	40	38	35	33
2.2	66	60	55	51	48	43	38	36	34	32
2.4	65	60	54	50	46	41	37	35	32	30
2.6	65	59	54	49	45	40	35	33	30	28
2.8	65	59	53	48	43	38	33	30	28	26
3.0	64	56	52	47	42	37	32	29	27	24
3.2	64	58	51	46	40	36	31	28	25	23
3.4	64	57	50	45	39	35	29	27	24	22
3.6	63	56	49	44	38	33	28	25	22	20
3.8	63	56	49	43	37	32	27	24	21	19
4.0	63	55	48	42	36	31	26	23	20	17
4.2	62	55	47	41	35	30	25	22	19	16
4.4	62	54	46	40	34	29	24	21	18	15
4.6	62	53	45	39	33	28	24	21	17	14
4.8	62	53	45	38	32	27	23	20	16	13
5.0	61	52	44	36	31	26	22	19	16	12
6.0	60	51	41	35	28	24	19	16	13	09
7.0	58	48	38	32	26	22	17	14	11	06
8.0	57	46	35	29	23	19	15	13	10	05
9.0	56	45	33	27	21	18	14	12	09	04
10.0	55	43	31	25	19	16	12	10	08	03

Per Cent Base† Reflectance: 60

Per Cent Wall Reflectance / Cavity Ratio	90	80	70	60	50	40	30	20	10	0
0.2	60	59	59	59	58	57	56	56	55	53
0.4	60	59	59	58	57	55	54	53	52	50
0.6	60	58	57	56	55	53	51	51	50	46
0.8	59	57	56	55	54	51	48	47	46	43
1.0	59	57	55	53	51	48	45	44	43	41
1.2	59	56	54	51	49	46	44	42	40	38
1.4	59	56	53	49	47	44	41	39	38	36
1.6	59	55	52	48	45	42	39	37	35	33
1.8	58	55	51	47	44	40	37	35	33	31
2.0	58	54	50	46	43	39	35	33	31	29
2.2	58	53	49	45	42	37	34	31	29	28
2.4	58	53	48	44	41	36	32	30	27	26
2.6	58	53	48	43	39	35	31	28	26	24
2.8	58	53	47	43	39	34	29	27	24	22
3.0	57	52	46	42	37	32	26	25	23	20
3.2	57	51	45	41	36	31	27	23	22	18
3.4	57	51	45	40	35	30	26	23	20	17
3.6	57	50	44	39	34	29	25	22	19	16
3.8	57	50	43	38	33	29	24	21	19	15
4.0	57	49	42	37	32	28	23	20	18	14
4.2	56	49	42	37	32	27	22	19	17	14
4.4	56	49	42	36	31	27	22	19	16	13
4.6	56	49	41	35	30	26	21	18	16	13
4.8	56	48	41	34	29	25	21	16	15	12
5.0	56	48	40	34	28	24	20	17	14	11
6.0	55	45	37	31	25	21	17	14	11	07
7.0	54	43	35	30	24	20	15	12	09	05
8.0	53	42	33	26	22	18	14	11	08	04
9.0	52	40	31	26	20	16	12	10	07	03
10.0	51	39	29	24	18	15	11	09	07	02

Per Cent Base† Reflectance: 50

Per Cent Wall Reflectance / Cavity Ratio	90	80	70	60	50	40	30	20	10	0
0.2	50	50	49	49	48	48	47	46	46	44
0.4	50	49	48	48	47	46	45	45	44	42
0.6	50	48	47	46	45	44	43	42	41	38
0.8	50	48	47	45	44	42	40	39	38	36
1.0	50	48	46	44	43	41	38	37	36	34
1.2	50	47	45	43	41	39	36	35	34	29
1.4	50	47	45	42	40	38	35	34	32	27
1.6	50	47	44	41	39	36	33	32	30	26
1.8	50	46	43	40	38	35	31	30	28	25
2.0	50	46	43	40	37	34	30	28	25	24
2.2	50	46	42	38	36	33	29	27	24	22
2.4	50	46	42	37	35	31	27	25	23	21
2.6	50	46	41	37	34	30	26	22	21	20
2.8	50	46	41	36	33	29	25	22	20	19
3.0	50	45	40	36	32	28	24	21	19	17
3.2	50	44	39	35	31	27	23	20	18	16
3.4	50	44	39	35	30	26	22	19	17	15
3.6	50	44	39	34	29	25	21	18	16	14
3.8	50	44	38	34	29	25	21	17	15	13
4.0	50	44	38	33	28	24	20	17	15	12
4.2	50	43	37	32	28	24	20	17	14	12
4.4	50	43	37	32	27	23	19	16	13	11
4.6	50	43	35	31	25	22	18	15	13	10
4.8	50	43	36	31	26	22	18	15	12	09
5.0	50	42	35	30	25	21	17	14	12	09
6.0	50	42	34	29	23	19	15	13	10	06
7.0	49	41	32	27	21	16	14	11	08	05
8.0	49	40	30	25	19	16	12	10	07	03
9.0	48	39	29	24	18	15	11	09	07	03
10.0	47	37	27	22	17	14	10	08	06	02

* Values in this table are based on a length to width ratio of 1.6.

† Ceiling, floor or floor of cavity.

Source: From *IES Lighting Handbook 1984 Reference Volume*, Fig. 9-39, pp. 9-29–9-30. Used with permission.