NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

ELECTRICAL DESIGN OF A SERVICE BUILDING

GRADUATION PROJECT

EE400

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ABSTRACT

The electrical design works are very important in the planning of Hotels, Super Markets, Schools, and other Service buildings. For satisfying the consumer requirements, electrical installation should be well designed and applied with a professional knowledge, because in the present day when we are choosing an armature we don't looking only to its watt value. We consider the lumen of the lamp the type and design of the armature if its suitable or not for the project, and sometimes the working temperature.

This project is about the electrical installation of a service building, this project needs well knowledge about electrical installation and also researching the present system. This project consist of the installation of lighting circuits, the installation of sockets, illumination with spots, fan and motor for central heating system, fire alarm system, television, data and telephone systems. For all of these, there are some regulations that has to be applied. All project is drawn in AutoCAD 2014.

INTRODUCTION

Illumination started with human generation, they always wished to be illuminated. Firstly they used fire to illuminate. Then with technology development the devices for illumination were developed. By the invention of oil these technologies has been improved. Oil lamp was a good but not enough invention for human. At 18th century by invention of electricity electrical lamps were inverted by Edison. Day by day illumination techniques were changed and by the invention of alternating current this technology became cheaper and safer. Nowadays we are still using alternating current for great amount of illumination demands. Nowadays , hundreds of megawatts of power are being used to illuminate roads, buildings hotels and to change our nights darkness in to light.

The electrical installation design has many categories based on different conditions and bases.

This work discuses the illumination and electrical power design of service building, different design aspects will be discussed and presented, calculations and result will be shown.

The chapters are illustrated in term of systems categories in eight chapters as following:

- Beginning chapter is about general information
- Second chapter is illumination
- Third chapter is about insulators
- Fourth chapter is earthing
- Fifth chapter is lighting
- Sixth chapter is using cables
- Seventh chapter is about protection of illumination
- And the last chapter is about luminaries.

CONTENTS

CHAPTER 1
GENERALS

1.1. Historical Review of Installation Work

Electricity was first used in mining for pumping. In the iron and steel industry, by 1917, electric furnaces of both the arc and induction type were producing over 100,000 tons of ingot and castings. The first all-welded ship was constructed in 1920; and the other ship building processes were operated by electric motor power for punching, shearing, drilling machines and woodworking machinery.

The first electric motor drives in light industries were in the form of one motor-unit per line of shafting. Each motor was started once a day and continued to run throughout the whole working day in one direction at a constant speed. All the various machines driven from the shafting were started, stopped, reversed or changed in direction and speed by mechanical means. The development of integral electric drives, with provisions for starting, stopping and speed changes, led to the extensive use of the motor in small kilowatt ranges to drive an associated single machine, e.g. a lathe. One of the pioneers in the use of motors was the firm of Bruce Peebles, Edinburgh. The firm supplied, in the 1890s, a number of weatherproof, totally enclosed motors for quarries in Dumfries shire, believed to be among the first of their type in Britain.

As one might expect to find in the early beginnings of any industry, the application, and the methods of application, of electricity for lighting, heating, and motive power was primitive in the extreme. Large-scale application of electrical energy was slow to develop. The first wide use of it was for lighting in houses, shops, and offices. By the 1870s, electric lighting had advanced from being a curiosity to something with a definite practical future. Arc lamps were the first form of lighting, particularly for the illumination of main streets. When the incandescent-filament lamp appeared on the scene electric lighting took on such a prominence that it severely threatened the use of gas for this purpose. But it was not until cheap and reliable metal-filament lamps were produced that electric lighting found a place in every home in the land. Even then, because of the low power of these early filament lamps, shop windows continued for some time to be lighted externally by arc lamps suspended from the fronts of buildings.

The earliest application of electrical energy as an agent for motive power in industry is still electricity's greatest contribution to industrial expansion. The year 1900 has been regarded as a time when industrialists awakened to the potential of the new form of power.

The General Electric Company had its origins in the 1880s, as a Company, which was able to supply every single item, which went to form a complete electrical installation. In addition it was guarantied that all the components offered for sale were technically suited to each other, were of adequate quality and were offered at an economic price. The first electric winder ever built in Britain was supplied in 1905 to a Lanark oil concern. Railway electrification started as long ago as 1883, but it was not until long after the turn of this century that any major development took place.

Many names of the early electric pioneers survive today. Julius Sax began to make electric bells in 1855, and later supplied the telephone with which Queen Victoria spoke between Osborne, in the Isle of Wight, and Southampton in 1878. He founded one of the earliest purely electric manufacturing firms, which exists today and still makes bells and signaling equipment.

Specializing in lighting, Falk Statesman & Co. Ltd began by marketing improved designs of oil lamps, then gas fittings, and ultimately electric lighting fittings.

Cable makers W. T. Glover & Co. were pioneers in the wire field. Glover was originally a designer of textile machinery, but by 1868 he was also making braided steel wires for the then fashionable crinolines. From this type of wire it was a natural step to the production of insulated conductors for electrical purposes. At the Crystal Palace Exhibition in 1885 he showed a great range of cables; he was also responsible for the wiring of the exhibition.

The well-known J. & P. firm (Johnson & Phillips) began with making telegraphic equipment, extended to generators and arc lamps, and then to power supply.

The coverings for the insulation of wires in the early days included textiles and gutta-percha. Progress in insulation provisions for cables was made when vulcanized rubber was introduced, and it is still used today.

Siemens Brothers made the first application of a lead sheath to rubber-insulated cables. The manner in which we name cables was also a product of Siemens, whose early system was to give a cable a certain length related to a standard resistance of 0.1 ohm. For many years ordinary VRI cables made up about 95 per cent of all installations.

They were used first in wood casing, and then in conduit. Wood casing was a very early invention. It was introduced to separate conductors, this separation being considered a necessary safeguard against the two wires touching and so causing fire. Choosing a cable at the turn of the century was quite a task. From one catalogue alone, one could choose from fifty-eight sizes of wire, with no less than fourteen different grades of rubber insulation. The grades were described by such terms as light, high, medium, or best insulation. Nowadays there are two grades of insulation: up to 600 V and 600 V/1,000 V. And the sizes of cables have been reduced to a more practicable seventeen.

Thus a No.90 cable in their catalogue was a cable of which 90 yards had a resistance of 0.1 ohm. The Standard Wire Gauge also generally knew Cable sizes.

During the 1890s the practice of using paper as an insulating material for cables was well established. One of the earliest makers was the company, which later became a member of the present-day BICC Group. The idea of using paper as an insulation material came from America to Britain where it formed part of the first wiring system for domestic premises. This was twin lead-sheathed cable. Bases for switches and other accessories associated with the system were of cast solder, to which the cable sheathing was wiped, and then all joints sealed with a compound. The compound was necessary because the paper insulation when dry tends to absorb moisture.

In 1911, the famous 'Henley Wiring System' came on the market. It comprised flat-twin cables with a lead-alloy sheath. Special junction boxes, if properly fixed, automatically affected good electrical continuity. The insulation was rubber. It became very popular. Indeed, it proved so easy to install that a lot of unqualified people appeared on the contracting scene as 'electricians'. When it received the approval of the IEE Rules, it became an established wiring system and is still in use today.

The main competitor to rubber as an insulating material appeared in the late 1930s. This material was PVC (polyvinyl chloride), a synthetic material that came from Germany. The material, though inferior to rubber so far as elastic properties were concerned, could withstand the effects of both oil and sunlight. During the Second World War PVC, used both as wire insulation and the protective sheath, became well established.

As experience increased with the use of TRS cables, it was made the basis of modified wiring systems. The first of these was the Calendar farm-wiring system

introduced in 1937. This was tough rubber sheathed cable with a semi-embedded braiding treated with a green-colored compound.

Perhaps one of the most interesting systems of wiring to come into existence was the MICS (mineral-insulated copper-sheathed cable), which used compressed magnesium oxide as the insulation, and had a copper sheath and copper conductors. The cable was first developed in 1897 and was first produced in France. It has been made in Britain since 1937, first by Pyrotenax Ltd, and later by other firms. Mineral insulation has also been used with conductors and sheathing of aluminum.

This system combined the properties of ordinary TRS and HSOS (house-service overhead system) cables.

So far as conductor material was concerned, copper was the most widely used. But aluminum was also applied as a conductor material. Aluminum, which has excellent electrical properties, has been produced on a large commercial scale since about 1890. Overhead lines of aluminum were first installed in 1898. Rubber-insulated aluminum cables of 3/0.036 inch and 3/0.045 inch were made to the order of the British Aluminum Company and used in the early years of this century for the wiring of the staff quarters at Kinlochleven in Argyllshire. Despite the fact that lead and lead-alloy proved to be of great value in the sheathing of cables, aluminum was looked to for a sheath of, in particular, light weight. Many experiments were carried out before a reliable system of aluminum-sheathed cable could be put on the market.

One of the first suggestions for steel used for conduit was made in 1883. It was then called 'small iron tubes'. However, the first conduits were of itemized paper. Steel for conduits did not appear on the wiring scene until about 1895. The revolution in conduit wiring dates from 1897, and is associated with the name 'Simplex' which is common enough today. It is said that the inventor, L. M. Waterhouse, got the idea of close-joint conduit by spending a sleepless night in a hotel bedroom staring at the bottom rail of his iron bedstead. In 1898 he began the production of light gauge close-joint conduits. A year later the screwed-conduit system was introduced.

Insulated conduits also were used for many applications in installation work, and are still used to meet some particular installation conditions. The 'Gilflex' system, for instance, makes use of a PVC tube, which can be bent cold, compared with earlier material, which required the use of heat for bending.

Accessories for use with wiring systems were the subjects of many experiments; many interesting designs came onto the market for the electrician to use in his work. When lighting became popular, there arose a need for the individual control of each lamp from its own control point. The 'branch switch' was used for this purpose.

Non-ferrous conduits were also a feature of the wiring scene. Heavy-gauge copper tubes were used for the wiring of the Rayland's Library in Manchester in 1886. Aluminum conduit, though suggested during the 1920s, did not appear on the market until steel became a valuable material for munitions during the Second World War.

The term 'switch' came over to this country from America, from railway terms which indicated a railway 'point', where a train could be 'switched' from one set of tracks to another. The 'switch', so far as the electric circuit was concerned, thus came to mean a device, which could switch an electric current from one circuit to another.

It was Thomas Edison who, in addition to pioneering the incandescent lamp, gave much thought to the provision of branch switches in circuit wiring. The term 'branch' meant a tee off from a main cable to feed small current-using items. The earliest switches were of the 'turn' type, in which the contacts were wiped together in a rotary motion to make the circuit. The first switches were really crude efforts: made of wood and with no positive ON or OFF position. Indeed, it was usual practice to make an inefficient contact to produce an arc to 'dim' the lights! Needless to say, this misuse of the early switches, in conjunction with their wooden construction, led to many fires. But new materials were brought forward for switch construction such as slate, marble, and, later, porcelain. Movements were also made more positive with definite ON and OFF positions. The 'turn' switch eventually gave way to the 'Tumbler' switch in popularity. It came into regular use about 1890. Where the name 'tumbler' originated is not clear; there are many sources, including the similarity of the switch action to the antics of Tumbler Pigeons. Many accessory names, which are household words to the electricians of today, appeared at the turn of the century: Verity's, McGeoch, Tucker, and Crabtree. Further developments to produce the semi-recessed, the flush, the ac only, and the 'silent' switch proceeded apace. The switches of today are indeed of long and worthy pedigrees.

Ceiling roses, too, have an interesting history; some of the first types incorporated fuses. The first rose for direct attachment to conduit came out in the early 1900s, introduced by Dorman & Smith Ltd.

Lord Kelvin, a pioneer of electric wiring systems and wiring accessories brought out the first patent for a plug-and-socket. The accessory was used mainly for lamp loads at first, and so carried very small currents. However, domestic appliances were beginning to appear on the market, which meant that sockets had to carry heavier currents. Two popular items were irons and curling-tong heaters. Crompton designed shuttered sockets in 1893. The modern shuttered type of socket appeared as a prototype in 1905, introduced by Diamond. It was one thing to produce a lamp operated from electricity. It was quite another thing to devise a way in which the lamp could be held securely while current was flowing in its circuit. The first lamps were fitted with wire tails for joining to terminal screws. It was Thomas Edison who introduced, in 1880, the screw cap, which still bears his name. It is said he got the idea from the stoppers fitted to kerosene cans of the time. Like much another really good idea, it superseded all its competitive lamp holders and its use extended through America and Europe. In Britain, however, it was not popular. The Edison & Swan Co. about 1886 introduced the bayonet-cap type of lamp-holder. The early type was soon improved to the lamp holders we know today.

Many sockets were individually fused, a practice, which was later meet the extended to the provision of a fuse in the plug.

These fuses were, however, only a small piece of wire between two terminals and caused such a lot of trouble that in 1911 the Institution of Electrical Engineers banned their use. One firm, which came into existence with the socket-and-plug, was M.K. Electric Ltd. The initials were for 'Multi-Contact' and associated with a type of socket outlet, which eventually became the standard design for this accessory. It was Scholes, under the name of 'Wylex', who introduced a revolutionary design of plug-and-socket: a hollow circular earth pin and rectangular current-carrying pins. This was really the first attempt to 'polarize', or to differentiate between live, earth and neutral pins.

One of the earliest accessories to have a cartridge fuse incorporated in it was the plug produced by Dorman & Smith Ltd. The fuse actually formed one of the pins, and could be screwed in or out when replacement was necessary. It is a rather long cry from those pioneering days to the present system of standard socket-outlets and plugs.

Early fuses consisted of lead wires; lead being used because of its low melting point. Generally, devices which contained fuses were called 'cutouts', a term still used today for the item in the sequence of supply-control equipment entering a building. Once the idea caught on of providing protection for a circuit in the form of fuses, brains

went to work to design fuses and fuse gear. Control gear first appeared encased in wood. But ironclad versions made their due appearance, particularly for industrial use during the nineties. They were usually called 'motor switches', and had their blades and contacts mounted on a slate panel. Among the first companies in the switchgear field were Bill & Co., Sanders & Co., and the MEM Co., whose 'Kantark' fuses are so well known today. In 1928 this Company introduced the 'splitter', which affected a useful economy in many of the smaller installations.

The story of electric wiring, its systems, and accessories tells an important aspect in the history of industrial development and in the history of social progress. The inventiveness of the old electrical personalities, Compton, Swan, Edison, Kelvin and many others, is well worth noting; for it is from their brain-children that the present-day electrical contracting industry has evolved to become one of the most important sections of activity in electrical engineering. For those who are interested in details of the evolution and development of electric wiring systems and accessories, good reading can be found in the book by J. Mellanby: The History of Electric Wiring (MacDonald, London).

It was not until the 1930s that the distribution of electricity in buildings by means of bus bars came into fashion, though the system had been used as far back as about 1880, particularly for street mains. In 1935 the English Electric Co. introduced a bus bar trunking system designed to meet the needs of the motorcar industry. It provided the overhead distribution of electricity into which system individual machines could be tapped wherever required; this idea caught on and designs were produced and put onto the market by Marryat & Place, GEC, and Ottermill.

1.2. Historical Review of Wiring Installation

The history of the development of non-legal and statutory rules and regulations for the wiring of buildings is no less interesting than that of wiring systems and accessories. When electrical energy received a utilization impetus from the invention of the incandescent lamp, many set themselves up as electricians or electrical wiremen. Others were gas plumbers who indulged in the installation of electrics as a matter of normal course. This was all very well: the contracting industry had to get started in some way, however ragged. But with so many amateurs troubles were bound to

multiply. And they did. It was not long before arc lamps, sparking commutators, and badly insulated conductors contributed to fires. It was the insurance companies, which gave their attention to the fire risk inherent in the electrical installations of the 1880s. Foremost among these was the Phoenix Assurance Co., whose engineer, Mr. Heaphy, was told to investigate the situation and draw up a report on his findings.

The result was the Phoenix Rules of 1882. These Rules were produced just a few months after those of the American Board of Fire Underwriters who are credited with the issue of the first wiring rules in the world.

Three months after the issue of the Phoenix Rules for wiring in 1882, the Society of Telegraph Engineers and Electricians (now the Institution of Electrical Engineers) issued the first edition of Rules and Regulations for the Prevention of Fire Risks arising from Electric lighting. These rules were drawn up by a committee of eighteen men, which included some of the famous names of the day: Lord Kelvin, Siemens, and Crompton. The Rules, however, were subjected to some criticism. Compared with the Phoenix Rules they left much to be desired. But the Society was working on the basis of laying down a set of principles rather than, as Heaphy did, drawing up a guide or 'Code of Practice'. A second edition of the Society's Rules was issued in 1888. The third edition was issued in 1897 and entitled General Rules recommended for Wiring for the Supply of Electrical Energy.

The Phoenix Rules were, however, the better set and went through many editions before revision was thought necessary. That these Rules contributed to a better standard of wiring, and introduced a high factor of safety in the electrical wiring and equipment of buildings, was indicated by a report in 1892, which showed the high incidence of electrical fires in the USA and the comparative freedom from fires of electrical origin in Britain.

The Rules have since been revised at fairly regular intervals as new developments and the results of experience can be written in for the considered attention of all those concerned with the electrical equipment of buildings. Basically the regulations were intended to act as a guide for electricians and others to provide a degree of safety in the use of electricity by inexperienced persons such as householders. The regulations were, and still are, not legal; that is, the law of the land cannot enforce them. Despite this apparent loophole, the regulations are accepted as a guide to the practice of installation work, which will ensure, at the very least, a minimum standard of work. The Institution of Electrical Engineers (IEE) was not alone in the insistence of

good standards in electrical installation work. In 1905, the Electrical Trades Union, through the London District Committee, in a letter to the Phoenix Assurance Co., said ' . . . they view with alarm the large extent to which bad work is now being carried out by electric light contractors . . .. As the carrying out of bad work is attended by fires and other risks, besides injuring the Trade, they respectfully ask you to. . Uphold a higher standard of work'.

While the IEE and the statutory regulations were making their positions stronger, the British Standards Institution brought out, and is still issuing, Codes of Practice to provide what are regarded as guides to good practice. The position of the Statutory Regulations in this country is that they form the primary requirements, which must by law be satisfied. The IEE Regulations and Codes of Practice indicate supplementary requirements. However, it is accepted that if an installation is carried out in accordance with the IEE Wiring Regulations, then it generally fulfils the requirements of the Electricity Supply Regulations. This means that a supply authority can insist upon all electrical work to be carried out to the standard of the IEE Regulations, but cannot insist on a standard which is in excess of the IEE requirements.

The legislation embodied in the Factory and Workshop Acts of 1901 and 1907 had a considerable influence on wiring practice. In the latter Act it was recognized for the first time that the generation, distribution and use of electricity in industrial premises could be dangerous. To control electricity in factories and other premises a draft set of Regulations was later to be incorporated into statutory requirements.

CHAPTER 2
ILLUMINATION

2.1. Illumination

In determining the value of illumination, not only the candle-power of the units, but the amount of reflected light must be considered for the given location of the lamps. Following is a formula based on the coefficient of reflection of the walls of the room, which serves for preliminary calculations: c. p. 1

$1 = 1 - k\, d_2$

I = Illumination in foot-candles.

c.p. = Candle-power of the unit.

k = Coefficient of reflection of the walls.

d = distance from the unit in feet.

Where several units of the same candle-power are used this formula becomes:

1 1 1 1

$I = c.\ p.\ (d_2 + d_{21} + d_{22} + ...)\ 1\text{-}k$ or, $c.\ p = 1$

(1 1 1 1 d_2 d_{21} d_{22} + ----------) 1-k where d, d_1, d_2, equal the distances from the point considered to the various light sources. If the lamps are of different candle-power the illumination may be determined by combining the illumination from each source as calculated separately. An example of calculation is given under "Arrangement of Lamps." The above method is not strictly accurate because it does not take account of the angle at which the light from each one of the sources strikes the assumed plane of illumination. If the rays of light is perpendicular to the plane, the formula 1 = c. p. gives cord2 rect values. If a is the angle which the ray of light makes with a line drawn from the light source perpendicular to the assumed plane, then the formula I = c. p. X cosine

a/ d_2. Therefore, by multiplying the candle-power value of each light source in the directtion of the illuminated point by the cosine of each angle a, a more accurate result will be obtained.

It is readily seen that the effect of reflected light from the ceilings is of more importance than that from the floor of a room. The value of k, in the above formula, will vary from 60% to 10%, but for rooms with a fairly light finish 50% may be taken as a good average value

2.2. Calculatıon

The formulates symbols:

Φ_{dir} = the flow of the direct light

Φ_s = the flow coming to working table.

Φ_{end} = the light flow coming by reflexion

E_s = the avarage level of light of working table

S = m^2 of working table

Φ_o = the sum of light flow (lumen)

The calculation of illumination by the light flow method. The calculation of internal illumination by efficiency method. This method is mostly used in internal illumination installations. As it is known the Φ light that cames to plane has the components Φdır and Φend (Φ_{dir} shows the flow of the direct light, Φ_s shows the flow coming to working table, Φ_{end} shows the light flow coming by reflexion)

$$\Phi_s = \Phi_{dir} + \Phi_{end} \qquad (2.1)$$

$\Phi_{dır}$ can be calculated easily but Φ_{end} is difficult to calculate. So that efficiency method is used in internal illumination installations. Now in order to understand this method let's think about an ideal room that it's walls and ceiling reflects the light totally, (δ=%100) and absorbs the light completely.(α = %100) and no object absorbing the light in it. The Φ_o comes out of the light sources falls on the plane S and it is absorbed their whatever the dimensions of the room, number of the lambs, settlement of the lambs, illumination system. The average illumination degree of the plane for an ideal room is

$$E_o = \Phi_0 / S \qquad (2.2)$$

E_O shows the avarage level of light of working table, Φo represents the total light flow from lambs in lumen and S represents the area of the plane in m^2. In reality some of the light flow is absorbed by walls, ceiling, and illumination devices. So that the average illumination degree of the plane is:

$$E_o = \Phi_0 \eta / S = \Phi_0 / S \qquad (2.3)$$

η factor is called the efficiency of illumination and it is a number less then 1.

$\eta = \Phi_a / \Phi_s$ Φ_a represents flow of light to plane and

Φ_s represents total flow of light that is given by light sources.

Efficiency of device illumination (η) is multiplication of the efficiency of devices and efficiency of the room.

$\eta = \Phi_{ayg} / \Phi_0$ η **ayg** represents the efficiency of device (2.4)

$\eta = \Phi_s / \Phi_{ayg}$ η **oda** represents the efficiency of room (2.5)

$$\eta = \eta_{ayg} - \eta_{oda} \qquad (2.6)$$

Efficiency of device is related with the illumination device. Efficiency of the room is related with geometric dimensions of room, reflection factors and colours of walls and ceiling, light distribution curves of illumination devices, height of them to plane and their places. Table 2.1 shows belowed in same situations that are used mostly.

Table 2.1: Illumination System

Illuminiation system	Direct illiminiation (nayg=%70)		Semi-direct illiminiation (nayg=%80)		Mixed illiminiation (nayg=%80)		Semi indirect illiminiation (nayg=%80)		Indirect illiminiation (nayg=%70)	
	n(%)		n(%)		n(%)		n(%)		n(%)	
Room index (a/h)	A	B	A	B	A	B	A	B	A	
0,5	13	9	9	5	12	7	11	6	9	
0,7	19	13	13	7	16	10	15	8	12	
1,0	25	19	17	10	21	13	19	12	15	
	35	30	24	15	27	17	25	16	20	1
	40	36	29	19	32	21	29	19	23	4
2,5	44	40	33	23	35	24	32	22	26	6
3,0	47	43	36	26	38	26	35	24	28	8
4,0	51	47	41	30	43	30	39	28	32	0
5,0	54	50	45	34	46	33	42	30	34	2
	57	53	51	39	51	37	46	34	36	4
10,0	59	55	57	40	55	40	51	37	38	6

In this Table;

a; lenght of one side of a square room

h; height of light sources to the plane in direct and semi-direct illumination system. Height of ceiling to the plane in direct; mixed and semi-direct illumination system.A; Situation where is ceiling is white (ρ_T= %75) and walls are quite white (ρ_D = %50)

B; Situation where is ceiling is quite white (ρ_T = %50) and wall are dark (ρ_D = %30)

İf the room is a rectangle (a,b) , efficiency is ;

$$\eta = \eta a + 1/3 (\eta a - \eta b) \qquad (2.7)$$

While preparing the table 10.1 , only two efficiency about illumination devices (η ayg = %70 and η ayg = %80) is taken.

If another illumination device that has the efficiency η^1 ayg is used (η^1 is an aygıt different from %70, %80 efficensy level) , the efficiency that is found from table is multiplied with a factor of η^1 ayg / η aygAfter finding the efficiency η , light flow that goes to plane (Φ_o) is found with the help of flow of light by illumination sources (Φ_s). Then the average illumination level is

$$E_o = \Phi_s / S \qquad (2.8)$$

If the average illumination level of plane is given and total light flow that light sources give (Φ_o) is looked for ;

$$\Phi_o = E_o S / h \qquad (2.9)$$

In below the dimensions of living room are given and number of armatures are found by performing necessory calculation.

Table 2.2: Illumination Units

NAME	SYMBOL	UNIT	EXPLANATION
Light flow		Lumen (lm)	It is the amount of the total light source gives in all directions. İn other words it is the port of the electrical energy converted into the light energy. That isgiven to light source.
Light intensity	I	candela (cd)	It is the amount of light flow in any direction. (the light flow may be constant but the light indensity may be different in various directions)
İlliminiation intensity	E	lux (lux)	It is the total light flow that comes to 1 m^2 area
flashing	L	cd / cm^2	It is th elight indensity that comes from light sources or unit surfaces that the light sources lighten.

Table 2.3: Illuminiation Equations

EQUATION	SYMBOL	EXPLANATION
$n = \Phi_T / \Phi_L$	n	Number of light bulbs
	Φ_T	Total light flow necessary (lm)
	Φ_L	Light flow given by a light bulb.
$k = a.b / h(a+b)$	k	Room index (according to dimensions)
	a	Length (m)
	b	width (m)
	h	Height of the light source to the working sueface (m)
	H	Height of the light source to the floor(m)
	h1	Height of the working surfaces to the flor (m)
$\Phi_T = E.A.d / \eta$	E	Necessary illiminiations level (lux) chosen from the table
	A	Surface area that will be lighted (m2)
	d	Pallution installmentfactors 1,25 - 1,75
	η	Efficensy factors of the installment it is chosen from the table according to wall, ceiling, flor reflexion factors, tipe of armature chosen, room index

Table 2.4: Typical flows of some lamps

TYPE OF LAMP	POWER OF LAMP (W)	AVERAGE FLOWS (lm)
GUW (GENERAL USİNG –WİRED)	60	610
	100	1230
FLUORESCANT	18/20	1100
	36/40	2850
	65/80	5600
PL (economic)	9	400
	11	600
	15	900
	20	1200
	23	1500
2D COMPACT FLOURESAN	16	1050
	28	2050
	38	3050
MERCURY (MBF)	50	1800
	125	6300
	400	12250
	1000	38000
MERCURY (MBIF)	250	17000
	1000	81000
H.PRESSURİZED SODİUM (SON PLUS)	100	10000
	400	54000
H.PRESSURİZED SODİUM (SON DELUXE)	150	12250
	400	38000
TUNGTEN HALOJEN	300	5950
	500	11000
	750	16500
	1000	22000
	1500	33000

Table 2.5: Light Sources

Light power	Rated luminous flux
15	120-135
25	215-240
40	340-480
60	620-805
75	855-960
100	1250-1380
150	2100-2280
200	2950-3220

Table 2.6: Hanger Height

Ceiling Height	Area Wideness	Cord Height
2.0	2.0 4.0 8.0 and upper	Ceiling Ceiling Ceiling
2.5	2.5 5.0 10.0 and upper	Ceiling (0.15) Ceiling (0.15) Ceiling (0.15)
3.0	3.0 6.0 12.0 and upper	0.4 (0.5) 0.25 (0.4) Ceiling (0.3)

Table 2.7: Bright Voice

Stair, Corridor, Shower and WC 10 m^2	20
Class, Library and Teacher room 40 m^2	80, 80 100, 100 120
Physical and Chemistry Lab. 100 m^2	120

CHAPTER 3
INSULATORS

3.1. Insulator

An insulator is defined as a material, which offers an extremely high resistance to the passage of an electric current. Were it not for this property of some materials we would not be able to apply electrical energy to so many uses today. Some materials are better insulators than others. The resistivity of all insulating materials decreases with an increase in temperature. Because of this, a limit in the rise in temperature is imposed in the applications of insulating materials, otherwise the insulation would break down to cause a short circuit or leakage current to earth. The materials used for insulation purposes in electrical work are extremely varied and are of a most diverse nature. Because no single insulating material can be used extensively, different materials are combined to give the required properties of mechanical strength, adaptability, and reliability. Solids, liquids, and gases are to be found used as insulation.

Insulating materials arc grouped into classes:

Class A - Cotton, silk, paper, and similar organic materials; impregnated or immersed in oil.

Class B - Mica, asbestos, and similar inorganic materials, generally found in a built-up form combined with cement binding cement. Also polyester enamel covering and glass-cloth and micanite.

Class C - Mica, porcelain glass quartz: and similar materials.

Class D - Polyvinyl acetal resin. Class H - Silicon-glass.

The following are some brief descriptions of some of the insulating materials more commonly found in electrical work.

It is used mainly for cable insulation and cannot be used for high temperatures as it hardens. Generally used with sulphur (vulcanized rubber) and china clay. Has high insulation-resistance value.

3.2. Polyvinyl chloride (PVC)

This is a plastics material, which will tend to flow when used in high temperatures. Has a lower insulation-resistance value than rubber. Used for cable insulation and sheathing against mechanical damage.

It must be used in an impregnated form (resin or oil). Used for cable insulation. Impregnated with paraffin wax, paper is used for making capacitors. Different types are available: Kraft, cotton, tissue, and pressboard.

It is used for insulators (overhead lines). In glass fiber form it is used for cable insulation where high temperatures are present, or where areas are designated 'hazardous'. Requires a suitable impregnation (with silicone varnish) to fill the spaces between the glass fibers.

This material is used between the segments of commutators of de machines, and under slip rings of ac machines. Used where high temperatures are involved such as the heating elements of electric irons. It is a mineral, which is present in most granite-rock formations; generally produced in sheet and block form. Micanite is the name given to the large sheets built up from small mica splitting and can be found backed with paper, cotton fabric, silk or glass-cloth or varnishes. Forms include tubes and washers.

It is used for overhead-line insulators and switchgear and transformer bushings as lead-ins for cables and conductors. Also found as switch-bases, and insulating beads for high-temperature insulation applications.

A very common synthetic material found in many aspects of electrical work (e.g. lamp holders, junction boxes), and used as a construction material for enclosing switches to be used with insulated wiring systems.

3.3. Insulating oil

This is a mineral oil used in transformers and in oil-filled circuit breakers where the arc drawn out when the contacts separate, is quenched by the oil. It is used to impregnate wood, paper, and pressboard. This oil breaks down when moisture is present.

This material is used extensively for 'potting' or encapsulating electronic items. In larger castings it is found as insulating bushings for switchgear and transformers.

This group of insulating materials includes both natural (silk, cotton, and jute) and synthetic (nylon, Terylene). They are often found in tape form, for winding-wire coil insulation. Air is the most important gas used for insulating purposes. Under certain conditions (humidity and dampness) it will break down. Nitrogen and hydrogen are used in electrical transformers and machines as both insulates and coolants.

Mineral oil is the most common insulator in liquid form. Others include carbon tetrachloride, silicone fluids and varnishes. Semi-liquid materials include waxes, bitumens and some synthetic resins. Carbon tetrachloride is found as an arc-quencher in high-voltage cartridge type fuses on overhead lines. Silicone fluids are used in transformers and as dashpot damping liquids. Varnishes are used for thin insulation covering for winding wires in electromagnets. Waxes are generally used for impregnating capacitors and fibres where the operating temperatures are not high. Bitumens are used for filling cable-boxes; some are used in a paint form. Resins of a synthetic nature form the basis of the materials known as 'plastics' (polyethylene, polyvinyl chloride, melamine and polystyrene). Natural resins are used in varnishes, and as bonding media for mica and paper sheets hot-pressed to make boards.

CHAPTER 4

EARTHING

4.1. Earthing

An efficient earthing arrangement is an essential part of every electrical installation and system to guard against the effects of leakage currents, short-circuits, static charges and lightning discharges. The basic reason for earthling is to prevent or minimize the risk of shock to human beings and livestock, and to reduce the risk of fire hazard. The earthing arrangement provides a low-resistance discharge path for currents, which would otherwise prove injurious or fatal to any person touching the metalwork associated with the faulty circuit. The prevention of electric shock risk in installations is a matter, which has been given close attention in these past few years, particularly since the rapid increase in the use of electricity for an ever-widening range of applications.

4.2. Earthing Terms

4.2.1. Earth:

A connection to the general mass of earth by means of an earth electrode.

4.2.2. Earth Electrode:

A metal plate, rod or other conductor band or driven in to the ground and used for earthing metal work.

4.2.3. Earthing Lead:

The final conductor by means of which the connection to the earth electrode is made.

4.2.4. Earth Continuity Conductor (ECC):

The conductor including any lam connecting to the earth or each other those part of an installation which are required to be earthed. The ECC may be in whole or part the metal conduit or the metal sheath of cables or the special continuity conductor of a cable or flexible cord incorporating such a conductor.

4.3. Earthing Systems:

In our electricity system, which is same to UK electricity, is an earthed system, which means that star or neutral point of the secondary side of distribution transformer is connected to the general mass of earth.

In this way, the star point is maintained at or about 0V. Unfortunately, this also means that persons or livestock in contact with a live part and earth is at risk of electric shock.

4.3.1. Lightning protection

Lightning discharges can generate large amounts of heat and release considerable mechanical forces, both due to the large currents involved. The recommendations for the protection of structures against lightning are contained in BS Code of Practice 6651 (Protection of Structures Against Lightning). The object of such a protective system is to lead away the very high transient values of voltage and current into the earth where they are safely dissipated. Thus a protective system, to be effective, should be solid and permanent. Two main factors are considered in determining whether a structure should be given protection against lightning discharges:

1. Whether it is located in an area where lightning is prevalent and whether, because of its height and/or its exposed position, it is most likely to be struck.

2. Whether it is one to which damage is likely to be serious by virtue of its use, contents, importance, or interest (e.g. explosives factory, church monument, railway station, spire, radio mast, wire fence, etc.).

It is explained in BS Code of Practice 6651 that the 'zone of protection' of a single vertical conductor fixed to a structure is considered to be a cone with an apex at the highest point of the conductor and a base of radius equal to the height. This means that a conductor 30 meters high will protect that part of the structure which comes within a cone extending to 60 meters in diameter at ground level Care is therefore necessary in ensuring that the whole of a structure or building falls within the protective zone; if it does not, two down conductors must be run to provide two protective zones within which the whole structure is contained. All metallic objects and projections, such

as metallic vent pipes and guttering, should be bonded to form part of the air-termination network. All down conductors should be cross-bonded.

The use of multiple electrodes is common. Rule 5 of the Phoenix Fire Office Rules states:

Earth connections and number: The earth connection should be made either by means of a copper plate buried in damp earth, or by means of the tubular earth system, or by connection to the water mains (not nowadays recommended). The number of connections should be in proportion to the ground area of the building, and there are few structures where less than two are necessary ... Church spires, high towers, factory chimneys having two down conductors should have two earths which may be interconnected.

All the component parts of a lightning-protective system should be either castings of leaded gunmetal, copper, naval brass or wrought phosphor bronze, or sheet copper or phosphor bronze. Steel, suitably protected from corrosion, may be used in special cases where tensile or compressive strength is needed.

Air terminations constitute that part of dice system, which distributes discharges into, or collects discharges from, the atmosphere. Roof conductors are generally of soft annealed copper strip and interconnect the various air terminations. Down conductors, between earth and the air terminations are also of soft-annealed copper strip. Test points are joints in down conductors, bonds, earth leads, which allow resistance tests to be made. The earth terminations are those parts of the system designed to collect discharges from, or distribute charges into, the general mass of earth. Down conductors are secured to the face of the structure by 'holdfasts' made from gunmetal The 'building-in' type is used for new structures; a caulking type is used for existing structures.

With a lightning protection system, the resistance to earth need not be less than 10 ohms. But in the case of important buildings, seven ohms is the maximum resistance. Because the effectiveness of a lightning conductor is dependent on its connection with moist earth, a poor earth connection may render the whole system useless The 'Hedges' patent tubular earth provides a permanent and efficient earth connection, which is inexpensive, simple in construction and easy to install. These earths, when driven firmly into the soil, do not lose their efficiency by changes in the soil due to drainage; they have a constant resistance by reason of their being kept in contact with moist soil by watering arrangements provided at ground level. In addition, tubular or rod earths are easier to install than plate earths, because the latter require excavation.

Lightning conductors should have as few joints as possible. If these are necessary, other than at the testing-clamp or the earth-electrode clamping points, flat tape should be tinned, soldered, and riveted; rod should be screw-jointed.

All lightning protective systems should he examined and tested by a competent engineer after completion, alteration, and extension.

4.3.2. Anti-static Earthing

'Static', which is a shortened term for 'static electric discharge' has been the subject of increasing concern in recent years partly due to the increasing use of highly insulating materials (various plastics and textile fibers).

4.3.3. Earthing Practice

A routine inspection and test should be made once a year and any defects remedied. In the case of a structure containing explosives or other inflammable materials, the inspection and test should be made every six months. The tests should include the resistance to earth and earth continuity. The methods of testing are similar to those described in the IEE Regulations, though tests for earth-resistance of earth electrodes require definite distances to be observed.

4.3.3.a. Direct Earthing

The term 'direct earthing' means connection to an earth electrode, of some recognized type, and reliance on the effectiveness of over current protective devices for protection against shock and fire hazards in the event of an earth fault. If direct earthing protects non-current-carrying metalwork, under fault conditions a potential difference will exist between the metalwork and the general mass of earth to which the earth electrode is connected. This potential will persist until the protective device comes into operation. The value of this potential difference depends on the line voltage, the substation or supply transformer earth resistance, the line resistance, the fault resistance, and finally, the earth resistance at the installation. Direct earth connections are made with electrodes in the soil at the consumer's premises. A further method of effecting connection to earth is that which makes use of the metallic sheaths of underground cables. But such sheaths are more generally used to provide a direct metallic connection for the return of earth-fault current to the neutral of the supply system rather than as a means of direct connection to earth.

The earth electrode, the means by which a connection with the general mass of earth is made, can take a number of forms, and can appear either as a single connection or as a network of multiple electrodes. Each type of electrode has its own advantages and disadvantages.

The design of an earth electrode system takes into consideration its resistance to ensure that this is of such a value that sufficient current will pass to earth to operate the protective system. It must also be designed to accommodate thermally the maximum fault current during the time it takes for the protective device to clear the fault. In designing for a specific ohmic resistance, the resistivity of the soil is perhaps the most important factor, although it is a variable one.

The current rating or fault-current capacity of earth electrodes must be adequate for the 'fault-current/time-delay' characteristic of the system under the worst possible conditions. Undue heating of the electrode, which would dry out the adjacent soil and increase the earth resistance, must be avoided. Calculated short-time ratings for earth electrodes of various types are available from electrode manufacturers. These ratings are based on the short-time current rating of the associated protective devices and a maximum temperature, which will not cause damage to the earth connections or to the equipment with which they may be in contact.

In general soils have a negative temperature coefficient of resistance. Sustained current loadings result in an initial decrease in electrode resistance and a consequent rise in the earth-fault current for a given applied voltage. However, as the moisture in the soil is driven away from the soil/electrode interface, the resistance rises rapidly and will ultimately approach infinity if the temperature rise is sufficient. This occurs in the region of 100 ^{0}C and results in the complete failure of the electrode.

The current density of the electrode is found by:

$$\textbf{Current density} = I / A\sqrt{t} = 92 \times 10^3 \qquad (4.1)$$

where I = short-circuit fault current; A = area (in cm^2); t = time in seconds (duration of the fault current). The formula assumes a temperature rise of 120^{0}C, over an ambient temperature of 25 ^{0}C, and the use of high-conductivity copper. The formula does not allow for any dissipation of heat into the ground or into the air.

Under fault conditions, the earth electrode is raised to a potential with respect to the earth surrounding it. This can be calculated from the prospective fault current and the earth resistance of the electrode. It results in the existence of voltages in soil around the electrode, which may harm telephone and pilot cables (whose cores are substantially at earth potential) owing to the voltage to which the sheaths of such cables are raised. The voltage gradient at the surface of the ground may also constitute a danger to life, especially where cattle and livestock are concerned. In rural areas, for instance, it is not uncommon for the earth-path resistance to be such that faults are not cleared within a short period of time and animals which congregate near the areas in which current carrying electrodes are installed are liable to receive fatal shocks. The same trouble occurs on farms where earth electrodes are sometimes used for individual appliances. The maximum voltage gradient over a span of 2 meters to a 25 mm diameter pipe electrode is reduced from 85 per cent of the total electrode potential when the top of the electrode is at ground level to 20 per cent and 5 per cent when the electrode is buried at 30 cm and 100 cm respectively. Thus, in areas where livestock are allowed to roam it is recommended that electrodes be buried with their tops well below the surface of the soil.

Corrosion of electrodes due to oxidation and direct chemical attack is sometimes a problem to be considered. Bare copper acquires a protective oxide film under normal atmospheric conditions which does not result in any progressive wasting away of the metal. It does, however, tend to increase the resistance of joints at contact surfaces. It is thus important to ensure that all contact surfaces in copper work, such as at test links, be carefully prepared so that good electrical connections are made. Test links should be bolted up tightly. Electrodes should not be installed in ground, which is contaminated by corrosive chemicals. If copper conductors must be run in an atmosphere containing hydrogen sulphide, or laid in ground liable to contamination by corrosive chemicals, they should be protected by a covering of PVC adhesive tape or a wrapping of some other suitable material, up to the point of connection with the earth electrode. Electrolytic corrosion will occur in addition to the other forms of attack if dissimilar metals are in contact and exposed to the action of moisture. Bolts and rivets used for making connections in copper work should be of either brass or copper. Annulated copper should not be run in direct contact with ferrous metals. Contact between bare copper and the lead sheath or armoring of cables should be avoided, especially underground. If it is impossible to avoid the connection of dissimilar metals, these

should be protected by painting with a moisture-resisting bituminous paint or compound, or by wrapping with PVC tape, to exclude all moisture.

The following are the types of electrodes used to make contact with the general mass of earth:

a) Plates. These are generally made from copper, zinc, steel, or cast iron, and may be solid or the lattice type. Because of their mass, they tend to be costly. With the steel or cast-iron types care must he taken to ensure that the termination of the earthing lead to the plate is water-proofed to prevent cathodic action taking place at the joint, If this happens, the conductor will eventually become detached from the plate and render the electrode practically useless. Plates are usually installed on edge in a hole in the ground about 2-3 meters deep, which is subsequently refilled with soil. Because one plate electrode is seldom sufficient to obtain a low-resistance earth connection, the cost of excavation associated with this type of electrode can be considerable. In addition, due to the plates being installed relatively near the surface of the ground, the resistance value is liable to fluctuate throughout the year due to the seasonal changes in the water content of the soil. To increase the area of contact between the plate and the surrounding ground, a layer of charcoal can be interposed. Coke, which is sometimes used as an alternative to charcoal, often has a high sulphur content, which can lead to serious corrosion and even complete destruction of the copper. The use of hygroscopic salts such as calcium chloride to keep the soil in a moist condition around the electrode can also lead to corrosion.

b) Rods. In general rod electrodes have many advantages over other types of electrode in that they are less costly to install. They do not require much space, are convenient to test and do not create large voltage gradients because the earth-fault current is dissipated vertically. Deeply installed electrodes are not subject to seasonal resistance changes. There are several types of rod electrodes. The solid copper rod gives excellent conductivity and is highly resistant to corrosion. But it tends to be expensive and, being relatively soft, is not ideally suited for driving deep into heavy soils because it is likely to bend if it comes up against a large rock. Rods made from galvanized steel are inexpensive and remain rigid when being installed. However, the life of galvanized steel in acidic soils is short. Another disadvantage is that the copper earthing lead connection

to the rod must be protected to prevent the ingress of moisture. The conductivity of steel is much less than that of copper, difficulties may arise, particularly under heavy fault current conditions when the temperature of the electrode wilts rise and therefore its inherent resistance.

This will tend to dry out the surrounding soil, increasing its resistivity value and resulting in a general increase in the earth resistance of the electrode. In fact, in very severe fault conditions, the resistance of the rod may rise so rapidly and to such an extent that protective equipment may fail to operate.

The bimetallic rod has a steel core and a copper exterior and offers the best alternative to either the copper or steel rod. The steel core gives the necessary rigidity while the copper exterior offers good conductivity and resistance to corrosion. In the extensible type of steel-cored rod, and rods made from bard-drawn copper, steel driving caps are used to avoid splaying the rod end as it is being driven into the soil. The first rod is also provided with a pointed steel tip. The extensible rods are fitted with bronze screwed couplings. Rods should be installed by means of a power driven hammer fitted with a special head. Although rods should be driven vertically into the ground, an angle not exceeding 60° to the vertical is recommended in order to avoid rock or other buried obstruction.

c) Strip. Copper strip is used where the soil is shallow and overlies rock. It should be buried in a trench to a depth of not less than 50 cm and should not be used where there is a possibility of the ground being disturbed (e.g. on farmland). The strip electrode is most effective if buried in ditches under hedgerows where the bacteriological action arising from the decay of vegetation maintains a low soil resistivity.

d) Earths mat. These consist of copper wire buried in trenches up to one meter deep. The mat can be laid out either linearly or in 'star' form and terminated at the down lead from the transformer or other items of equipment to be earthed. The total length of conductor used can often exceed 100 meters. The cost of trenching alone can be expensive. Often scrap overhead line conductor was used but because of the increasing amount of aluminum now being used, scrap copper conductor is scarce. The most common areas where this system is still used are where rock is present near the surface of the soil, making deep excavation impracticable. As with plate electrodes, this method of earthing is subject to seasonal changes in resistance. Also, there is the danger of

voltage gradients being created by earth faults along the lengths of buried conductor, causing a risk to livestock.

4.4. Important Points of Earthing:

To maintain the potential of any part of a system at a definite value with respect to earth.

I. To allow current to flow to earth in the event of a fault so that, the protective gears will operate to isolate the faulty circuit.

II. To make sure that in the event of a fault, apparatus "Normally death (0V)" cannot reach a dangerous potential whit respect to earth.

4.5. Electric Shock:

This is the passage of current through the body of such magnitude as to have significant harmful effects these value of currents are;

1mA-2mA	Barely perceptible, no harmful effects
5mA-10mA	Throw off, painful sensation
10mA-15mA	Muscular contraction, cannot let go
20mA-30mA	Impaired breathing
50mA and above	Ventricular fibrillation and earth.

There are two ways in which we can be at risk.

a-) Touching live parts of equipment for systems. That is intended to be live. This is called direct contact.

b-) Touching conductive parts which are not meant to be live, but which have become live due to a fault. This is called indirect contact.

4.6. Earth testing

IEE Regulations requires that tests he made on every installation to ensure that the earthing arrangement provided for that installation is effective and offers the users of the installation a satisfactory degree of protection against earth-leakage currents. The following are the individual tests prescribed by the Regulations.

4.6.1. Circuit-protective conductors

Regulation 713-02-01 requires that every circuit-protective conductor (CPC) be

tested to verify that it is electrically sound and correctly connected. The IEE Regulations Guidance Notes on inspection and testing give details on the recognized means used to test the CPC. For each final circuit, the CPC forms part of the earth-loop impedance path, its purpose being to connect all exposed conductive parts in the circuit to the main earth terminal. The CPC can take a number of forms. If metallic conduit or trunking is used, the usual figure for ohmic resistance of one-meter length is 5 milliohms/m.

Generally if the total earth-loop impedance (Z_s) for a particular final circuit is within the maximum Z_s limits, the CPC is then regarded as being satisfactory. However, some testing specifications for large installations do require a separate test of each CPC to be carried out. The following descriptions of such tests refer to a.c. installations.

4.6.2. Reduced a.c. test

In certain circumstances, the testing equipment in the a.c. test described above is not always available and it is often necessary to use hand-testers, which deliver a low value of test current at the frequency of the mains supply. After allowing for the resistance of the test lead, a value for impedance of 0.5 ohm maximum should be obtained where the CPC, or part of it, is made from steel conduit. If the CPC is in whole or in part made of copper, copper-alloy, or aluminum, the maximum value is one ohm.

4.6.3. Direct current

Where it is not convenient to use a.c. for the test, D.C. may be used instead. Before the D.C. is applied, an inspection must be made to ensure that no inductor is incorporated in the length of the CPC. Subject to the requirements of the total earth-loop impedance, the maximum values for impedance for the CPC should be 0.5 ohm (if of steel) or one ohm (if of copper, copper-alloy or aluminum).

The resistance of an earth-continuity conductor, which contains imperfect joints, varies with the test current. It is therefore recommended that a D.C. resistance test for quality is made, first at low current, secondly with high current, and finally with low current. The low-current tests should be made with an instrument delivering not more than 200 mA into one ohm; the high-current test should be made at 10 A or such higher current as is practicable.

The open-circuit voltage of the test set should be less than 30 V. Any substantial variations in the readings (say 25 per cent) will indicate faulty joints in the conductor;

these should be rectified. If the values obtained are within the variation limit, no further test of the CPC is necessary.

4.6.4. Residual current devices

IEE Regulation 713-12-01 requires that where an RCD provides protection against indirect contact, the unit must have its effectiveness tested by the simulation of a fault condition. This test is independent of the unit's own test facility. The consumer who is advised to ensure that the RCD trips when a test current, provided by an internal resistor, is applied to the trip-coil of the unit designs the latter for use. Thus, on pressing the 'Test' button the unit should trip immediately. If it does not it may indicate that a fault exists and the unit should not be used with its associated socket-outlet, particularly if the outlet is to be used for outdoor equipment.

The RCD has a normal tripping current of 30 mA and an operating time not exceeding 40 ms at a test current of 150 mA.

RCD testers are commercially available, which allow a range of tripping currents to be applied to the unit, from 10 mA upwards. In general the lower the tripping current the longer will be the time of disconnection.

It should be noted that a double pole RCD is required for caravans and caravan sites and for agricultural and horticultural installations where socket-outlets are designed for equipment to be used other than 'that essential to the welfare of livestock'.

4.6.5. Earth-electrode resistance area

The general mass of earth is used in electrical work to maintain the potential of any part of a system at a definite value with respect to earth (usually taken as zero volts). It also allows a current to flow in the event of a fault to earth, so that protective gear will operate to isolate the faulty circuit. One particular aspect of the earth electrode resistance area is that its resistance is by no means constant. It varies with the amount of moisture in the soil and is therefore subject to seasonal and other changes. As the general mass of earth forms part of the earth-fault loop path, it is essential at times to know its actual value of resistance, and particularly of that area within the vicinity of the earth electrode. The effective resistance area of an earth electrode extends for some distance around the actual electrode; but the surface voltage dies away very rapidly as the distance from the electrode increases.

The basic method of measuring the earth-electrode resistance is to pass current into the soil via the electrode and to measure the voltage needed to produce this current. The type of soil largely determines its resistivity. The ability of the soil to conduct currents is essentially electrolytic in nature, and is therefore affected by moisture in the soil and by the chemical composition and concentration of salts dissolved in the contained water. Grain size and distribution, and closeness of packing are also contributory factors, since these control the manner in which moisture is held in the soil. Many of these factors vary locally. The following table shows some typical values of soil resistivity.

Table 4.1: Soil Resistivity Values

Type of soil	**Approximate value in ohm-cm**
Marshy ground	200 to 350
Loam and clay	400 to 15,000
Chalk	6000 to 40,000
Sand	9000 to 800,000
Peat	5000 to 50,000
Sandy gravel	5000 to 50,000
Rock	100,000 upwards

When the site of an earth electrode is to be considered, the following types of soil are recommended, in order of preference:

1. Wet marshy ground, which is not too well drained.

2. Clay, loamy soil, arable land, clayey soil, and clayey soil mixed with small quantities of sand.

3. Clay and loam mixed with varying proportions of sand, gravel, and stones.

4. Damp and wet sand, peat.

Dry sand, gravel, chalk, limestone, whinstone, granite, and any very stony ground should be avoided, as should all locations where virgin rock is very close to the surface. Chemical treatment of the soil is sometimes used to improve its conductivity Common salt is very suitable for this purpose. Calcium chloride, sodium carbonate, and other substances are also beneficial, but before any chemical treatment is applied it should be verified that no corrosive actions would be set up, particularly on the earth electrode.

Either a hand-operated tester or a mains-energized double-wound transformer can be used, the latter requiring an ammeter and a high-resistance voltmeter. The former method gives a direct reading in ohms on the instrument scale; the latter method requires a calculation in the form:

$$R = V / I \tag{4.2}$$

The procedure is the same in each case. An auxiliary electrode is driven into the ground at a distance of about 30 meters away from the electrode under test (the consumer's electrode). A third electrode is driven midway between them. To ensure that the resistance area of the first two electrodes does not overlap, the third electrode is moved 6 meters farther from, and nearer to, the electrode under test. The three tests should give similar results, the average value being taken as the mean resistance of the earth electrode.

One disadvantage of using the simple method of earth electrode resistance measurement is that the effects of emfs (owing to electrolytic action in the soil) have to be taken into account when testing. Also, there is the possibility of stray earth currents being leakages from local distribution systems. Because of this it is usual to use a commercial instrument, the Megger earth tester being a typical example.

4.6.6. Earth-fault loop impedance

Regulation 113-11-01 stipulates that where earth-leakage relies on the operation of over current devices, an earth-loop impedance test should be carried out to prove the effectiveness of the installation's earthing arrangement. Although the supply authority makes its own earth-loop impedance tests, the electrical contractor is still required to carry out his own tests. The tests carried out by a supply authority will not absolve the contractor from his legal responsibilities for the safe and effective operation of protection equipment which he may install as part of a wiring installation. This applies both to new installations and extensions to existing installations. Earth-loop impedance tests must be carried out on all extension work of major importance to ensure that the earth-continuity path right back to the consumer's earthing terminal is effective and will enable the protective equipment to operate under fault conditions.

4.6.7. Phase-earth loop test

This test closely simulates the condition which would arise should an earth- fault

NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

ELECTRICAL DESIGN OF A SERVICE BUILDING

GRADUATION PROJECT

EE400

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ABSTRACT

The electrical design works are very important in the planning of Hotels, Super Markets, Schools, and other Service buildings. For satisfying the consumer requirements, electrical installation should be well designed and applied with a professional knowledge, because in the present day when we are choosing an armature we don't looking only to its watt value. We consider the lumen of the lamp the type and design of the armature if its suitable or not for the project, and sometimes the working temperature.

This project is about the electrical installation of a service building, this project needs well knowledge about electrical installation and also researching the present system. This project consist of the installation of lighting circuits, the installation of sockets, illumination with spots, fan and motor for central heating system, fire alarm system, television, data and telephone systems. For all of these, there are some regulations that has to be applied. All project is drawn in AutoCAD 2014.

INTRODUCTION

Illumination started with human generation, they always wished to be illuminated. Firstly they used fire to illuminate. Then with technology development the devices for illumination were developed. By the invention of oil these technologies has been improved. Oil lamp was a good but not enough invention for human. At 18th century by invention of electricity electrical lamps were inverted by Edison. Day by day illumination techniques were changed and by the invention of alternating current this technology became cheaper and safer. Nowadays we are still using alternating current for great amount of illumination demands. Nowadays , hundreds of megawatts of power are being used to illuminate roads, buildings hotels and to change our nights darkness in to light.

The electrical installation design has many categories based on different conditions and bases.

This work discuses the illumination and electrical power design of service building, different design aspects will be discussed and presented, calculations and result will be shown.

The chapters are illustrated in term of systems categories in eight chapters as following:

- Beginning chapter is about general information
- Second chapter is illumination
- Third chapter is about insulators
- Fourth chapter is earthing
- Fifth chapter is lighting
- Sixth chapter is using cables
- Seventh chapter is about protection of illumination
- And the last chapter is about luminaries.

CONTENTS

CHAPTER 1
GENERALS

1.1. Historical Review of Installation Work

Electricity was first used in mining for pumping. In the iron and steel industry, by 1917, electric furnaces of both the arc and induction type were producing over 100,000 tons of ingot and castings. The first all-welded ship was constructed in 1920; and the other ship building processes were operated by electric motor power for punching, shearing, drilling machines and woodworking machinery.

The first electric motor drives in light industries were in the form of one motor-unit per line of shafting. Each motor was started once a day and continued to run throughout the whole working day in one direction at a constant speed. All the various machines driven from the shafting were started, stopped, reversed or changed in direction and speed by mechanical means. The development of integral electric drives, with provisions for starting, stopping and speed changes, led to the extensive use of the motor in small kilowatt ranges to drive an associated single machine, e.g. a lathe. One of the pioneers in the use of motors was the firm of Bruce Peebles, Edinburgh. The firm supplied, in the 1890s, a number of weatherproof, totally enclosed motors for quarries in Dumfries shire, believed to be among the first of their type in Britain.

As one might expect to find in the early beginnings of any industry, the application, and the methods of application, of electricity for lighting, heating, and motive power was primitive in the extreme. Large-scale application of electrical energy was slow to develop. The first wide use of it was for lighting in houses, shops, and offices. By the 1870s, electric lighting had advanced from being a curiosity to something with a definite practical future. Arc lamps were the first form of lighting, particularly for the illumination of main streets. When the incandescent-filament lamp appeared on the scene electric lighting took on such a prominence that it severely threatened the use of gas for this purpose. But it was not until cheap and reliable metal-filament lamps were produced that electric lighting found a place in every home in the land. Even then, because of the low power of these early filament lamps, shop windows continued for some time to be lighted externally by arc lamps suspended from the fronts of buildings.

The earliest application of electrical energy as an agent for motive power in industry is still electricity's greatest contribution to industrial expansion. The year 1900 has been regarded as a time when industrialists awakened to the potential of the new form of power.

The General Electric Company had its origins in the 1880s, as a Company, which was able to supply every single item, which went to form a complete electrical installation. In addition it was guarantied that all the components offered for sale were technically suited to each other, were of adequate quality and were offered at an economic price. The first electric winder ever built in Britain was supplied in 1905 to a Lanark oil concern. Railway electrification started as long ago as 1883, but it was not until long after the turn of this century that any major development took place.

Many names of the early electric pioneers survive today. Julius Sax began to make electric bells in 1855, and later supplied the telephone with which Queen Victoria spoke between Osborne, in the Isle of Wight, and Southampton in 1878. He founded one of the earliest purely electric manufacturing firms, which exists today and still makes bells and signaling equipment.

Specializing in lighting, Falk Statesman & Co. Ltd began by marketing improved designs of oil lamps, then gas fittings, and ultimately electric lighting fittings.

Cable makers W. T. Glover & Co. were pioneers in the wire field. Glover was originally a designer of textile machinery, but by 1868 he was also making braided steel wires for the then fashionable crinolines. From this type of wire it was a natural step to the production of insulated conductors for electrical purposes. At the Crystal Palace Exhibition in 1885 he showed a great range of cables; he was also responsible for the wiring of the exhibition.

The well-known J. & P. firm (Johnson & Phillips) began with making telegraphic equipment, extended to generators and arc lamps, and then to power supply.

The coverings for the insulation of wires in the early days included textiles and gutta-percha. Progress in insulation provisions for cables was made when vulcanized rubber was introduced, and it is still used today.

Siemens Brothers made the first application of a lead sheath to rubber-insulated cables. The manner in which we name cables was also a product of Siemens, whose early system was to give a cable a certain length related to a standard resistance of 0.1 ohm. For many years ordinary VRI cables made up about 95 per cent of all installations.

They were used first in wood casing, and then in conduit. Wood casing was a very early invention. It was introduced to separate conductors, this separation being considered a necessary safeguard against the two wires touching and so causing fire. Choosing a cable at the turn of the century was quite a task. From one catalogue alone, one could choose from fifty-eight sizes of wire, with no less than fourteen different grades of rubber insulation. The grades were described by such terms as light, high, medium, or best insulation. Nowadays there are two grades of insulation: up to 600 V and 600 V/1,000 V. And the sizes of cables have been reduced to a more practicable seventeen.

Thus a No.90 cable in their catalogue was a cable of which 90 yards had a resistance of 0.1 ohm. The Standard Wire Gauge also generally knew Cable sizes.

During the 1890s the practice of using paper as an insulating material for cables was well established. One of the earliest makers was the company, which later became a member of the present-day BICC Group. The idea of using paper as an insulation material came from America to Britain where it formed part of the first wiring system for domestic premises. This was twin lead-sheathed cable. Bases for switches and other accessories associated with the system were of cast solder, to which the cable sheathing was wiped, and then all joints sealed with a compound. The compound was necessary because the paper insulation when dry tends to absorb moisture.

In 1911, the famous 'Henley Wiring System' came on the market. It comprised flat-twin cables with a lead-alloy sheath. Special junction boxes, if properly fixed, automatically affected good electrical continuity. The insulation was rubber. It became very popular. Indeed, it proved so easy to install that a lot of unqualified people appeared on the contracting scene as 'electricians'. When it received the approval of the IEE Rules, it became an established wiring system and is still in use today.

The main competitor to rubber as an insulating material appeared in the late 1930s. This material was PVC (polyvinyl chloride), a synthetic material that came from Germany. The material, though inferior to rubber so far as elastic properties were concerned, could withstand the effects of both oil and sunlight. During the Second World War PVC, used both as wire insulation and the protective sheath, became well established.

As experience increased with the use of TRS cables, it was made the basis of modified wiring systems. The first of these was the Calendar farm-wiring system

introduced in 1937. This was tough rubber sheathed cable with a semi-embedded braiding treated with a green-colored compound.

Perhaps one of the most interesting systems of wiring to come into existence was the MICS (mineral-insulated copper-sheathed cable), which used compressed magnesium oxide as the insulation, and had a copper sheath and copper conductors. The cable was first developed in 1897 and was first produced in France. It has been made in Britain since 1937, first by Pyrotenax Ltd, and later by other firms. Mineral insulation has also been used with conductors and sheathing of aluminum.

This system combined the properties of ordinary TRS and HSOS (house-service overhead system) cables.

So far as conductor material was concerned, copper was the most widely used. But aluminum was also applied as a conductor material. Aluminum, which has excellent electrical properties, has been produced on a large commercial scale since about 1890. Overhead lines of aluminum were first installed in 1898. Rubber-insulated aluminum cables of 3/0.036 inch and 3/0.045 inch were made to the order of the British Aluminum Company and used in the early years of this century for the wiring of the staff quarters at Kinlochleven in Argyllshire. Despite the fact that lead and lead-alloy proved to be of great value in the sheathing of cables, aluminum was looked to for a sheath of, in particular, light weight. Many experiments were carried out before a reliable system of aluminum-sheathed cable could be put on the market.

One of the first suggestions for steel used for conduit was made in 1883. It was then called 'small iron tubes'. However, the first conduits were of itemized paper. Steel for conduits did not appear on the wiring scene until about 1895. The revolution in conduit wiring dates from 1897, and is associated with the name 'Simplex' which is common enough today. It is said that the inventor, L. M. Waterhouse, got the idea of close-joint conduit by spending a sleepless night in a hotel bedroom staring at the bottom rail of his iron bedstead. In 1898 he began the production of light gauge close-joint conduits. A year later the screwed-conduit system was introduced.

Insulated conduits also were used for many applications in installation work, and are still used to meet some particular installation conditions. The 'Gilflex' system, for instance, makes use of a PVC tube, which can be bent cold, compared with earlier material, which required the use of heat for bending.

Accessories for use with wiring systems were the subjects of many experiments; many interesting designs came onto the market for the electrician to use in his work. When lighting became popular, there arose a need for the individual control of each lamp from its own control point. The 'branch switch' was used for this purpose.

Non-ferrous conduits were also a feature of the wiring scene. Heavy-gauge copper tubes were used for the wiring of the Rayland's Library in Manchester in 1886. Aluminum conduit, though suggested during the 1920s, did not appear on the market until steel became a valuable material for munitions during the Second World War.

The term 'switch' came over to this country from America, from railway terms which indicated a railway 'point', where a train could be 'switched' from one set of tracks to another. The 'switch', so far as the electric circuit was concerned, thus came to mean a device, which could switch an electric current from one circuit to another.

It was Thomas Edison who, in addition to pioneering the incandescent lamp, gave much thought to the provision of branch switches in circuit wiring. The term 'branch' meant a tee off from a main cable to feed small current-using items. The earliest switches were of the 'turn' type, in which the contacts were wiped together in a rotary motion to make the circuit. The first switches were really crude efforts: made of wood and with no positive ON or OFF position. Indeed, it was usual practice to make an inefficient contact to produce an arc to 'dim' the lights! Needless to say, this misuse of the early switches, in conjunction with their wooden construction, led to many fires. But new materials were brought forward for switch construction such as slate, marble, and, later, porcelain. Movements were also made more positive with definite ON and OFF positions. The 'turn' switch eventually gave way to the 'Tumbler' switch in popularity. It came into regular use about 1890. Where the name 'tumbler' originated is not clear; there are many sources, including the similarity of the switch action to the antics of Tumbler Pigeons. Many accessory names, which are household words to the electricians of today, appeared at the turn of the century: Verity's, McGeoch, Tucker, and Crabtree. Further developments to produce the semi-recessed, the flush, the ac only, and the 'silent' switch proceeded apace. The switches of today are indeed of long and worthy pedigrees.

Ceiling roses, too, have an interesting history; some of the first types incorporated fuses. The first rose for direct attachment to conduit came out in the early 1900s, introduced by Dorman & Smith Ltd.

Lord Kelvin, a pioneer of electric wiring systems and wiring accessories brought out the first patent for a plug-and-socket. The accessory was used mainly for lamp loads at first, and so carried very small currents. However, domestic appliances were beginning to appear on the market, which meant that sockets had to carry heavier currents. Two popular items were irons and curling-tong heaters. Crompton designed shuttered sockets in 1893. The modern shuttered type of socket appeared as a prototype in 1905, introduced by Diamond. It was one thing to produce a lamp operated from electricity. It was quite another thing to devise a way in which the lamp could be held securely while current was flowing in its circuit. The first lamps were fitted with wire tails for joining to terminal screws. It was Thomas Edison who introduced, in 1880, the screw cap, which still bears his name. It is said he got the idea from the stoppers fitted to kerosene cans of the time. Like much another really good idea, it superseded all its competitive lamp holders and its use extended through America and Europe. In Britain, however, it was not popular. The Edison & Swan Co. about 1886 introduced the bayonet-cap type of lamp-holder. The early type was soon improved to the lamp holders we know today.

Many sockets were individually fused, a practice, which was later meet the extended to the provision of a fuse in the plug.

These fuses were, however, only a small piece of wire between two terminals and caused such a lot of trouble that in 1911 the Institution of Electrical Engineers banned their use. One firm, which came into existence with the socket-and-plug, was M.K. Electric Ltd. The initials were for 'Multi-Contact' and associated with a type of socket outlet, which eventually became the standard design for this accessory. It was Scholes, under the name of 'Wylex', who introduced a revolutionary design of plug-and-socket: a hollow circular earth pin and rectangular current-carrying pins. This was really the first attempt to 'polarize', or to differentiate between live, earth and neutral pins.

One of the earliest accessories to have a cartridge fuse incorporated in it was the plug produced by Dorman & Smith Ltd. The fuse actually formed one of the pins, and could be screwed in or out when replacement was necessary. It is a rather long cry from those pioneering days to the present system of standard socket-outlets and plugs.

Early fuses consisted of lead wires; lead being used because of its low melting point. Generally, devices which contained fuses were called 'cutouts', a term still used today for the item in the sequence of supply-control equipment entering a building. Once the idea caught on of providing protection for a circuit in the form of fuses, brains

went to work to design fuses and fuse gear. Control gear first appeared encased in wood. But ironclad versions made their due appearance, particularly for industrial use during the nineties. They were usually called 'motor switches', and had their blades and contacts mounted on a slate panel. Among the first companies in the switchgear field were Bill & Co., Sanders & Co., and the MEM Co., whose 'Kantark' fuses are so well known today. In 1928 this Company introduced the 'splitter', which affected a useful economy in many of the smaller installations.

The story of electric wiring, its systems, and accessories tells an important aspect in the history of industrial development and in the history of social progress. The inventiveness of the old electrical personalities, Compton, Swan, Edison, Kelvin and many others, is well worth noting; for it is from their brain-children that the present-day electrical contracting industry has evolved to become one of the most important sections of activity in electrical engineering. For those who are interested in details of the evolution and development of electric wiring systems and accessories, good reading can be found in the book by J. Mellanby: The History of Electric Wiring (MacDonald, London).

It was not until the 1930s that the distribution of electricity in buildings by means of bus bars came into fashion, though the system had been used as far back as about 1880, particularly for street mains. In 1935 the English Electric Co. introduced a bus bar trunking system designed to meet the needs of the motorcar industry. It provided the overhead distribution of electricity into which system individual machines could be tapped wherever required; this idea caught on and designs were produced and put onto the market by Marryat & Place, GEC, and Ottermill.

1.2. Historical Review of Wiring Installation

The history of the development of non-legal and statutory rules and regulations for the wiring of buildings is no less interesting than that of wiring systems and accessories. When electrical energy received a utilization impetus from the invention of the incandescent lamp, many set themselves up as electricians or electrical wiremen. Others were gas plumbers who indulged in the installation of electrics as a matter of normal course. This was all very well: the contracting industry had to get started in some way, however ragged. But with so many amateurs troubles were bound to

multiply. And they did. It was not long before arc lamps, sparking commutators, and badly insulated conductors contributed to fires. It was the insurance companies, which gave their attention to the fire risk inherent in the electrical installations of the 1880s. Foremost among these was the Phoenix Assurance Co., whose engineer, Mr. Heaphy, was told to investigate the situation and draw up a report on his findings.

The result was the Phoenix Rules of 1882. These Rules were produced just a few months after those of the American Board of Fire Underwriters who are credited with the issue of the first wiring rules in the world.

Three months after the issue of the Phoenix Rules for wiring in 1882, the Society of Telegraph Engineers and Electricians (now the Institution of Electrical Engineers) issued the first edition of Rules and Regulations for the Prevention of Fire Risks arising from Electric lighting. These rules were drawn up by a committee of eighteen men, which included some of the famous names of the day: Lord Kelvin, Siemens, and Crompton. The Rules, however, were subjected to some criticism. Compared with the Phoenix Rules they left much to be desired. But the Society was working on the basis of laying down a set of principles rather than, as Heaphy did, drawing up a guide or 'Code of Practice'. A second edition of the Society's Rules was issued in 1888. The third edition was issued in 1897 and entitled General Rules recommended for Wiring for the Supply of Electrical Energy.

The Phoenix Rules were, however, the better set and went through many editions before revision was thought necessary. That these Rules contributed to a better standard of wiring, and introduced a high factor of safety in the electrical wiring and equipment of buildings, was indicated by a report in 1892, which showed the high incidence of electrical fires in the USA and the comparative freedom from fires of electrical origin in Britain.

The Rules have since been revised at fairly regular intervals as new developments and the results of experience can be written in for the considered attention of all those concerned with the electrical equipment of buildings. Basically the regulations were intended to act as a guide for electricians and others to provide a degree of safety in the use of electricity by inexperienced persons such as householders. The regulations were, and still are, not legal; that is, the law of the land cannot enforce them. Despite this apparent loophole, the regulations are accepted as a guide to the practice of installation work, which will ensure, at the very least, a minimum standard of work. The Institution of Electrical Engineers (IEE) was not alone in the insistence of

good standards in electrical installation work. In 1905, the Electrical Trades Union, through the London District Committee, in a letter to the Phoenix Assurance Co., said ' . . . they view with alarm the large extent to which bad work is now being carried out by electric light contractors . . .. As the carrying out of bad work is attended by fires and other risks, besides injuring the Trade, they respectfully ask you to. . Uphold a higher standard of work'.

While the IEE and the statutory regulations were making their positions stronger, the British Standards Institution brought out, and is still issuing, Codes of Practice to provide what are regarded as guides to good practice. The position of the Statutory Regulations in this country is that they form the primary requirements, which must by law be satisfied. The IEE Regulations and Codes of Practice indicate supplementary requirements. However, it is accepted that if an installation is carried out in accordance with the IEE Wiring Regulations, then it generally fulfils the requirements of the Electricity Supply Regulations. This means that a supply authority can insist upon all electrical work to be carried out to the standard of the IEE Regulations, but cannot insist on a standard which is in excess of the IEE requirements.

The legislation embodied in the Factory and Workshop Acts of 1901 and 1907 had a considerable influence on wiring practice. In the latter Act it was recognized for the first time that the generation, distribution and use of electricity in industrial premises could be dangerous. To control electricity in factories and other premises a draft set of Regulations was later to be incorporated into statutory requirements.

CHAPTER 2
ILLUMINATION

2.1. Illumination

In determining the value of illumination, not only the candle-power of the units, but the amount of reflected light must be considered for the given location of the lamps. Following is a formula based on the coefficient of reflection of the walls of the room, which serves for preliminary calculations: c. p. 1

$1 = 1 - k\, d_2$

I = Illumination in foot-candles.

c.p. = Candle-power of the unit.

k = Coefficient of reflection of the walls.

d = distance from the unit in feet.

Where several units of the same candle-power are used this formula becomes:

1 1 1 1

$I = c.\ p.\ (d_2 + d_{21} + d_{22} + ...)\ 1\text{-}k$ or, $c.\ p = 1$

(1 1 1 1 d_2 d_{21} d_{22} + ----------) 1-k where d, d_1, d_2, equal the distances from the point considered to the various light sources. If the lamps are of different candle-power the illumination may be determined by combining the illumination from each source as calculated separately. An example of calculation is given under "Arrangement of Lamps." The above method is not strictly accurate because it does not take account of the angle at which the light from each one of the sources strikes the assumed plane of illumination. If the rays of light is perpendicular to the plane, the formula 1 = c. p. gives cord2 rect values. If a is the angle which the ray of light makes with a line drawn from the light source perpendicular to the assumed plane, then the formula I = c. p. X cosine

a/ d_2. Therefore, by multiplying the candle-power value of each light source in the directtion of the illuminated point by the cosine of each angle a, a more accurate result will be obtained.

It is readily seen that the effect of reflected light from the ceilings is of more importance than that from the floor of a room. The value of k, in the above formula, will vary from 60% to 10%, but for rooms with a fairly light finish 50% may be taken as a good average value

2.2. Calculatıon

The formulates symbols:

Φ_{dir} = the flow of the direct light

Φ_s = the flow coming to working table.

Φ_{end} = the light flow coming by reflexion

E_s = the avarage level of light of working table

S = m^2 of working table

Φ_o = the sum of light flow (lumen)

The calculation of illumination by the light flow method. The calculation of internal illumination by efficiency method. This method is mostly used in internal illumination installations. As it is known the Φ light that cames to plane has the components Φdır and Φend (Φ_{dir} shows the flow of the direct light, Φ_s shows the flow coming to working table, Φ_{end} shows the light flow coming by reflexion)

$$\Phi_s = \Phi_{dir} + \Phi_{end} \qquad (2.1)$$

$\Phi_{dır}$ can be calculated easily but Φ_{end} is difficult to calculate. So that efficiency method is used in internal illumination installations. Now in order to understand this method let's think about an ideal room that it's walls and ceiling reflects the light totally, (δ=%100) and absorbs the light completely.(α = %100) and no object absorbing the light in it. The Φ_o comes out of the light sources falls on the plane S and it is absorbed their whatever the dimensions of the room, number of the lambs, settlement of the lambs, illumination system. The average illumination degree of the plane for an ideal room is

$$E_o = \Phi_0 / S \qquad (2.2)$$

E_O shows the avarage level of light of working table, Φo represents the total light flow from lambs in lumen and S represents the area of the plane in m^2. In reality some of the light flow is absorbed by walls, ceiling, and illumination devices. So that the average illumination degree of the plane is:

$$E_o = \Phi_0 \eta / S = \Phi_0 / S \qquad (2.3)$$

η factor is called the efficiency of illumination and it is a number less then 1.

$\eta = \Phi_a / \Phi_s$ Φ_a represents flow of light to plane and

Φ_s represents total flow of light that is given by light sources.

Efficiency of device illumination (η) is multiplication of the efficiency of devices and efficiency of the room.

$\eta = \Phi_{ayg} / \Phi_0$ η **ayg** represents the efficiency of device (2.4)

$\eta = \Phi_s / \Phi_{ayg}$ η **oda** represents the efficiency of room (2.5)

$$\eta = \eta_{ayg} - \eta_{oda} \qquad (2.6)$$

Efficiency of device is related with the illumination device. Efficiency of the room is related with geometric dimensions of room, reflection factors and colours of walls and ceiling, light distribution curves of illumination devices, height of them to plane and their places. Table 2.1 shows belowed in same situations that are used mostly.

Table 2.1: Illumination System

Illuminiation system	Direct illiminiation (nayg=%70)		Semi-direct illiminiation (nayg=%80)		Mixed illiminiation (nayg=%80)		Semi indirect illiminiation (nayg=%80)		Indirect illiminiation (nayg=%70)	
	n(%)		n(%)		n(%)		n(%)		n(%)	
Room index (a/h)	A	B	A	B	A	B	A	B	A	
0,5	13	9	9	5	12	7	11	6	9	
0,7	19	13	13	7	16	10	15	8	12	
1,0	25	19	17	10	21	13	19	12	15	
	35	30	24	15	27	17	25	16	20	1
	40	36	29	19	32	21	29	19	23	4
2,5	44	40	33	23	35	24	32	22	26	6
3,0	47	43	36	26	38	26	35	24	28	8
4,0	51	47	41	30	43	30	39	28	32	0
5,0	54	50	45	34	46	33	42	30	34	2
	57	53	51	39	51	37	46	34	36	4
10,0	59	55	57	40	55	40	51	37	38	6

In this Table;

a; lenght of one side of a square room

h; height of light sources to the plane in direct and semi-direct illumination system. Height of ceiling to the plane in direct; mixed and semi-direct illumination system.A; Situation where is ceiling is white (ρ_T= %75) and walls are quite white (ρ_D = %50)

B; Situation where is ceiling is quite white (ρ_T = %50) and wall are dark (ρ_D = %30)

İf the room is a rectangle (a,b) , efficiency is ;

$$\eta = \eta a + 1/3 (\eta a - \eta b) \qquad (2.7)$$

While preparing the table 10.1 , only two efficiency about illumination devices (η ayg = %70 and η ayg = %80) is taken.

If another illumination device that has the efficiency η^1 ayg is used (η^1 is an aygıt different from %70, %80 efficensy level) , the efficiency that is found from table is multiplied with a factor of η^1 ayg / η aygAfter finding the efficiency η , light flow that goes to plane (Φ_o) is found with the help of flow of light by illumination sources (Φ_s). Then the average illumination level is

$$E_o = \Phi_s / S \qquad (2.8)$$

If the average illumination level of plane is given and total light flow that light sources give (Φ_o) is looked for ;

$$\Phi_o = E_o S / h \qquad (2.9)$$

In below the dimensions of living room are given and number of armatures are found by performing necessory calculation.

Table 2.2: Illumination Units

NAME	SYMBOL	UNIT	EXPLANATION
Light flow		Lumen (lm)	It is the amount of the total light source gives in all directions. İn other words it is the port of the electrical energy converted into the light energy. That isgiven to light source.
Light intensity	I	candela (cd)	It is the amount of light flow in any direction. (the light flow may be constant but the light indensity may be different in various directions)
İlliminiation intensity	E	lux (lux)	It is the total light flow that comes to 1 m^2 area
flashing	L	cd / cm^2	It is th elight indensity that comes from light sources or unit surfaces that the light sources lighten.

Table 2.3: Illuminiation Equations

EQUATION	SYMBOL	EXPLANATION
$n = \Phi_T / \Phi_L$	n	Number of light bulbs
	Φ_T	Total light flow necessary (lm)
	Φ_L	Light flow given by a light bulb.
$k = a.b / h(a+b)$	k	Room index (according to dimensions)
	a	Length (m)
	b	width (m)
	h	Height of the light source to the working sueface (m)
	H	Height of the light source to the floor(m)
	h1	Height of the working surfaces to the flor (m)
$\Phi_T = E.A.d / \eta$	E	Necessary illiminiations level (lux) chosen from the table
	A	Surface area that will be lighted (m2)
	d	Pallution installmentfactors 1,25 - 1,75
	η	Efficensy factors of the installment it is chosen from the table according to wall, ceiling, flor reflexion factors, tipe of armature chosen, room index

Table 2.4: Typical flows of some lamps

TYPE OF LAMP	POWER OF LAMP (W)	AVERAGE FLOWS (lm)
GUW (GENERAL USİNG –WİRED)	60	610
	100	1230
FLUORESCANT	18/20	1100
	36/40	2850
	65/80	5600
PL (economic)	9	400
	11	600
	15	900
	20	1200
	23	1500
2D COMPACT FLOURESAN	16	1050
	28	2050
	38	3050
MERCURY (MBF)	50	1800
	125	6300
	400	12250
	1000	38000
MERCURY (MBIF)	250	17000
	1000	81000
H.PRESSURİZED SODİUM (SON PLUS)	100	10000
	400	54000
H.PRESSURİZED SODİUM (SON DELUXE)	150	12250
	400	38000
TUNGTEN HALOJEN	300	5950
	500	11000
	750	16500
	1000	22000
	1500	33000

Table 2.5: Light Sources

Light power	Rated luminous flux
15	120-135
25	215-240
40	340-480
60	620-805
75	855-960
100	1250-1380
150	2100-2280
200	2950-3220

Table 2.6: Hanger Height

Ceiling Height	Area Wideness	Cord Height
2.0	2.0 4.0 8.0 and upper	Ceiling Ceiling Ceiling
2.5	2.5 5.0 10.0 and upper	Ceiling (0.15) Ceiling (0.15) Ceiling (0.15)
3.0	3.0 6.0 12.0 and upper	0.4 (0.5) 0.25 (0.4) Ceiling (0.3)

Table 2.7: Bright Voice

Stair, Corridor, Shower and WC 10 m^2	20
Class, Library and Teacher room 40 m^2	80, 80 100, 100 120
Physical and Chemistry Lab. 100 m^2	120

CHAPTER 3
INSULATORS

3.1. Insulator

An insulator is defined as a material, which offers an extremely high resistance to the passage of an electric current. Were it not for this property of some materials we would not be able to apply electrical energy to so many uses today. Some materials are better insulators than others. The resistivity of all insulating materials decreases with an increase in temperature. Because of this, a limit in the rise in temperature is imposed in the applications of insulating materials, otherwise the insulation would break down to cause a short circuit or leakage current to earth. The materials used for insulation purposes in electrical work are extremely varied and are of a most diverse nature. Because no single insulating material can be used extensively, different materials are combined to give the required properties of mechanical strength, adaptability, and reliability. Solids, liquids, and gases are to be found used as insulation.

Insulating materials arc grouped into classes:

Class A - Cotton, silk, paper, and similar organic materials; impregnated or immersed in oil.

Class B - Mica, asbestos, and similar inorganic materials, generally found in a built-up form combined with cement binding cement. Also polyester enamel covering and glass-cloth and micanite.

Class C - Mica, porcelain glass quartz: and similar materials.

Class D - Polyvinyl acetal resin. Class H - Silicon-glass.

The following are some brief descriptions of some of the insulating materials more commonly found in electrical work.

It is used mainly for cable insulation and cannot be used for high temperatures as it hardens. Generally used with sulphur (vulcanized rubber) and china clay. Has high insulation-resistance value.

3.2. Polyvinyl chloride (PVC)

This is a plastics material, which will tend to flow when used in high temperatures. Has a lower insulation-resistance value than rubber. Used for cable insulation and sheathing against mechanical damage.

It must be used in an impregnated form (resin or oil). Used for cable insulation. Impregnated with paraffin wax, paper is used for making capacitors. Different types are available: Kraft, cotton, tissue, and pressboard.

It is used for insulators (overhead lines). In glass fiber form it is used for cable insulation where high temperatures are present, or where areas are designated 'hazardous'. Requires a suitable impregnation (with silicone varnish) to fill the spaces between the glass fibers.

This material is used between the segments of commutators of de machines, and under slip rings of ac machines. Used where high temperatures are involved such as the heating elements of electric irons. It is a mineral, which is present in most granite-rock formations; generally produced in sheet and block form. Micanite is the name given to the large sheets built up from small mica splitting and can be found backed with paper, cotton fabric, silk or glass-cloth or varnishes. Forms include tubes and washers.

It is used for overhead-line insulators and switchgear and transformer bushings as lead-ins for cables and conductors. Also found as switch-bases, and insulating beads for high-temperature insulation applications.

A very common synthetic material found in many aspects of electrical work (e.g. lamp holders, junction boxes), and used as a construction material for enclosing switches to be used with insulated wiring systems.

3.3. Insulating oil

This is a mineral oil used in transformers and in oil-filled circuit breakers where the arc drawn out when the contacts separate, is quenched by the oil. It is used to impregnate wood, paper, and pressboard. This oil breaks down when moisture is present.

This material is used extensively for 'potting' or encapsulating electronic items. In larger castings it is found as insulating bushings for switchgear and transformers.

This group of insulating materials includes both natural (silk, cotton, and jute) and synthetic (nylon, Terylene). They are often found in tape form, for winding-wire coil insulation. Air is the most important gas used for insulating purposes. Under certain conditions (humidity and dampness) it will break down. Nitrogen and hydrogen are used in electrical transformers and machines as both insulates and coolants.

Mineral oil is the most common insulator in liquid form. Others include carbon tetrachloride, silicone fluids and varnishes. Semi-liquid materials include waxes, bitumens and some synthetic resins. Carbon tetrachloride is found as an arc-quencher in high-voltage cartridge type fuses on overhead lines. Silicone fluids are used in transformers and as dashpot damping liquids. Varnishes are used for thin insulation covering for winding wires in electromagnets. Waxes are generally used for impregnating capacitors and fibres where the operating temperatures are not high. Bitumens are used for filling cable-boxes; some are used in a paint form. Resins of a synthetic nature form the basis of the materials known as 'plastics' (polyethylene, polyvinyl chloride, melamine and polystyrene). Natural resins are used in varnishes, and as bonding media for mica and paper sheets hot-pressed to make boards.

CHAPTER 4

EARTHING

4.1. Earthing

An efficient earthing arrangement is an essential part of every electrical installation and system to guard against the effects of leakage currents, short-circuits, static charges and lightning discharges. The basic reason for earthling is to prevent or minimize the risk of shock to human beings and livestock, and to reduce the risk of fire hazard. The earthing arrangement provides a low-resistance discharge path for currents, which would otherwise prove injurious or fatal to any person touching the metalwork associated with the faulty circuit. The prevention of electric shock risk in installations is a matter, which has been given close attention in these past few years, particularly since the rapid increase in the use of electricity for an ever-widening range of applications.

4.2. Earthing Terms

4.2.1. Earth:

A connection to the general mass of earth by means of an earth electrode.

4.2.2. Earth Electrode:

A metal plate, rod or other conductor band or driven in to the ground and used for earthing metal work.

4.2.3. Earthing Lead:

The final conductor by means of which the connection to the earth electrode is made.

4.2.4. Earth Continuity Conductor (ECC):

The conductor including any lam connecting to the earth or each other those part of an installation which are required to be earthed. The ECC may be in whole or part the metal conduit or the metal sheath of cables or the special continuity conductor of a cable or flexible cord incorporating such a conductor.

4.3. Earthing Systems:

In our electricity system, which is same to UK electricity, is an earthed system, which means that star or neutral point of the secondary side of distribution transformer is connected to the general mass of earth.

In this way, the star point is maintained at or about 0V. Unfortunately, this also means that persons or livestock in contact with a live part and earth is at risk of electric shock.

4.3.1. Lightning protection

Lightning discharges can generate large amounts of heat and release considerable mechanical forces, both due to the large currents involved. The recommendations for the protection of structures against lightning are contained in BS Code of Practice 6651 (Protection of Structures Against Lightning). The object of such a protective system is to lead away the very high transient values of voltage and current into the earth where they are safely dissipated. Thus a protective system, to be effective, should be solid and permanent. Two main factors are considered in determining whether a structure should be given protection against lightning discharges:

1. Whether it is located in an area where lightning is prevalent and whether, because of its height and/or its exposed position, it is most likely to be struck.

2. Whether it is one to which damage is likely to be serious by virtue of its use, contents, importance, or interest (e.g. explosives factory, church monument, railway station, spire, radio mast, wire fence, etc.).

It is explained in BS Code of Practice 6651 that the 'zone of protection' of a single vertical conductor fixed to a structure is considered to be a cone with an apex at the highest point of the conductor and a base of radius equal to the height. This means that a conductor 30 meters high will protect that part of the structure which comes within a cone extending to 60 meters in diameter at ground level Care is therefore necessary in ensuring that the whole of a structure or building falls within the protective zone; if it does not, two down conductors must be run to provide two protective zones within which the whole structure is contained. All metallic objects and projections, such

as metallic vent pipes and guttering, should be bonded to form part of the air-termination network. All down conductors should be cross-bonded.

The use of multiple electrodes is common. Rule 5 of the Phoenix Fire Office Rules states:

Earth connections and number: The earth connection should be made either by means of a copper plate buried in damp earth, or by means of the tubular earth system, or by connection to the water mains (not nowadays recommended). The number of connections should be in proportion to the ground area of the building, and there are few structures where less than two are necessary ... Church spires, high towers, factory chimneys having two down conductors should have two earths which may be interconnected.

All the component parts of a lightning-protective system should be either castings of leaded gunmetal, copper, naval brass or wrought phosphor bronze, or sheet copper or phosphor bronze. Steel, suitably protected from corrosion, may be used in special cases where tensile or compressive strength is needed.

Air terminations constitute that part of dice system, which distributes discharges into, or collects discharges from, the atmosphere. Roof conductors are generally of soft annealed copper strip and interconnect the various air terminations. Down conductors, between earth and the air terminations are also of soft-annealed copper strip. Test points are joints in down conductors, bonds, earth leads, which allow resistance tests to be made. The earth terminations are those parts of the system designed to collect discharges from, or distribute charges into, the general mass of earth. Down conductors are secured to the face of the structure by 'holdfasts' made from gunmetal The 'building-in' type is used for new structures; a caulking type is used for existing structures.

With a lightning protection system, the resistance to earth need not be less than 10 ohms. But in the case of important buildings, seven ohms is the maximum resistance. Because the effectiveness of a lightning conductor is dependent on its connection with moist earth, a poor earth connection may render the whole system useless The 'Hedges' patent tubular earth provides a permanent and efficient earth connection, which is inexpensive, simple in construction and easy to install. These earths, when driven firmly into the soil, do not lose their efficiency by changes in the soil due to drainage; they have a constant resistance by reason of their being kept in contact with moist soil by watering arrangements provided at ground level. In addition, tubular or rod earths are easier to install than plate earths, because the latter require excavation.

Lightning conductors should have as few joints as possible. If these are necessary, other than at the testing-clamp or the earth-electrode clamping points, flat tape should be tinned, soldered, and riveted; rod should be screw-jointed.

All lightning protective systems should he examined and tested by a competent engineer after completion, alteration, and extension.

4.3.2. Anti-static Earthing

'Static', which is a shortened term for 'static electric discharge' has been the subject of increasing concern in recent years partly due to the increasing use of highly insulating materials (various plastics and textile fibers).

4.3.3. Earthing Practice

A routine inspection and test should be made once a year and any defects remedied. In the case of a structure containing explosives or other inflammable materials, the inspection and test should be made every six months. The tests should include the resistance to earth and earth continuity. The methods of testing are similar to those described in the IEE Regulations, though tests for earth-resistance of earth electrodes require definite distances to be observed.

4.3.3.a. Direct Earthing

The term 'direct earthing' means connection to an earth electrode, of some recognized type, and reliance on the effectiveness of over current protective devices for protection against shock and fire hazards in the event of an earth fault. If direct earthing protects non-current-carrying metalwork, under fault conditions a potential difference will exist between the metalwork and the general mass of earth to which the earth electrode is connected. This potential will persist until the protective device comes into operation. The value of this potential difference depends on the line voltage, the substation or supply transformer earth resistance, the line resistance, the fault resistance, and finally, the earth resistance at the installation. Direct earth connections are made with electrodes in the soil at the consumer's premises. A further method of effecting connection to earth is that which makes use of the metallic sheaths of underground cables. But such sheaths are more generally used to provide a direct metallic connection for the return of earth-fault current to the neutral of the supply system rather than as a means of direct connection to earth.

The earth electrode, the means by which a connection with the general mass of earth is made, can take a number of forms, and can appear either as a single connection or as a network of multiple electrodes. Each type of electrode has its own advantages and disadvantages.

The design of an earth electrode system takes into consideration its resistance to ensure that this is of such a value that sufficient current will pass to earth to operate the protective system. It must also be designed to accommodate thermally the maximum fault current during the time it takes for the protective device to clear the fault. In designing for a specific ohmic resistance, the resistivity of the soil is perhaps the most important factor, although it is a variable one.

The current rating or fault-current capacity of earth electrodes must be adequate for the 'fault-current/time-delay' characteristic of the system under the worst possible conditions. Undue heating of the electrode, which would dry out the adjacent soil and increase the earth resistance, must be avoided. Calculated short-time ratings for earth electrodes of various types are available from electrode manufacturers. These ratings are based on the short-time current rating of the associated protective devices and a maximum temperature, which will not cause damage to the earth connections or to the equipment with which they may be in contact.

In general soils have a negative temperature coefficient of resistance. Sustained current loadings result in an initial decrease in electrode resistance and a consequent rise in the earth-fault current for a given applied voltage. However, as the moisture in the soil is driven away from the soil/electrode interface, the resistance rises rapidly and will ultimately approach infinity if the temperature rise is sufficient. This occurs in the region of 100 ^{0}C and results in the complete failure of the electrode.

The current density of the electrode is found by:

$$\textbf{Current density} = I / A\sqrt{t} = 92 \times 10^3 \qquad (4.1)$$

where I = short-circuit fault current; A = area (in cm^2); t = time in seconds (duration of the fault current). The formula assumes a temperature rise of 120^{0}C, over an ambient temperature of 25 ^{0}C, and the use of high-conductivity copper. The formula does not allow for any dissipation of heat into the ground or into the air.

Under fault conditions, the earth electrode is raised to a potential with respect to the earth surrounding it. This can be calculated from the prospective fault current and the earth resistance of the electrode. It results in the existence of voltages in soil around the electrode, which may harm telephone and pilot cables (whose cores are substantially at earth potential) owing to the voltage to which the sheaths of such cables are raised. The voltage gradient at the surface of the ground may also constitute a danger to life, especially where cattle and livestock are concerned. In rural areas, for instance, it is not uncommon for the earth-path resistance to be such that faults are not cleared within a short period of time and animals which congregate near the areas in which current carrying electrodes are installed are liable to receive fatal shocks. The same trouble occurs on farms where earth electrodes are sometimes used for individual appliances. The maximum voltage gradient over a span of 2 meters to a 25 mm diameter pipe electrode is reduced from 85 per cent of the total electrode potential when the top of the electrode is at ground level to 20 per cent and 5 per cent when the electrode is buried at 30 cm and 100 cm respectively. Thus, in areas where livestock are allowed to roam it is recommended that electrodes be buried with their tops well below the surface of the soil.

Corrosion of electrodes due to oxidation and direct chemical attack is sometimes a problem to be considered. Bare copper acquires a protective oxide film under normal atmospheric conditions which does not result in any progressive wasting away of the metal. It does, however, tend to increase the resistance of joints at contact surfaces. It is thus important to ensure that all contact surfaces in copper work, such as at test links, be carefully prepared so that good electrical connections are made. Test links should be bolted up tightly. Electrodes should not be installed in ground, which is contaminated by corrosive chemicals. If copper conductors must be run in an atmosphere containing hydrogen sulphide, or laid in ground liable to contamination by corrosive chemicals, they should be protected by a covering of PVC adhesive tape or a wrapping of some other suitable material, up to the point of connection with the earth electrode. Electrolytic corrosion will occur in addition to the other forms of attack if dissimilar metals are in contact and exposed to the action of moisture. Bolts and rivets used for making connections in copper work should be of either brass or copper. Annulated copper should not be run in direct contact with ferrous metals. Contact between bare copper and the lead sheath or armoring of cables should be avoided, especially underground. If it is impossible to avoid the connection of dissimilar metals, these

should be protected by painting with a moisture-resisting bituminous paint or compound, or by wrapping with PVC tape, to exclude all moisture.

The following are the types of electrodes used to make contact with the general mass of earth:

a) Plates. These are generally made from copper, zinc, steel, or cast iron, and may be solid or the lattice type. Because of their mass, they tend to be costly. With the steel or cast-iron types care must he taken to ensure that the termination of the earthing lead to the plate is water-proofed to prevent cathodic action taking place at the joint, If this happens, the conductor will eventually become detached from the plate and render the electrode practically useless. Plates are usually installed on edge in a hole in the ground about 2-3 meters deep, which is subsequently refilled with soil. Because one plate electrode is seldom sufficient to obtain a low-resistance earth connection, the cost of excavation associated with this type of electrode can be considerable. In addition, due to the plates being installed relatively near the surface of the ground, the resistance value is liable to fluctuate throughout the year due to the seasonal changes in the water content of the soil. To increase the area of contact between the plate and the surrounding ground, a layer of charcoal can be interposed. Coke, which is sometimes used as an alternative to charcoal, often has a high sulphur content, which can lead to serious corrosion and even complete destruction of the copper. The use of hygroscopic salts such as calcium chloride to keep the soil in a moist condition around the electrode can also lead to corrosion.

b) Rods. In general rod electrodes have many advantages over other types of electrode in that they are less costly to install. They do not require much space, are convenient to test and do not create large voltage gradients because the earth-fault current is dissipated vertically. Deeply installed electrodes are not subject to seasonal resistance changes. There are several types of rod electrodes. The solid copper rod gives excellent conductivity and is highly resistant to corrosion. But it tends to be expensive and, being relatively soft, is not ideally suited for driving deep into heavy soils because it is likely to bend if it comes up against a large rock. Rods made from galvanized steel are inexpensive and remain rigid when being installed. However, the life of galvanized steel in acidic soils is short. Another disadvantage is that the copper earthing lead connection

to the rod must be protected to prevent the ingress of moisture. The conductivity of steel is much less than that of copper, difficulties may arise, particularly under heavy fault current conditions when the temperature of the electrode wilts rise and therefore its inherent resistance.

This will tend to dry out the surrounding soil, increasing its resistivity value and resulting in a general increase in the earth resistance of the electrode. In fact, in very severe fault conditions, the resistance of the rod may rise so rapidly and to such an extent that protective equipment may fail to operate.

The bimetallic rod has a steel core and a copper exterior and offers the best alternative to either the copper or steel rod. The steel core gives the necessary rigidity while the copper exterior offers good conductivity and resistance to corrosion. In the extensible type of steel-cored rod, and rods made from bard-drawn copper, steel driving caps are used to avoid splaying the rod end as it is being driven into the soil. The first rod is also provided with a pointed steel tip. The extensible rods are fitted with bronze screwed couplings. Rods should be installed by means of a power driven hammer fitted with a special head. Although rods should be driven vertically into the ground, an angle not exceeding 60° to the vertical is recommended in order to avoid rock or other buried obstruction.

c) Strip. Copper strip is used where the soil is shallow and overlies rock. It should be buried in a trench to a depth of not less than 50 cm and should not be used where there is a possibility of the ground being disturbed (e.g. on farmland). The strip electrode is most effective if buried in ditches under hedgerows where the bacteriological action arising from the decay of vegetation maintains a low soil resistivity.

d) Earths mat. These consist of copper wire buried in trenches up to one meter deep. The mat can be laid out either linearly or in 'star' form and terminated at the down lead from the transformer or other items of equipment to be earthed. The total length of conductor used can often exceed 100 meters. The cost of trenching alone can be expensive. Often scrap overhead line conductor was used but because of the increasing amount of aluminum now being used, scrap copper conductor is scarce. The most common areas where this system is still used are where rock is present near the surface of the soil, making deep excavation impracticable. As with plate electrodes, this method of earthing is subject to seasonal changes in resistance. Also, there is the danger of

voltage gradients being created by earth faults along the lengths of buried conductor, causing a risk to livestock.

4.4. Important Points of Earthing:

To maintain the potential of any part of a system at a definite value with respect to earth.

I. To allow current to flow to earth in the event of a fault so that, the protective gears will operate to isolate the faulty circuit.

II. To make sure that in the event of a fault, apparatus "Normally death (0V)" cannot reach a dangerous potential whit respect to earth.

4.5. Electric Shock:

This is the passage of current through the body of such magnitude as to have significant harmful effects these value of currents are;

1mA-2mA	Barely perceptible, no harmful effects
5mA-10mA	Throw off, painful sensation
10mA-15mA	Muscular contraction, cannot let go
20mA-30mA	Impaired breathing
50mA and above	Ventricular fibrillation and earth.

There are two ways in which we can be at risk.

a-) Touching live parts of equipment for systems. That is intended to be live. This is called direct contact.

b-) Touching conductive parts which are not meant to be live, but which have become live due to a fault. This is called indirect contact.

4.6. Earth testing

IEE Regulations requires that tests he made on every installation to ensure that the earthing arrangement provided for that installation is effective and offers the users of the installation a satisfactory degree of protection against earth-leakage currents. The following are the individual tests prescribed by the Regulations.

4.6.1. Circuit-protective conductors

Regulation 713-02-01 requires that every circuit-protective conductor (CPC) be

tested to verify that it is electrically sound and correctly connected. The IEE Regulations Guidance Notes on inspection and testing give details on the recognized means used to test the CPC. For each final circuit, the CPC forms part of the earth-loop impedance path, its purpose being to connect all exposed conductive parts in the circuit to the main earth terminal. The CPC can take a number of forms. If metallic conduit or trunking is used, the usual figure for ohmic resistance of one-meter length is 5 milliohms/m.

Generally if the total earth-loop impedance (Z_s) for a particular final circuit is within the maximum Z_s limits, the CPC is then regarded as being satisfactory. However, some testing specifications for large installations do require a separate test of each CPC to be carried out. The following descriptions of such tests refer to a.c. installations.

4.6.2. Reduced a.c. test

In certain circumstances, the testing equipment in the a.c. test described above is not always available and it is often necessary to use hand-testers, which deliver a low value of test current at the frequency of the mains supply. After allowing for the resistance of the test lead, a value for impedance of 0.5 ohm maximum should be obtained where the CPC, or part of it, is made from steel conduit. If the CPC is in whole or in part made of copper, copper-alloy, or aluminum, the maximum value is one ohm.

4.6.3. Direct current

Where it is not convenient to use a.c. for the test, D.C. may be used instead. Before the D.C. is applied, an inspection must be made to ensure that no inductor is incorporated in the length of the CPC. Subject to the requirements of the total earth-loop impedance, the maximum values for impedance for the CPC should be 0.5 ohm (if of steel) or one ohm (if of copper, copper-alloy or aluminum).

The resistance of an earth-continuity conductor, which contains imperfect joints, varies with the test current. It is therefore recommended that a D.C. resistance test for quality is made, first at low current, secondly with high current, and finally with low current. The low-current tests should be made with an instrument delivering not more than 200 mA into one ohm; the high-current test should be made at 10 A or such higher current as is practicable.

The open-circuit voltage of the test set should be less than 30 V. Any substantial variations in the readings (say 25 per cent) will indicate faulty joints in the conductor;

these should be rectified. If the values obtained are within the variation limit, no further test of the CPC is necessary.

4.6.4. Residual current devices

IEE Regulation 713-12-01 requires that where an RCD provides protection against indirect contact, the unit must have its effectiveness tested by the simulation of a fault condition. This test is independent of the unit's own test facility. The consumer who is advised to ensure that the RCD trips when a test current, provided by an internal resistor, is applied to the trip-coil of the unit designs the latter for use. Thus, on pressing the 'Test' button the unit should trip immediately. If it does not it may indicate that a fault exists and the unit should not be used with its associated socket-outlet, particularly if the outlet is to be used for outdoor equipment.

The RCD has a normal tripping current of 30 mA and an operating time not exceeding 40 ms at a test current of 150 mA.

RCD testers are commercially available, which allow a range of tripping currents to be applied to the unit, from 10 mA upwards. In general the lower the tripping current the longer will be the time of disconnection.

It should be noted that a double pole RCD is required for caravans and caravan sites and for agricultural and horticultural installations where socket-outlets are designed for equipment to be used other than 'that essential to the welfare of livestock'.

4.6.5. Earth-electrode resistance area

The general mass of earth is used in electrical work to maintain the potential of any part of a system at a definite value with respect to earth (usually taken as zero volts). It also allows a current to flow in the event of a fault to earth, so that protective gear will operate to isolate the faulty circuit. One particular aspect of the earth electrode resistance area is that its resistance is by no means constant. It varies with the amount of moisture in the soil and is therefore subject to seasonal and other changes. As the general mass of earth forms part of the earth-fault loop path, it is essential at times to know its actual value of resistance, and particularly of that area within the vicinity of the earth electrode. The effective resistance area of an earth electrode extends for some distance around the actual electrode; but the surface voltage dies away very rapidly as the distance from the electrode increases.

The basic method of measuring the earth-electrode resistance is to pass current into the soil via the electrode and to measure the voltage needed to produce this current. The type of soil largely determines its resistivity. The ability of the soil to conduct currents is essentially electrolytic in nature, and is therefore affected by moisture in the soil and by the chemical composition and concentration of salts dissolved in the contained water. Grain size and distribution, and closeness of packing are also contributory factors, since these control the manner in which moisture is held in the soil. Many of these factors vary locally. The following table shows some typical values of soil resistivity.

Table 4.1: Soil Resistivity Values

Type of soil	**Approximate value in ohm-cm**
Marshy ground	200 to 350
Loam and clay	400 to 15,000
Chalk	6000 to 40,000
Sand	9000 to 800,000
Peat	5000 to 50,000
Sandy gravel	5000 to 50,000
Rock	100,000 upwards

When the site of an earth electrode is to be considered, the following types of soil are recommended, in order of preference:

1. Wet marshy ground, which is not too well drained.

2. Clay, loamy soil, arable land, clayey soil, and clayey soil mixed with small quantities of sand.

3. Clay and loam mixed with varying proportions of sand, gravel, and stones.

4. Damp and wet sand, peat.

Dry sand, gravel, chalk, limestone, whinstone, granite, and any very stony ground should be avoided, as should all locations where virgin rock is very close to the surface. Chemical treatment of the soil is sometimes used to improve its conductivity Common salt is very suitable for this purpose. Calcium chloride, sodium carbonate, and other substances are also beneficial, but before any chemical treatment is applied it should be verified that no corrosive actions would be set up, particularly on the earth electrode.

Either a hand-operated tester or a mains-energized double-wound transformer can be used, the latter requiring an ammeter and a high-resistance voltmeter. The former method gives a direct reading in ohms on the instrument scale; the latter method requires a calculation in the form:

$$R = V / I \tag{4.2}$$

The procedure is the same in each case. An auxiliary electrode is driven into the ground at a distance of about 30 meters away from the electrode under test (the consumer's electrode). A third electrode is driven midway between them. To ensure that the resistance area of the first two electrodes does not overlap, the third electrode is moved 6 meters farther from, and nearer to, the electrode under test. The three tests should give similar results, the average value being taken as the mean resistance of the earth electrode.

One disadvantage of using the simple method of earth electrode resistance measurement is that the effects of emfs (owing to electrolytic action in the soil) have to be taken into account when testing. Also, there is the possibility of stray earth currents being leakages from local distribution systems. Because of this it is usual to use a commercial instrument, the Megger earth tester being a typical example.

4.6.6. Earth-fault loop impedance

Regulation 113-11-01 stipulates that where earth-leakage relies on the operation of over current devices, an earth-loop impedance test should be carried out to prove the effectiveness of the installation's earthing arrangement. Although the supply authority makes its own earth-loop impedance tests, the electrical contractor is still required to carry out his own tests. The tests carried out by a supply authority will not absolve the contractor from his legal responsibilities for the safe and effective operation of protection equipment which he may install as part of a wiring installation. This applies both to new installations and extensions to existing installations. Earth-loop impedance tests must be carried out on all extension work of major importance to ensure that the earth-continuity path right back to the consumer's earthing terminal is effective and will enable the protective equipment to operate under fault conditions.

4.6.7. Phase-earth loop test

This test closely simulates the condition which would arise should an earth- fault

occurs. The instruments used for the test create an artificial fault to earth between the 'me and earth conductors, and the fault current, which is limited by a resistor or some other means, is allowed to flow for a very short period. During this time, there is a voltage drop across the limiting device, the magnitude of which depends on the value of the earth loop. The voltage drop is used to operate an instrument movement, with an associated scale calibrated in ohms. The contribution of the consumer's earthing conductor should be not more than one ohm. This is to ensure that the voltage drop across any two Points on the conductor is kept to a low value and, under fault conditions there will be no danger to any person touching it at the time of the test.

The testers, which are commercially available, include both digital readouts and analogue scales, and incorporate indications of the circuit condition (correct polarity and a proven earth connection). The readings are in ohms and represent the earth-loop impedance (Z_s). Once a reading is obtained, reference must be made to IEE Regulations Tables 41B1 to 41D, which give the maximum values of Z_s which refer to: (a) the type of over current device used to protect the circuit and (b) the rating of the device. Reference should also be made to any previous test reading to see whether any increase in Z_s has occurred in the meantime. Any increase may indicate a deteriorating condition in the CPC or earthing lead and should be investigated immediately. The values of Z_s indicated in the Tables are maximum values, which must not be exceeded if the relevant circuits are to be disconnected within the disconnection times stated.

Before a test is made, the instrument should be 'proved' by using a calibration unit, which will ensure that it reads correctly during the test. It is also recommended that the serial number and type or model used for the test should be recorded, so that future tests made by the same tester will produce readings, which are correlated.

CHAPTER 5

LIGHTING

.1.Light sources

- Characteristics of Light Sources
- Incandescent Lamps
- Fluorescent Lamps
- High-Intensity Discharge Lamps

Commercial, industrial, and retail facilities use several different light sources. Each ımp type has particular advantages; selecting the appropriate source depends on ıstallation requirements, life-cycle cost, color qualities, dimming capability, and the ffect wanted. Three types of lamps are commonly used:

- incandescent
- fluorescent
- high intensity discharge
- mercury vapor
- metal halide
- high pressure sodium
- low pressure sodium

Before describing each of these lamp types, the following sections describe ıaracteristics that are common to all of them.

.1.1.Characteristics of Light Sources

Electric light sources have three characteristics: efficiency, color temperature, ıd color rendering index (CRI). Exhibit 4 summarizes these characteristics.

.1.2.Efficiency

Some lamp types are more efficient in converting energy into visible light than thers. The efficacy of a lamp refers to the number of lumens leaving the lamp

compared to the number of watts required by the lamp (and ballast). It is expressed in lumens per watt. Sources with higher efficacy require less electrical energy to light a space.

5.1.3.Color Temperature

Another characteristic of a light source is the color temperature. This is a measurement of "warmth" or "coolness" provided by the lamp. People usually prefer a warmer source in lower illuminance areas, such as dining areas and living rooms, and a cooler source in higher illuminance areas, such as grocery stores.

Color temperature refers to the color of a blackbody radiator at a given absolute temperature, expressed in Kelvins. A blackbody radiator changes color as its temperature increases (first to red, then to orange, yellow, and finally bluish white at the highest temperature. A "warm" color light source actually has a lower color temperature. For example, a cool-white fluorescent lamp appears bluish in color with a color temperature of around 4100 K. A warmer fluorescent lamp appears more yellowish with a color temperature around 3000 K. Refer to Exhibit 5 for color temperatures of various light sources.

5.1.4.Color Rendering Index

The CRI is a relative scale (ranging from 0 - 100). indicating how perceived colors match actual colors. It measures the degree that perceived colors of objects, illuminated by a given light source, conform to the colors of those same objects when they are lighted by a reference standard light source. The higher the color rendering index, the less color shift or distortion occurs.

The CRI number does not indicate which colors will shift or by how much; it is rather an indication of the average shift of eight standard colors. Two different light sources may have identical CRI values, but colors may appear quite different under these two sources.

5.2.Incandescent lamps

5.2.1.Standard Incandescent Lamp

Incandescent lamps are one of the oldest electric lighting technologies available. With efficacies ranging from 6 to 24 lumens per watt, incandescent lamps are the least energy-efficient electric light source and have a relatively short life (750-2500 hours).

Light is produced by passing a current through a tungsten filament, causing it to become hot and glow. With use, the tungsten slowly evaporates, eventually causing the filament to break.

These lamps are available in many shapes and finishes. The two most common types of shapes are the common "A-type" lamp and the reflector-shaped lamps.

5.2.2.Tungsten-Halogen Lamps

The tungsten halogen lamp is another type of incandescent lamp. In a halogen lamp, a small quartz capsule contains the filament and a halogen gas. The small capsule size allows the filament to operate at a higher temperature, which produces light at a higher efficacy than standard incandescents. The halogen gas combines with the evaporated tungsten, redepositing it on the filament. This process extends the life of the filament and keeps the bulb wall from blackening and reducing light output.

Because the filament is relatively small, this source is often used where a highly focused beam is desired. Compact halogen lamps are popular in retail applications for display and accent lighting. In addition, tungsten-halogen lamps generally produce a whiter light than other incandescent lamps, are more efficient, last longer, and have improved lamp lumen depreciation.

5.2.3.Incandescent A-Lamp

More efficient halogen lamps are available. These sources use an infrared coating on the quartz bulb or an advanced reflector design to redirect infrared light back to the filament. The filament then glows hotter and the efficiency of the source is increased.

5.2.4.Fluorescent Lamps

Fluorescent lamps are the most commonly used commercial light source in North America. In fact, fluorescent lamps illuminate 71% of the commercial space in the United States. Their popularity can be attributed to their relatively high efficacy, diffuse light distribution characteristics, and long operating life.

- Fluorescent lamp construction consists of a glass tube with the following features:
- filled with an argon or argon-krypton gas and a small amount of mercury
- coated on the inside with phosphors
- equipped with an electrode at both ends

5.2.5.Fluorescent lamps provide light by the following process:

- An electric discharge (current) is maintained between the electrodes through the mercury vapor and inert gas.
- This current excites the mercury atoms, causing them to emit non-visible ultraviolet (UV) radiation.
- This UV radiation is converted into visible light by the phosphors lining the tube.

Discharge lamps (such as fluorescent) require a ballast to provide correct starting voltage and to regulate the operating current after the lamp has started.

5.2.6.Full-Size Fluorescent Lamps

Full-size fluorescent lamps are available in several shapes, including straight, U-shaped, and circular configurations. Lamp diameters range from 1" to 2.5". The most common lamp type is the four-foot (F40), 1.5" diameter (T12) straight fluorescent lamp. More efficient fluorescent lamps are now available in smaller diameters, including the T10 (1.25 ") and T8 (1").

Fluorescent lamps are available in color temperatures ranging from warm (2700(K) "incandescent-like" colors to very cool (6500(K) "daylight" colors. "Cool white" (4100(K) is the most common fluorescent lamp color. Neutral white (3500(K) is becoming popular for office and retail use.

Improvements in the phosphor coating of fluorescent lamps have improved color rendering and made some fluorescent lamps acceptable in many applications previously dominated by incandescent lamps.

5.2.7.Performance Considerations

The performance of any luminaire system depends on how well its components work together. With fluorescent lamp-ballast systems, light output, input watts, and efficacy are sensitive to changes in the ambient temperature. When the ambient temperature around the lamp is significantly above or below 25C (77F), the performance of the system can change. Exhibit 6 shows this relationship for two common lamp-ballast systems: the F40T12 lamp with a magnetic ballast and the F32T8 lamp with an electronic ballast.

As you can see, the optimum operating temperature for the F32T8 lamp-ballast system is higher than for the F40T12 system. Thus, when the ambient temperature is greater than 25C (77F), the performance of the F32T8 system may be higher than the performance under ANSI conditions. Lamps with smaller diameters (such as T-5 twin tube lamps) peak at even higher ambient temperatures.

5.2.8.Compact Fluorescent Lamps

Advances in phosphor coatings and reductions of tube diameters have facilitated the development of compact fluorescent lamps.

Manufactured since the early 1980s, they are a long-lasting, energy-efficient substitute for the incandescent lamp.

Various wattages, color temperatures, and sizes are available. The wattages of the compact fluorescents range from 5 to 40 (replacing incandescent lamps ranging from 25 to 150 watts (and provide energy savings of 60 to 75 percent. While producing light similar in color to incandescent sources, the life expectancy of a compact fluorescent is about 10 times that of a standard incandescent lamp. Note, however, that the use of compact fluorescent lamps is very limited in dimming applications.

The compact fluorescent lamp with an Edison screw-base offers an easy means to upgrade an incandescent luminaire. Screw-in compact fluorescents are available in two types:

- Integral Units. These consist of a compact fluorescent lamp and ballast in self-contained units. Some integral units also include a reflector and/or glass enclosure.
- Modular Units. The modular type of retrofit compact fluorescent lamp is similar to the integral units, except that the lamp is replaceable.

A Specifier Report that compares the performance of various name-brand compact fluorescent lamps is now available from the National Lighting Product Information Program ("Screw-Base Compact Fluorescent Lamp Products," Specifier Reports, Volume 1, Issue 6, April 1993).

5.2.9.High-Intensity Discharge Lamps

High-intensity discharge (HID) lamps are similar to fluorescents in that an arc is generated between two electrodes. The arc in a HID source is shorter, yet it generates much more light, heat, and pressure within the arc tube.

Originally developed for outdoor and industrial applications, HID lamps are also used in office, retail, and other indoor applications. Their color rendering characteristics have been improved and lower wattages have recently become available (as low as 18 watts.

There are several advantages to HID sources:

- relatively long life (5,000 to 24,000+ hrs)
- relatively high lumen output per watt
- relatively small in physical size

However, the following operating limitations must also be considered. First, HID lamps require time to warm up. It varies from lamp to lamp, but the average warm-up time is 2 to 6 minutes. Second, HID lamps have a "restrike" time, meaning a momentary interruption of current or a voltage drop too low to maintain the arc will extinguish the

lamp. At that point, the gases inside the lamp are too hot to ionize, and time is needed for the gases to cool and pressure to drop before the arc will restrike. This process of restriking takes between 5 and 15 minutes, depending on which HID source is being used. Therefore, good applications of HID lamps are areas where lamps are not switched on and off intermittently.

The following HID sources are listed in increasing order of efficacy:

- mercury vapor
- metal halide
- high pressure sodium
- low pressure sodium

5.2.10.Mercury Vapor

Clear mercury vapor lamps, which produce a blue-green light, consist of a mercury-vapor arc tube with tungsten electrodes at both ends. These lamps have the lowest efficacies of the HID family, rapid lumen depreciation, and a low color rendering index. Because of these characteristics, other HID sources have replaced mercury vapor lamps in many applications. However, mercury vapor lamps are still popular sources for landscape illumination because of their 24,000 hour lamp life and vivid portrayal of green landscapes.

The arc is contained in an inner bulb called the arc tube. The arc tube is filled with high purity mercury and argon gas. The arc tube is enclosed within the outer bulb, which is filled with nitrogen.

Color-improved mercury lamps use a phosphor coating on the inner wall of the bulb to improve the color rendering index, resulting in slight reductions in efficiency.

5.2.11.Metal Halide

These lamps are similar to mercury vapor lamps but use metal halide additives inside the arc tube along with the mercury and argon. These additives enable the lamp to produce more visible light per watt with improved color rendition.

Wattages range from 32 to 2,000, offering a wide range of indoor and outdoor applications. The efficacy of metal halide lamps ranges from 50 to 115 lumens per watt (typically about double that of mercury vapor. In short, metal halide lamps have several advantages.

- high efficacy
- good color rendering
- wide range of wattages

However, they also have some operating limitations:

- The rated life of metal halide lamps is shorter than other HID sources; lower-wattage lamps last less than 7500 hours while high-wattage lamps last an average of 15,000 to 20,000 hours.
- The color may vary from lamp to lamp and may shift over the life of the lamp and during dimming.

Because of the good color rendition and high lumen output, these lamps are good for sports arenas and stadiums. Indoor uses include large auditoriums and convention halls. These lamps are sometimes used for general outdoor lighting, such as parking facilities, but a high pressure sodium system is typically a better choice.

5.2.12.High Pressure Sodium

The high pressure sodium (HPS) lamp is widely used for outdoor and industrial applications. Its higher efficacy makes it a better choice than metal halide for these applications, especially when good color rendering is not a priority. HPS lamps differ from mercury and metal-halide lamps in that they do not contain starting electrodes; the ballast circuit includes a high-voltage electronic starter. The arc tube is made of a ceramic material which can withstand temperatures up to 2372F. It is filled with xenon to help start the arc, as well as a sodium-mercury gas mixture.

The efficacy of the lamp is very high (as much as 140 lumens per watt. For example, a 400-watt high pressure sodium lamp produces 50,000 initial lumens. The same wattage metal halide lamp produces 40,000 initial lumens, and the 400-watt mercury vapor lamp produces only 21,000 initially.

Sodium, the major element used, produces the "golden" color that is characteristic of HPS lamps. Although HPS lamps are not generally recommended for applications where color rendering is critical, HPS color rendering properties are being improved. Some HPS lamps are now available in "deluxe" and "white" colors that provide higher color temperature and improved color rendition. The efficacy of low-wattage "white" HPS lamps is lower than that of metal halide lamps (lumens per watt of low-wattage metal halide is 75-85, while white HPS is 50-60 LPW).

5.2.13.Low Pressure Sodium

Although low pressure sodium (LPS) lamps are similar to fluorescent systems (because they are low pressure systems), they are commonly included in the HID family. LPS lamps are the most efficacious light sources, but they produce the poorest quality light of all the lamp types. Being a monochromatic light source, all colors appear black, white, or shades of gray under an LPS source. LPS lamps are available in wattages ranging from 18-180.

LPS lamp use has been generally limited to outdoor applications such as security or street lighting and indoor, low-wattage applications where color quality is not important (e.g. stairwells). However, because the color rendition is so poor, many municipalities do not allow them for roadway lighting.

Because the LPS lamps are "extended" (like fluorescent), they are less effective in directing and controlling a light beam, compared with "point sources" like high-pressure sodium and metal halide. Therefore, lower mounting heights will provide better results with LPS lamps. To compare a LPS installation with other alternatives, calculate the installation efficacy as the average maintained footcandles divided by the input watts per square foot of illuminated area. The input wattage of an LPS system increases over time to maintain consistent light output over the lamp life.

The low-pressure sodium lamp can explode if the sodium comes in contact with water. Dispose of these lamps according to the manufacturer's instructions.

5.3.Ballasts

- Fluorescent Ballasts
- HID Ballasts

All discharge lamps (fluorescent and HID) require an auxiliary piece of equipment called a ballast. Ballasts have three main functions:

- provide correct starting voltage, because lamps require a higher voltage to start than to operate
- match the line voltage to the operating voltage of the lamp
- limit the lamp current to prevent immediate destruction, because once the arc is struck the lamp impedance decreases

Because ballasts are an integral component of the lighting system, they have a direct impact on light output. The ballast factor is the ratio of a lamp's light output using a standard reference ballast, compared to the lamp's rated light output on a laboratory standard ballast. General purpose ballasts have a ballast factor that is less than one; special ballasts may have a ballast factor greater than one.

5.3.1.Fluorescent Ballasts

The two general types of fluorescent ballasts are magnetic and electronic ballasts:

5.3.2.Magnetic Ballasts

Magnetic ballasts (also referred to as electromagnetic ballasts) fall into one of the following categories:

- standard core-coil (no longer sold in the US for most applications)
- high-efficiency core-coil
- cathode cut-out or hybrid

Standard core-coil magnetic ballasts are essentially core-coil transformers that are relatively inefficient in operating fluorescent lamps. The high-efficiency ballast replaces the aluminum wiring and lower grade steel of the standard ballast with copper wiring and enhanced ferromagnetic materials. The result of these material upgrades is a 10

percent system efficiency improvement. However, note that these "high efficiency" ballasts are the least efficient magnetic ballasts that are available for operating full-size fluorescent lamps. More efficient ballasts are described below.

"Cathode cut-out" (or "hybrid") ballasts are high-efficiency core-coil ballasts that incorporate electronic components that cut off power to the lamp cathodes (filaments) after the lamps are lit, resulting in an additional 2-watt savings per standard lamp. Also, many partial-output T12 hybrid ballasts provide up to 10% less light output while consuming up to 17% less energy than energy-efficient magnetic ballasts. Full-output T8 hybrid ballasts are nearly as efficient as rapid-start two-lamp T8 electronic ballasts.

5.3.3.Electronic Ballasts

In nearly every full-size fluorescent lighting application, electronic ballasts can be used in place of conventional magnetic "core-and-coil" ballasts. Electronic ballasts improve fluorescent system efficacy by converting the standard 60 Hz input frequency to a higher frequency, usually 25,000 to 40,000 Hz. Lamps operating at these higher frequencies produce about the same amount of light, while consuming 12 to 25 percent less power. Other advantages of electronic ballasts include less audible noise, less weight, virtually no lamp flicker, and dimming capabilities (with specific ballast models).

There are three electronic ballast designs available:

Standard T12 electronic ballasts (430 mA)

These ballasts are designed for use with conventional (T12 or T10) fluorescent lighting systems. Some electronic ballasts that are designed for use with 4' lamps can operate up to four lamps at a time. Parallel wiring is another feature now available that allows all companion lamps in the ballast circuit to continue operating in the event of a lamp failure. Electronic ballasts are also available for 8' standard and high-output T12 lamps.

T8 Electronic ballasts (265 mA)

Specifically designed for use with T8 (1-inch diameter) lamps, the T8 electronic ballast provides the highest efficiency of any fluorescent lighting system. Some T8

electronic ballasts are designed to start the lamps in the conventional rapid start mode, while others are operated in the instant start mode. The use of instant start T8 electronic ballasts may result in up to 25 percent reduction in lamp life (at 3 hours per start) but produces slight increases in efficiency and light output. (Note: Lamp life ratings for instant start and rapid start are the same for 12 or more hours per start.)

Dimmable electronic ballasts

These ballasts permit the light output of the lamps to be dimmed based on input from manual dimmer controls or from devices that sense daylight or occupancy.

Types of Fluorescent Circuits

There are three main types of fluorescent circuits:

- rapid start
- instant start
- preheat

The specific fluorescent circuit in use can be identified by the label on the ballast.

The rapid start circuit is the most used system today. Rapid start ballasts provide continuous lamp filament heating during lamp operation (except when used with a cathode cut-out ballast or lamp). Users notice a very short delay after "flipping the switch," before the lamp is started.

The instant start system ignites the arc within the lamp instantly. This ballast provides a higher starting voltage, which eliminates the need for a separate starting circuit. This higher starting voltage causes more wear on the filaments, resulting in reduced lamp life compared with rapid starting.

The preheat circuit was used when fluorescent lamps first became available. This technology is used very little today, except for low-wattage magnetic ballast applications such as compact fluorescents. A separate starting switch, called a starter, is used to aid in forming the arc. The filament needs some time to reach proper temperature, so the lamp does not strike for a few seconds.

5.3.4.HID Ballasts

Like fluorescent lamps, HID lamps require a ballast to start and operate. The purposes of the ballast are similar: to provide starting voltage, to limit the current, and to match the line voltage to the arc voltage.

With HID ballasts, a major performance consideration is lamp wattage regulation when the line voltage varies. With HPS lamps, the ballast must compensate for changes in the lamp voltage as well as for changes in the line voltages.

Installing the wrong HID ballast can cause a variety of problems:

- waste energy and increase operating cost
- severely shorten lamp life
- significantly add to system maintenance costs
- produce lower-than-desired light levels
- increase wiring and circuit breaker installation costs
- result in lamp cycling when voltage dips occur

Capacitive switching is available in new HID luminaires with special HID ballasts. The most common application for HID capacitive switching is in occupancy-sensed bi-level lighting control. Upon sensing motion, the occupancy sensor will send a signal to the bi-level HID system that will rapidly bring the light levels from a standby reduced level to approximately 80% of full output, followed by the normal warm-up time between 80% and 100% of full light output. Depending on the lamp type and wattage, the standby lumens are roughly 15-40% of full output and the input watts are 30-60% of full wattage. Therefore, during periods that the space is unoccupied and the system is dimmed, savings of 40-70% are achieved.

Electronic ballasts for some types of HID lamps are starting to become commercially available. These ballasts offer the advantages of reduced size and weight, as well as better color control; however, electronic HID ballasts offer minimal efficiency gains over magnetic HID ballasts.

CHAPTER 6

CABLES

6.1.Types of Cables

The range of types of cables used in electrical work is very wide: from heavy lead-sheathed and armored paper-insulated cables to the domestic flexible cable used to connect a hair-drier to the supply. Lead, tough-rubber, PVC and other types of sheathed cables used for domestic and industrial wiring are generally placed under the heading of power cables. There are, however, other insulated copper conductors (they are sometimes aluminum), which, though by definitions are termed cables, are sometimes not regarded as such. Into this category fall for these rubber and PVC insulated conductors drawn into some form of conduit or trucking for domestic and factory wiring, and similar conductors employed for the wiring of electrical equipment. In addition, there are the various types of insulated flexible conductors including those used for portable appliances and pendant fittings.

The main group of cables is 'flexible cables', so termed to indicate that they consist of or more cores, each containing a group of wires, the diameters of the wires and the construction of the cable being such that they afford flexibility.

Type of cables used:

1. Single core cable
2. Two-core cable
3. Three-core cable
4. Composite cable
5. Power cable
6. Wiring cable
7. Overhead cable
8. Equipment cable
9. Appliance Wiring cable
10. Twin Twisted cable
11. Three-Core Twisted
12. Twin Circular cable
13. Three Core

14. Coaxial cable

15. Tel. cable

6.1.1.Single-core

These are natural or tinned copper wires. The insulating materials include butyl - ubber, silicon-rubber, and the more familiar PVC.

The synthetic rubbers are provided with braiding and are self-colored. The IEE Regulations recognize these insulating materials for twin-and multi-core flexible cables ather than for use as single conductors in conduit or trunking wiring systems. But that re available from the cable manufacturers for specific insulation requirements. Sizes ary from 1 to 36 mm squared (PVC) and 50 mm squared (synthetic rubbers).

6.1.2.Two-core

Two-core or 'twin' cables are flat or circular. The insulation and sheathing materials re those used for single-core cables. The circular cables require cotton filler threads to ain the circular shape. Flat cables have their two cores laid side by side.

6.1.3.Three-core

These cables are the same in all respects to single-and two-core cables except, of ourse, they carry three cores.

6.1.4.Composite cables

Composite cables are those, which, in an addition to carrying the currency-carrying ircuit conductors, also contain a circuit-protective conductor.

To summarize, the following group of cable types and applications are to be found n electrical work, and the electrician, at one time or another during his career, may be sked to install them.

6.1.5.Wiring cables

Switch board wiring; domestic at workshop flexible cables and cords. Mainly opper conductors.

6.1.6.Power cables.

Heavy cables, generally lead sheathed and armored; control cables for electrical

uipment. Both are copper and aluminum conductors.

- **Mining cables**

In this field cables are used for trailing cables to supply equipment; shot-firing bles; roadway lighting; lift -shaft wiring; signaling, telephone and control cables. dequate protection and fireproofing are features of cables for this application field.

6.1.7.Ship-wiring cables

These cables are generally lead-sheathed and armored, and mineral-insulated, metal-eathed. Cables must comply with Lloyd's Rules and Regulations, and with Admiralty quirements.

6.1.8.Overhead cables

The cables are Bare, lightly-insulated and insulated conductors of copper, copper--dmium and aluminum generally. It is sometimes with steel core for added strength. or overhead distribution cables are PVC and in most cases comply with British elecom requirements.

6.1.9.Communication cables

This group includes television down-leads and radio-relay cables; radio frequency bles; telephone cables.

6.1.10.Welding cables

These are flexible cables and heavy cords with either copper or aluminum nductors.

6.1.11.Electric-sign cables

PVC-and rubber-insulated cables for high-voltage discharge lamps able to withstand e high voltages.

6.1.12.Equipment wires

Special wires for use with instruments often insulated with special materials such as icon, rubber and irradiated polythene.

6.1.13.Appliance-wiring cables

This group includes high-temperature cables for electric radiators, cookers, and so ı. Insulation used includes nylon, asbestos, and varnished cambric.

6.1.14.Heating cables

Cables are for floor-warming, road-heating, soil-warming, ceiling-heating, and milar applications.

6.1.15.Flexible cords

A flexible cord is defined as a flexible cable in which the csa of each conductor does ot exceed 4 mm squared. The most common types of flexible cords are used in omestic and light industrial work. The diameter of each strand or wire varies from 0.21) 0.31 mm. Flexible cord come in many sizes and types; for convenience they are roups as follows:

I.Twin-twisted: These consist of one single insulated stranded conductors twisted ogether to form a core-cable. Insulation used is vulcanized rubber and PVC. Color dentification in red and black is often provided. The rubber is protected by a braiding f cotton, glazed-cotton, and rayon-barding and artificial silk. The PVC-insulated onductors are not provided with additional protection.

II.Three-core (twisted): Generally as two -twisted cords but with a third conductor olored green, for eating lighting fittings.

III.Three-core (circular): Generally as twin-core circular except that the third onductor is colored green and yellow for earthing purposes.

IV.Four-care (circular): Generally as twin- core circular. Colors are brown and lue.

V.Parallel twin: These are two stranded conductors laid together in parallel and nsulated to form a uniform cable with rubber or PVC.

VI.Twin-core (flat): This consists of two stranded conductors insulated with

rubber, colored red and black. Lay side-by-side and braided with artificial silk.

VII.High-temperature lighting, flexible cord: With the increasing use of filament lamps which produce very high temperatures, the temperature at the terminals of a lamp holder can reach 71 centigrade or more. In most instances the usual flexible insulators (rubber and PVC) are quite unsuitable and special flexible cords for lighting are now available. Conductors are generally of nickel-plated copper wires, each conductor being provided with two lapping of glass fiber. The braiding is also varnished with silicone. Cords are made in the twisted form (two-and three-core).

VIII.Flexible cables: These cables are made with stranded conductors, the diameters being 0.3, 0.4, 0.5, and 0.6 mm. They are generally used for trailing cables and similar applications where heavy currents up to 630 A are to be carried, for instance, to welding plant.

IX.Coaxiel cables (antenna cable): Antenna cables are a special cable which is used to transfer high frequency. Coaxial cable is a type of flexible cables. We use this cable for TV. We are using this type of cable between television sockets and from television to antenna.

X.Telephone cables: Telephone cable is special cable. We use telephone circuit in the buildings and also for intercom circuits. These cables are very slim. Telephone cables are not same as electric cables. There are a lot of sizes the telephone cables. Telephone cables are 0.5mm and every time one cable is extra near this cables.

Table 6.1: Telephone cables sizes

1x2+0.5 mm^2
2x2+0.5 mm^2
3x2+0.5 mm^2
4x2+0.5 mm^2
6x2+0.5 mm^2
10x2+0.5 mm^2
15x2+0.5 mm^2
20x2+0.5 mm^2

6.2 Conductor Identification:

The wiring regulations require that all conductors have to be identified by some meaning to indicate their functions i.e. phase conductors of a 3 phase system are colored by red, yellow, blue with neutral colored by black, protective conductors are identified by green or yellow and green.

- In Turkey Standards;

Red	Phase
Black	Neutral
Green	Earth

- There are some methods to identify the conductors:

1. Coloring of the conductor insulation
2. Printed numbers on the conductor
3. Colored adhesive cases at the termination of the conductor
4. Colored see levels types at the termination of the conductors
5. Numbered paint for bare conductors
6. Colored discs fixed to the termination of conductors' e.g. on a distribution board.

- Cables sizes: Cables are in different common sizes 0.75 mm^2, 1 mm^2, 1.5 mm^2, 2.5 mm^2, 4 mm^2, 6 mm^2, 10 mm^2, 16 mm^2, 25 mm^2, 35 mm^2, 50 mm^2, 70 mm^2, 95 mm^2, 120 mm^2, 150 mm^2, 185 mm^2, 240 mm^2, 300 mm^2, 400 mm^2 and 500 mm^2.

CHAPTER 7
PROTECTION OF ILLUMINATION

The meaning of the word protection, as used in electrical industry, is not different to in every day used. People protect them selves against personal or financial loss by ns of insurance and from injury or discomfort by the use of the correct protective ning the further protect there property by the installation of security measure such as s and for alarm systems.

In the same way electrical system need to be protected against mechanical damage effect of the environment, and electrical over current to be installed in such a ion that's person and or dive stock are protected from the dangerous that such an trical installation may create.

7.1.Reasons for protections

7.1.1.Mechanical Damage

Mechanical damage is the term used to describe the physical harm sustains by ous parts of electrical sets. Generally it happens by impact hitting cable with a mer. Cables sheath being rubbed against wall corner or by collision (e.g. sharp ct falling to cut a cable prevent damage of cable sheath conduits, ducts trunking and ng).

7.1.2.Fire Risk:

Electrical fire cawed by;

a-) A fault defect all missing in the firing

b-) Faults or defects in appliances

c-) Mal-operation or abuse the electrical circuit (e.g. overloading)

7.1.3.Corrosion:

Wherever metal is used there is often the attendant problem of corrosion and it's vented. There are two necessary preventions for corrosion:

a-) The prevention of contact between two dissimilar metals ex copper & aluminum.

b-) Prohibition of soldering fluxes which remains acidic or corrosive at the compilation of a soldering operation ex cable joint together.

c-) The protection metal sheaths of cables and metal conductions fittings where they come into contact with lime, cement or plaster and certain hard woods ex: corrosion of the metal boxes.

d-) Protection of cables wiring systems and equipment's against the corrosive action of water, oil or dumbness if not they are suitable designed to with these conditions.

7.1.4.Over current

Over current, excess current the result of either and overload or a short circuit. The overloading occurs when an extra load is taken from the supply. This load being connected in parallel with the existing load in a circuit decreases. The overload resistance of the circuit and current increases which causes heating the cables and deteriorate the cable insulation and short-circuit. Short circuit is a direct contact between live conductors

a-) Neautral condactor. (Fuse)

b-) Earthed metal work (Operators)

7.2.Protectors of Over Current

a-) Fuses

b-) Circuit Breakers

7.2.1.Fuse

A device for opening a circuit by means of a conductor designed to melt when an excessive current flows along it.

There are three types of fuses.

a-) Rewrieable

b-) Cartridge

c-) HBC (High Breaking Capacity)

7.2.1.a. Rewireable Fuse:

A rewireable fuse consists of a fuse, holder, a fuse element and a fuse carrier. The holder and carrier are being made porselain or bakelite. These fuses have designed with color codes, which are marked on the fuse holder as follows;

Table 7.1: Fuse current rating and color codes

Current Rating	Color Codes
5A	White
15A	Blue
20A	Yellow
30A	Red
45A	Green
60A	Purple

But, this type of fuse has disadvantages. Putting wrong fuse element can be damaged and spark so fire risk, can open circuit at starting-current surges.

Note: Today's they have not used anymore.

7.2.1.b.Cartridge Fuse

A cartridge fuse consists of a porcelain tube with metal and caps to which the element is attached. The tube is filled silica. They have the advantage ever the rewirable fuse of not deteriorating, of accuracy in breaking at rated values and of not arcing when interrupting faults. They are however, expensive to replace.

7.2.1.c.High –Breaking Capacity (HBC)

It is a sophisticated variation of the cartridge fuse and is normally found protecting motor circuits and industrial installations. Porcelain body filled with silica with a silver element and lug type and caps. It is very fast acting and can discriminate between a starting surge and an overload.

7.2.2.Circuit-breakers

The circuit breakers can be regarded as a switch, which can be opened automatically by means of a 'tripping' device. It is, however, more than this

Whereas a switch is capable of making and breaking a current not greatly in excess f its rated normal current, the circuit-breaker can make and break a circuit, particularly ı abnormal conditions such as the occasion of a short-circuit in an installation. It thus isconnects automatically a faulty circuit.

A circuit breaker is selected for a particular duty, taking into consideration the ollowing.

(a) The normal current it will have to carry

(b) The amount of current which the supply will feed into the circuit fault, which urrent the circuit-breaker will have to interrupt without damage to itself.

The circuit breaker generally has a mechanism which, when in the closed position, olds the contacts together. The contacts are separated when the release mechanism of e circuit breaker is operated by hand or automatically by magnetic means. The circuit eaker with magnetic 'tripping' (the term used to indicate the opening of the device) nploys a solenoid, which is an air-cooled coil. In the hollow of the coil is located an on cylinder attached to a trip mechanism consisting of a series of pivoted links. When e circuit breaker is closed, the main current will pass through the solenoid. When the rcuit rises above a certain value (due to an overload or a fault), the cylinder moves ithin the solenoid to cause the attached linkage to collapse and, in turn, separate the rcuit-breaker contacts.

Circuit breakers are used in many installations in place of fuses because of a number definite advantages. First, in the event of an overload or fault all poles of the circuit e positively disconnected. The devices are also capable of remote control by push ttons, by under-voltage release coils, or by earth-leakage trip coils. The over-current tting of the circuit breakers can be adjusted to suit the load conditions of the circuit to controlled. Time-lag devices can also be introduced so that the time taken for pping can be delayed because, in some instances, a fault can clear itself, and so avoid e need for a circuit breaker to disconnect not only the faulty circuit, but also other althy circuits, which may be associated with it. The time-lag facility is also useful in otor circuits, to allow the circuit-breaker to stay closed while the motor takes the high tial starting current during the run-up to attain its normal speed. After they have pped, circuit breakers can be closed immediately without loss of time. Circuit-breaker ntacts separate either in air or in insulating oil.

In certain circumstances, circuit breakers must be used with 'back-up' protection, ich involves the provision of HBC (high breaking capacity) fuses in the main circuit-

breaker circuit. In this instance, an extremely heavy over current, such as is caused by a short circuit, is handled by the fuses, to leave the circuit breaker to deal with the over currents caused by overloads

In increasing use for modern electrical installations is the miniature circuit-breaker (MCB). It is used as an alternative to the fuse, and has certain advantages: it can be reset or reclosed easily; it gives a close degree of small over current protection (the tripping factor is 1.1); it will trip on a small sustained over current, but not on a harmless transient over current such as a switching surge. For all applications the MCB tends to give much better overall protection against both fire and shock risks than can be obtained with the use of normal HBC or rewirable fuses. Miniature circuit breakers are available in distribution-board units for final circuit protection.

One main disadvantage of the MCB is the initial cost, although it has the long-term advantage. There is also tendency for the tripping mechanism to stick or become sluggish in operation after long periods of inaction It is recommended that the MCB be tripped at frequent intervals to 'ease the springs' and so ensure that it performs its prescribed duty with no damage either to itself or to the circuit it protects.

7.3.Values of fuses;

6A, 10A, 16A, 20A, 25A, 32A, 40A, 50A, 63A.

7.4.Earth Leakages:

Protection for Earth Leakages:

Using ELCB, which stands for Earth Leakage Circuit Breaker, does this type of protection. There are two types of earth leakage circuit breaker.

7.5.Current Operated ELCB (C/O ELCB)

Current flowing through the live conductor and back through the neutral conductor and there will be opposite magnetic area in the iron ring, so that the trip coils does not operate If a live to earth fault or a neutral to earth fault happens the incoming and returning current will not be same and magnetic field will circulate in the iron ring to operate the trip coil. This type of operators is used in today.

The following are some of the points, which the inspecting electrician should look for:

1) Flexible cables not secure at plugs.

2) Frayed cables.

3) Cables without mechanical protection.

4) Use of unearthed metalwork.

5) Circuits over-fused.

6) Poor or broken earth connections and especially sign of corrosion.

7) Unguarded elements of the radiant fires.

8) Unauthorized additions to final circuits resulting in overloaded circuit cables.

9) Unprotected or unearthed socket-outlets.

10) Appliances with earthing requirements being supplied from two-pin BC adaptors.

11) Bell-wire used to carry mains voltages.

12) Use of portable heating appliances in bathrooms.

13) Broken connectors, such as plugs.

14) Signs of heating at socket-outlet contacts.

The following are the requirements for electrical safety:

1) Ensuring that all conductors are sufficient for the design load current of circuits.

2) All equipment, wiring systems, and accessories must be appropriate to the working conditions.

3) All circuits are protected against over current using devices, which have ratings appropriate to the current-carrying capacity of the conductors

4) All exposed conductive pans are connected together by means of CPCs.

5) All extraneous conductive parts are bonded together by means of main bonding conductors and supplementary bonding conductors are taken to the installation main earth terminal.

6) All control and over current protective devices are installed in the phase conductor.

7) All electrical equipment has the means for their control and isolation.

8) All joints and connections must be mechanically secure and electrically continuous and be accessible at all times.

9) No additions to existing installations should be made unless the existing

conductors are sufficient in size to carry the extra loading.

10) All electrical conductors have to be installed with adequate protection against physical damage and be suitably insulated for the circuit voltage at which they are to operate.

11) In situations where a fault current to earth is not sufficient to operate an over current device, an RCD must be installed.

12) All electrical equipment intended for use outside equipotent zone must be fed from socket-outlets incorporating an RCD.

13) The detailed inspection and testing of installation before they are connected to a mains supply, and at regular intervals there after.

CHAPTER 8
LUMINARIES

8.1.Luminaries

- Luminarie Efficiency
- Directing Light

A luminarie, or light fixture, is a unit consisting of the following components:

- lamps
- lamp sockets
- ballasts
- reflective material
- lenses, refractors, or louvers
- housing

8.1.1.Luminarie

The main function of the luminaire is to direct light using reflective and shielding materials. Many lighting upgrade projects consist of replacing one or more of these components to improve fixture efficiency. Alternatively, users may consider replacing the entire luminaire with one that I designed to efficiently provide the appropriate quantity and quality of illumination.

There are several different types of luminaires. The following is a listing of some of the common luminaire types:

- general illumination fixtures such as 2x4, 2x2, & 1x4 fluorescent troffers
- downlights
- indirect lighting (light reflected off the ceiling/walls)
- spot or accent lighting
- task lighting
- outdoor area and flood lighting

8.1.2.Luminarie Efficiency

The efficiency of a luminaire is the percentage of lamp lumens produced that tually exit the fixture. The use of louvers can improve visual comfort, but because ey reduce the lumen output of the fixture, efficiency is reduced. Generally, the most ficient fixtures have the poorest visual comfort (e.g. bare strip industrial fixtures). onversely, the fixture that provides the highest visual comfort level is the least ficient. Thus, a lighting designer must determine the best compromise between ficiency and VCP when specifying luminaires. Recently, some manufacturers have rted offering fixtures with excellent VCP and efficiency. These so-called"super tures" combine state-of-the-art lens or louver designs to provide the best of both orlds.

Surface deterioration and accumulated dirt in older, poorly maintained fixtures can so cause reductions in luminaire efficiency. Refer to Lighting Maintenance for more formation.

8.2.Directing Light

Each of the above luminaire types consist of a number of components that are signed to work together to produce and direct light. Because the subject of light oduction has been covered by the previous section, the text below focuses on the mponents used to direct the light produced by the lamps.

8.3.Reflectors

Reflectors are designed to redirect the light emitted from a lamp in order to achieve lesired distribution of light intensity outside of the luminaire.

In most incandescent spot and flood lights, highly specular (mirror-like) reflectors e usually built into the lamps.

One energy-efficient upgrade option is to install a custom-designed reflector to hance the light control and efficiency of the fixture, which may allow partial lamping. Retrofit reflectors are useful for upgrading the efficiency of older, teriorated luminaire surfaces. A variety of reflector materials are available: highly lective white paint, silver film laminate, and two grades of anodized aluminum sheet

(standard or enhanced reflectivity). Silver film laminate is generally considered to have the highest reflectance, but is considered less durable.

Proper design and installation of reflectors can have more effect on performance than the reflector materials. In combination with delamping, however, the use of reflectors may result in reduced light output and may redistribute the light, which may or may not be acceptable for a specific space or application. To ensure acceptable performance from reflectors, arrange for a trial installation and measure "before" and "after" light levels using the procedures outlined in Lighting Evaluations. For specific name-brand performance data, refer to Specifier Reports, "Specular Reflectors," Volume 1, Issue 3, National Lighting Product Information Program.

8.4.Lenses and Louvers

Most indoor commercial fluorescent fixtures use either a lens or a louver to prevent direct viewing of the lamps. Light that is emitted in the so-called "glare zone" (angles above 45 degrees from the fixture's vertical axis) can cause visual discomfort and reflections, which reduce contrast on work surfaces or computer screens. Lenses and louvers attempt to control these problems.

8.4.1.Lenses

Lenses made from clear ultraviolet-stabilized acrylic plastic deliver the most light output and uniformity of all shielding media. However, they provide less glare control than louvered fixtures. Clear lens types include prismatic, batwing, linear batwing, and polarized lenses. Lenses are usually much less expensive than louvers. White translucent diffusers are much less efficient than clear lenses, and they result in relatively low visual comfort probability. New low-glare lens materials are available for retrofit and provide high visual comfort (VCP>80) and high efficiency.

8.4.2.Louvers

Louvers provide superior glare control and high visual comfort compared with lens-diffuser systems. The most common application of louvers is to eliminate the fixture glare reflected on computer screens. So-called "deep-cell" parabolic louvers (with 5-7" cell apertures and depths of 2-4" (provide a good balance between visual

omfort and luminaire efficiency. Although small-cell parabolic louvers provide the ghest level of visual comfort, they reduce luminaire efficiency to about 35-45 percent. or retrofit applications, both deep-cell and small-cell louvers are available for use with xisting fixtures. Note that the deep-cell louver retrofit adds 2-4" to the overall depth of troffer; verify that sufficient plenum depth is available before specifying the deep-cell etrofit.

8.4.3.Distribution

One of the primary functions of a luminaire is to direct the light to where it is eeded. The light distribution produced by luminaires is characterized by the luminating Engineering Society as follows:

- Direct (90 to 100 percent of the light is directed downward for maximum se.
- Indirect (90 to 100 percent of the light is directed to the ceilings and pper walls and is reflected to all parts of a room.
- Semi-Direct (60 to 90 percent of the light is directed downward with the emainder directed upward.
- General Diffuse or Direct-Indirect (equal portions of the light are irected upward and downward.
- Highlighting (the beam projection distance and focusing ability haracterize this luminarie.

The lighting distribution that is characteristic of a given luminaire is described sing the candela distribution provided by the luminaire manufacturer (see diagram on ext page). The candela distribution is represented by a curve on a polar graph showing ne relative luminous intensity 360 around the fixture (looking at a cross-section of the xture. This information is useful because it shows how much light is emitted in each irection and the relative proportions of downlighting and uplighting. is the angle,

T (mm²) | 3x25+16

CONCLUSION

Designing electrical installation and illumination projects, are of the most important tasks in electrical engineering. The importance comes from the creativity factor. The electrical engineer uses his or her imagination for creating something that is not present and he or she has to think and apply in a very unusual and complex way. This was our motivation for choosing a project about electrical installation.

While working in the topic of electrical installation everyone, technicians or engineers should be very careful because small mistakes can cause big damages in application.

In this project all regulation standards of Turkey standards have been applied very carefully.

T (mm²)	3x25+16

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