NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

ELECTRICAL INSTALLATION PROJECT FOR APARTMENT AND BUSSINESS CENTER

Graduation Project
EE-400

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ABSTRACT

In life nearly all equipments requires electrical energy for their operation. Therefore, in order to satisfy this requirements electrical installation should be well designed and applied with professionally knowledge. This emphasizes the impotance of the electrical engineers.

My project is about electrical installation of an apartment and bussiness center, and this project needs well knowledge about electrical installation and also researcing the present systems.

This project consists the installation of lighting circuits, the installation of sockets, illumination, loudspeaker, tv and telephone systems. For all of these, there are some regulations that has to be applied.All projects are drawn in AutoCAD 2007.

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INTRODUCTION

Drawing electrical installation projects is one of the most important aspect of electrical engineering. All of the drawings should be based on the principles of the IEE standards and T.R.N.C. standards and also has to include the regulations. Before starting the drawing all of the details has to be considered and applied very carefully

The first chapter introduces with some brief information about the historical development of electricity, changes in the life, industrial attacts and historical review of wiring installations.

Chapter two presents the generation transmission distribution from the power station step by step until it reaches to the costumer use.

Chapter three gives information about the protection. Why we use protection, what is the protection methods, faults that may occur, risks,corrosion and leakages.

Chapter four presents the insulators which is used in all types of installations including high voltage transmission.

Chapter five is concerned on the most impotant aspect of elctrical installation which is the earthing process. It gives information about the earthhing terms, systems, important points, electric shock and testing the earthing system.

Chapter six is devoted to the types of cables, and how to identify cables.

Chapter seven gives information about some special installations that is applied to the buildings such like suond, TV, telephone, etc.

Chapter eight is about illumination of buildings

The appendix is found illumination calculation.

The conclusion presents important results obtained by the author and the important points that has to be considered in engineering life.

CHAPTER 1: GENERALS

1.1 Historical Review of Installation Work

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 bean regarded as a time when industrialists awakened to the potential of the new form of power.

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. 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.

Electrical installations in the early days were quite primitive and often dangerous. It is on record that in 1881, the installation in Hatfield House was carried out by an aristocratic amateur. That the installation was dangerous did not perturb visitors to the house who'... when the naked wires on the gallery ceiling broke into flame... nonchalantly threw up cushions to put out the fire and then went on with their conversation'...

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.

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.

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. 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.

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.

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. 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, aluminium was looked to for a sheath of, in particular, light weight. Many experiments were carried out before a reliable system of aluminium-sheathed cable could be put on the market.

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 aluminium.

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.

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. Aluminium 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.

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. 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.

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 many 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.

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 H'. 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.

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.

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).

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.

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.

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 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'.

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.

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.

CHAPTER 2: GENERATION AND TRANSMISSION

The generation of electric is to convert the mechanical energy into the electrical energy. Mechanical energy mean that motors which makes the turbine turn.

Electrical energy must be at definite value. And also frequency must be 50Hz or at other countries 60Hz. The voltage which is generated (the output of the generator) is 11KV. After the station the lines which transfer the generated voltage to the costumers at expected value. These can be done in some rules. If the voltage transfers as it is generated up to costumers. There will be voltage drop and looses. So voltage is stepped up. When the voltage is stepped up, current will decrease. That is why the voltage is increased. This is done as it is depending on ohm's law. Actually these mean low current. Used cables will become thin. This will be economic and it will be easy to install transmission lines. If we cannot do this, we will have to use thicker cable.

To transfer the generated voltage these steps will be done. Generated voltage (11KV) is applied to the step-up transformer to have 66KV. This voltage is carried up to a sub-station. In this sub-station the voltage will be stepped-down again to 11KV. At the end the voltage stepped-down to 415V that is used by costumers. As a result the value of the voltage has to be at definite value. These;

a-) line to line – 380 V

b-) line to neutral – 220V

c-) line to earth – 0V

d-) earth to neutral – 0V

2.1 Electricity Generation

Electricity generation is the first process in the delivery of electricity to consumers. The other processes are electric power transmission and electricity distribution which are normally carried out by the Electrical power industry.

Centralized power generation became possible when it was recognized that alternating current electric power lines can transport electricity at low costs across great distances by taking advantage of the ability to transform the voltage using power transformers.

Electricity has been generated for the purpose of powering human technologies for at least 120 years from various sources of energy. The first power plants were run on wood, while today we rely mainly on coal, nuclear, natural gas, hydroelectric, and petroleum power and a small amount from solar energy, tidal harnesses, wind generators, and geothermal sources.

Electricity demand

The demand for electricity can be met in two different ways. The primary method thus far has been for public or private utilities to construct large scale centralized projects to generate and transmit the electricity required to fuel economies. Many of these projects have caused unpleasant environmental effects such as air or radiation pollution and the flooding of large areas of land.

Distributed generation creates power on a smaller scale at locations throughout the electricity network. Often these sites generate electricity as a byproduct of other industrial processes such as using gas from landfills to drive turbines.

2.2 Methods of Generating Electricity

2.2.1. Turbines

Rotating turbines attached to electrical generators produce most commercially available electricity. Turbines are driven by a fluid which acts as an intermediate energy carrier. The fluids typically used are:

steam - Water is boiled by nuclear fission or the burning of fossil fuels (coal, natural gas, or petroleum). Some newer plants use the sun as the heat source: solar parabolic troughs and solar power towers concentrate sunlight to heat a heat transfer fluid, which is then used to produce steam.

water - Turbine blades are acted upon by flowing water, produced by hydroelectric dams or tidal forces,

wind - Most wind turbines generate electricity from naturally occurring wind. Solar updraft towers use wind that is artificially produced inside the chimney by heating it with sunlight.

hot gases - Turbines are driven directly by gases produced by the combustion of natural gas or oil.

Combined cycle gas turbine plants are driven by both steam and gas. They generate power by burning natural gas in a gas turbine and use residual heat to generate additional electricity from steam. These plants offer efficiencies of up to 60%.

2.2.2. Reciprocating engines

Small electricity generators are often powered by reciprocating engines burning diesel, biogas or natural gas. Diesel engines are often used for back up generation, usually at low voltages. Biogas is often combusted where it is produced, such as a landfill or wastewater treatment plant, with a reciprocating engine or a microturbine, which is a small gas turbine.

2.2.3. Photovoltaic panels

Unlike the solar heat concentrators mentioned above, photovoltaic panels convert sunlight directly to electricity. Although sunlight is free and abundant, solar electricity is still usually somewhat more expensive to produce than large-scale mechanically generated power due to the cost of the panels. Low-efficiency silicon solar cells have been decreasing in cost though, and multijunction cells with close to 30% conversion efficiency are now commercially available. Over 40% efficiency has been demonstrated in experimental systems.[3], (Until recently, photovoltaics were most commonly used in remote sites where there is no access to a commercial power grid, or as a supplemental electricity source for individual homes and businesses. Recent advances in manufacturing efficiency and photovoltaic technology, combined with subsidies driven by environmental concerns, have dramatically accelerated the deployment of solar panels. Installed solar capacity is growing by 30% per year in several regions including Germany, Japan, California and New Jersey.

2.2.4. Other generation methods

Various other technologies have been studied and developed for power generation. Solid-state generation (without moving parts) is of particular interest in portable applications. This area is largely dominated by thermoelectric (TE) devices, though thermionic (TI) and thermophotovoltaic (TPV) systems have been developed as well. Typically, TE devices are used at lower temperatures than TI and TPV systems. Piezoelectric devices are used for power generation from mechanical strain, particularly in power harvesting. Betavoltaics are another type of solid-state power generator which produces electricity from radioactive decay.

Fluid-based magnetohydrodynamic (MHD) power generation has been studied as a method for extracting electrical power from nuclear reactors and also from more conventional fuel combustion systems.

Electrochemical electricity generation is also important in portable and mobile applications. Currently, most electrochemical power comes from closed electrochemical cells ("batteries") [4], which are arguably utilized more as storage systems than generation systems, but open electrochemical systems, known as fuel cells, have been undergoing a great deal of research and development in the last few years. Fuel cells can be used to extract power either from natural fuels or from synthesized fuels (mainly electrolytic hydrogen) and so can be viewed as either generation systems or storage systems depending on their use.

2.3. AC Power Transmission

AC power transmission is the transmission of electric power by alternating current. Usually transmission lines use three phase AC current. In electric railways, single phase AC current is sometimes used in a railway electrification system. In urban areas, trains may be powered by DC at 600 volts or so.

Today, transmission-level voltages are usually considered to be 110 kV and above. Lower voltages such as 66 kV and 33 kV are usually considered sub-transmission voltages but are occasionally used on long lines with light loads. Voltages less than 33 kV are usually used for distribution. Voltages above 230 kV are considered extra high voltage and require different designs compared to equipment used at lower

voltages. Overhead transmission lines are uninsulated wire, so design of these lines requires minimum clearances to be observed to maintain safety.

2.4. Losses

Transmitting electricity at high voltage reduces the fraction of energy lost to Joule heating. For a given amount of power, a higher voltage reduces the current and thus the resistive losses in the conductor. Long distance transmission is typically done with overhead lines at voltages of 110 to 1200 kV. However, at extremely high voltages, more than 2000 kV between conductor and ground, corona discharge losses are so large that they can offset the lower resistance loss in the line conductors.

Transmission and distribution losses in the USA were estimated at 7.2% in 1995 [2], and in the UK at 7.4% in 1998. [3]

In an alternating current transmission line, the inductance and capacitance of the line conductors can be significant. The currents that flow in these components of transmission line impedance constitute reactive power, which transmits no energy to the load. Reactive current flow causes extra losses in the transmission circuit. The ratio of real power (transmitted to the load) to apparent power is the power factor. As reactive current increases, the reactive power increases and the power factor decreases. For systems with low power factors, losses are higher than for systems with high power factors. Utilities add capacitor banks and other components throughout the system — such as phase-shifting transformers, static VAR compensators, and flexible AC transmission systems (FACTS) — to control reactive power flow for reduction of losses and stabilization of system voltage.

Electrical power is always partially lost by transmission. This applies to short distances such as between components on a printed circuit board as well as to cross country high voltage lines. Power lost is proportional to the resistance of the wire and the square of the current.

For a system which delivers a certain amount of power, P, over a particular voltage, V, the current flowing through the cables is given by $I = \frac{P}{V}$. Thus, the power lost in the lines, $P_{loss} = RI^2 = R(\frac{P}{V})^2 = \frac{RP^2}{V^2}$.

Therefore, the power lost is proportional to the resistance and inversely proportional to the square of the voltage. A higher transmission voltage reduces the current and thus the power lost during transmission.

CHAPTER 3: PROTECTION

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

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

3.1. Reasons For Protection

3.1.1. Mechanical Damage

Mechanical damage is the term used to describe the physical harm sustains by various parts of electrical sets. Generally by impact hitting cable with a hammer by obrasing. Cables sheath being rubbed against wall corner or by collision (e.g. sharp object falling to cut a cable prevent damage of cable sheath conduits, ducts tranking and casing)

3.1.2. 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)

3.1.3. Corrosion:

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

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

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.

3.1.4. 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 the short-circuit. Short circuit is a direct contact between live conductors

a-) Neutral conductor. (Fuse)

b-) Earthed metal work (Operators)

3.2. Protectors of over current

a-) Fuses

b-) Circuit Breakers

3.2.1. 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-) Rewire able

b-) Cartridge

c-)HBC (High Breaking Capacity)

3.2.1. 1. Rewire able Fuse:

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

Table 3.1. 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.

3.2.1.2. 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 rewire able fuse of not deteriorating, of accuracy in breaking at rated values and of not arcing when interrupting faults. They are however, expensive to replace.

3.2.1.3. 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.

3.2.2. 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 of its rated normal current, the circuit-breaker can make and break a circuit, particularly in abnormal conditions such as the occasion of a short-circuit in an installation. It thus disconnects automatically a faulty circuit.

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

following. (a) The normal current it will have to carry and (b) the amount of current which the supply will feed into the circuit fault, which current the circuit-breaker will have to interrupt without damage to itself.

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

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

In certain circumstances, circuit breakers must be used with 'back-up' protection, which 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 rewire able 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.

3.3. Values of fuses;

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

3.4. 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.

3.5. 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 in case 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 4: INSULATORS

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 E - Polyvinyl acetyl resin. Class H - Silicon-glass.

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

4.1. Rubber

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

4.2. 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.

4.3. Paper

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.

4.4. Glass

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.

4.5. Mica

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.

4.6. Ceramics

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.

4.7. Bakelite

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.

4.8. 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.

4.9. Epoxide Resin

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

4.10. Textiles

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.

4.11. Gases

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.

4.12. Liquids

Mineral oil is the most common insulant 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 fibers 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 5: 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 earthing 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.

5.1. Earthing Terms

5.1.1 Earth

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

5.1.2 Earth Electrode

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

5.1.3 Earthing Lead

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

5.1.4 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.

5.2 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.

5.2.1. 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. 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.

5.2.2. 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).

5.2.3. Earthing practice

5.2.3.1. 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 100^0C and results in the complete failure of the electrode.

The current density of the electrode is found by:

Current density = I / A = $92 \times 10^3 / \sqrt{t}$

Where I = short-circuit fault current, A = area (in cm2), t = time in seconds (duration of the fault current).

The formula assumes a temperature rise of 120^0C, over an ambient temperature of 25^0C, 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. Because 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 aluminium 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.

5.3. 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.

5.4. 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.

5.5. 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.

5.5.1. 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.

5.5.2. 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 aluminium, the maximum value is one ohm.

5.5.3. 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 aluminium).

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.

5.5.4. 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'.

5.5.5. 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 5.1 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: **Resistance = Voltage / Current**

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 do 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.

5.5.6. 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.

5.5.7. 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

NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

ELECTRICAL INSTALLATION PROJECT FOR APARTMENT AND BUSSINESS CENTER

Graduation Project
EE-400

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ABSTRACT

In life nearly all equipments requires electrical energy for their operation. Therefore, in order to satisfy this requirements electrical installation should be well designed and applied with professionally knowledge. This emphasizes the impotance of the electrical engineers.

My project is about electrical installation of an apartment and bussiness center, and this project needs well knowledge about electrical installation and also researcing the present systems.

This project consists the installation of lighting circuits, the installation of sockets, illumination, loudspeaker, tv and telephone systems. For all of these, there are some regulations that has to be applied.All projects are drawn in AutoCAD 2007.

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INTRODUCTION

Drawing electrical installation projects is one of the most important aspect of electrical engineering. All of the drawings should be based on the principles of the IEE standards and T.R.N.C. standards and also has to include the regulations. Before starting the drawing all of the details has to be considered and applied very carefully

The first chapter introduces with some brief information about the historical development of electricity, changes in the life, industrial attacts and historical review of wiring installations.

Chapter two presents the generation transmission distribution from the power station step by step until it reaches to the costumer use.

Chapter three gives information about the protection. Why we use protection, what is the protection methods, faults that may occur, risks,corrosion and leakages.

Chapter four presents the insulators which is used in all types of installations including high voltage transmission.

Chapter five is concerned on the most impotant aspect of elctrical installation which is the earthing process. It gives information about the earthhing terms, systems, important points, electric shock and testing the earthing system.

Chapter six is devoted to the types of cables, and how to identify cables.

Chapter seven gives information about some special installations that is applied to the buildings such like suond, TV, telephone, etc.

Chapter eight is about illumination of buildings

The appendix is found illumination calculation.

The conclusion presents important results obtained by the author and the important points that has to be considered in engineering life.

CHAPTER 1: GENERALS

1.1 Historical Review of Installation Work

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 bean regarded as a time when industrialists awakened to the potential of the new form of power.

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. 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.

Electrical installations in the early days were quite primitive and often dangerous. It is on record that in 1881, the installation in Hatfield House was carried out by an aristocratic amateur. That the installation was dangerous did not perturb visitors to the house who'... when the naked wires on the gallery ceiling broke into flame... nonchalantly threw up cushions to put out the fire and then went on with their conversation'...

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.

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.

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. 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.

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.

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. 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, aluminium was looked to for a sheath of, in particular, light weight. Many experiments were carried out before a reliable system of aluminium-sheathed cable could be put on the market.

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 aluminium.

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.

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. Aluminium 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.

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. 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.

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 many 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.

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 H'. 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.

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.

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).

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.

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.

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 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'.

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.

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.

CHAPTER 2: GENERATION AND TRANSMISSION

The generation of electric is to convert the mechanical energy into the electrical energy. Mechanical energy mean that motors which makes the turbine turn.

Electrical energy must be at definite value. And also frequency must be 50Hz or at other countries 60Hz. The voltage which is generated (the output of the generator) is 11KV. After the station the lines which transfer the generated voltage to the costumers at expected value. These can be done in some rules. If the voltage transfers as it is generated up to costumers. There will be voltage drop and looses. So voltage is stepped up. When the voltage is stepped up, current will decrease. That is why the voltage is increased. This is done as it is depending on ohm's law. Actually these mean low current. Used cables will become thin. This will be economic and it will be easy to install transmission lines. If we cannot do this, we will have to use thicker cable.

To transfer the generated voltage these steps will be done. Generated voltage (11KV) is applied to the step-up transformer to have 66KV. This voltage is carried up to a sub-station. In this sub-station the voltage will be stepped-down again to 11KV. At the end the voltage stepped-down to 415V that is used by costumers. As a result the value of the voltage has to be at definite value. These;

a-) line to line – 380 V

b-) line to neutral – 220V

c-) line to earth – 0V

d-) earth to neutral – 0V

2.1 Electricity Generation

Electricity generation is the first process in the delivery of electricity to consumers. The other processes are electric power transmission and electricity distribution which are normally carried out by the Electrical power industry.

Centralized power generation became possible when it was recognized that alternating current electric power lines can transport electricity at low costs across great distances by taking advantage of the ability to transform the voltage using power transformers.

Electricity has been generated for the purpose of powering human technologies for at least 120 years from various sources of energy. The first power plants were run on wood, while today we rely mainly on coal, nuclear, natural gas, hydroelectric, and petroleum power and a small amount from solar energy, tidal harnesses, wind generators, and geothermal sources.

Electricity demand

The demand for electricity can be met in two different ways. The primary method thus far has been for public or private utilities to construct large scale centralized projects to generate and transmit the electricity required to fuel economies. Many of these projects have caused unpleasant environmental effects such as air or radiation pollution and the flooding of large areas of land.

Distributed generation creates power on a smaller scale at locations throughout the electricity network. Often these sites generate electricity as a byproduct of other industrial processes such as using gas from landfills to drive turbines.

2.2 Methods of Generating Electricity

2.2.1. Turbines

Rotating turbines attached to electrical generators produce most commercially available electricity. Turbines are driven by a fluid which acts as an intermediate energy carrier. The fluids typically used are:

steam - Water is boiled by nuclear fission or the burning of fossil fuels (coal, natural gas, or petroleum). Some newer plants use the sun as the heat source: solar parabolic troughs and solar power towers concentrate sunlight to heat a heat transfer fluid, which is then used to produce steam.

water - Turbine blades are acted upon by flowing water, produced by hydroelectric dams or tidal forces,

wind - Most wind turbines generate electricity from naturally occurring wind. Solar updraft towers use wind that is artificially produced inside the chimney by heating it with sunlight.

hot gases - Turbines are driven directly by gases produced by the combustion of natural gas or oil.

Combined cycle gas turbine plants are driven by both steam and gas. They generate power by burning natural gas in a gas turbine and use residual heat to generate additional electricity from steam. These plants offer efficiencies of up to 60%.

2.2.2. Reciprocating engines

Small electricity generators are often powered by reciprocating engines burning diesel, biogas or natural gas. Diesel engines are often used for back up generation, usually at low voltages. Biogas is often combusted where it is produced, such as a landfill or wastewater treatment plant, with a reciprocating engine or a microturbine, which is a small gas turbine.

2.2.3. Photovoltaic panels

Unlike the solar heat concentrators mentioned above, photovoltaic panels convert sunlight directly to electricity. Although sunlight is free and abundant, solar electricity is still usually somewhat more expensive to produce than large-scale mechanically generated power due to the cost of the panels. Low-efficiency silicon solar cells have been decreasing in cost though, and multijunction cells with close to 30% conversion efficiency are now commercially available. Over 40% efficiency has been demonstrated in experimental systems.[3], (Until recently, photovoltaics were most commonly used in remote sites where there is no access to a commercial power grid, or as a supplemental electricity source for individual homes and businesses. Recent advances in manufacturing efficiency and photovoltaic technology, combined with subsidies driven by environmental concerns, have dramatically accelerated the deployment of solar panels. Installed solar capacity is growing by 30% per year in several regions including Germany, Japan, California and New Jersey.

2.2.4. Other generation methods

Various other technologies have been studied and developed for power generation. Solid-state generation (without moving parts) is of particular interest in portable applications. This area is largely dominated by thermoelectric (TE) devices, though thermionic (TI) and thermophotovoltaic (TPV) systems have been developed as well. Typically, TE devices are used at lower temperatures than TI and TPV systems. Piezoelectric devices are used for power generation from mechanical strain, particularly in power harvesting. Betavoltaics are another type of solid-state power generator which produces electricity from radioactive decay.

Fluid-based magnetohydrodynamic (MHD) power generation has been studied as a method for extracting electrical power from nuclear reactors and also from more conventional fuel combustion systems.

Electrochemical electricity generation is also important in portable and mobile applications. Currently, most electrochemical power comes from closed electrochemical cells ("batteries") [4], which are arguably utilized more as storage systems than generation systems, but open electrochemical systems, known as fuel cells, have been undergoing a great deal of research and development in the last few years. Fuel cells can be used to extract power either from natural fuels or from synthesized fuels (mainly electrolytic hydrogen) and so can be viewed as either generation systems or storage systems depending on their use.

2.3. AC Power Transmission

AC power transmission is the transmission of electric power by alternating current. Usually transmission lines use three phase AC current. In electric railways, single phase AC current is sometimes used in a railway electrification system. In urban areas, trains may be powered by DC at 600 volts or so.

Today, transmission-level voltages are usually considered to be 110 kV and above. Lower voltages such as 66 kV and 33 kV are usually considered sub-transmission voltages but are occasionally used on long lines with light loads. Voltages less than 33 kV are usually used for distribution. Voltages above 230 kV are considered extra high voltage and require different designs compared to equipment used at lower

voltages. Overhead transmission lines are uninsulated wire, so design of these lines requires minimum clearances to be observed to maintain safety.

2.4. Losses

Transmitting electricity at high voltage reduces the fraction of energy lost to Joule heating. For a given amount of power, a higher voltage reduces the current and thus the resistive losses in the conductor. Long distance transmission is typically done with overhead lines at voltages of 110 to 1200 kV. However, at extremely high voltages, more than 2000 kV between conductor and ground, corona discharge losses are so large that they can offset the lower resistance loss in the line conductors.

Transmission and distribution losses in the USA were estimated at 7.2% in 1995 [2], and in the UK at 7.4% in 1998. [3]

In an alternating current transmission line, the inductance and capacitance of the line conductors can be significant. The currents that flow in these components of transmission line impedance constitute reactive power, which transmits no energy to the load. Reactive current flow causes extra losses in the transmission circuit. The ratio of real power (transmitted to the load) to apparent power is the power factor. As reactive current increases, the reactive power increases and the power factor decreases. For systems with low power factors, losses are higher than for systems with high power factors. Utilities add capacitor banks and other components throughout the system — such as phase-shifting transformers, static VAR compensators, and flexible AC transmission systems (FACTS) — to control reactive power flow for reduction of losses and stabilization of system voltage.

Electrical power is always partially lost by transmission. This applies to short distances such as between components on a printed circuit board as well as to cross country high voltage lines. Power lost is proportional to the resistance of the wire and the square of the current.

For a system which delivers a certain amount of power, P, over a particular voltage, V, the current flowing through the cables is given by $I = \frac{P}{V}$. Thus, the power lost in the lines, $P_{loss} = RI^2 = R(\frac{P}{V})^2 = \frac{RP^2}{V^2}$.

Therefore, the power lost is proportional to the resistance and inversely proportional to the square of the voltage. A higher transmission voltage reduces the current and thus the power lost during transmission.

CHAPTER 3: PROTECTION

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

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

3.1. Reasons For Protection

3.1.1. Mechanical Damage

Mechanical damage is the term used to describe the physical harm sustains by various parts of electrical sets. Generally by impact hitting cable with a hammer by obrasing. Cables sheath being rubbed against wall corner or by collision (e.g. sharp object falling to cut a cable prevent damage of cable sheath conduits, ducts tranking and casing)

3.1.2. 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)

3.1.3. Corrosion:

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

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

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.

3.1.4. 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 the short-circuit. Short circuit is a direct contact between live conductors

a-) Neutral conductor. (Fuse)

b-) Earthed metal work (Operators)

3.2. Protectors of over current

a-) Fuses

b-) Circuit Breakers

3.2.1. 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-) Rewire able

b-) Cartridge

c-)HBC (High Breaking Capacity)

3.2.1. 1. Rewire able Fuse:

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

Table 3.1. 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.

3.2.1.2. 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 rewire able fuse of not deteriorating, of accuracy in breaking at rated values and of not arcing when interrupting faults. They are however, expensive to replace.

3.2.1.3. 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.

3.2.2. 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 of its rated normal current, the circuit-breaker can make and break a circuit, particularly in abnormal conditions such as the occasion of a short-circuit in an installation. It thus disconnects automatically a faulty circuit.

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

following. (a) The normal current it will have to carry and (b) the amount of current which the supply will feed into the circuit fault, which current the circuit-breaker will have to interrupt without damage to itself.

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

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

In certain circumstances, circuit breakers must be used with 'back-up' protection, which 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 rewire able 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.

3.3. Values of fuses;

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

3.4. 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.

3.5. 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 in case 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 4: INSULATORS

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 E - Polyvinyl acetyl resin. Class H - Silicon-glass.

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

4.1. Rubber

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

4.2. 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.

4.3. Paper

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.

4.4. Glass

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.

4.5. Mica

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.

4.6. Ceramics

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.

4.7. Bakelite

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.

4.8. 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.

4.9. Epoxide Resin

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

4.10. Textiles

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.

4.11. Gases

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.

4.12. Liquids

Mineral oil is the most common insulant 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 fibers 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 5: 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 earthing 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.

5.1. Earthing Terms

5.1.1 Earth

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

5.1.2 Earth Electrode

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

5.1.3 Earthing Lead

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

5.1.4 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.

5.2 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.

5.2.1. 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. 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.

5.2.2. 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).

5.2.3. Earthing practice

5.2.3.1. 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 100^0C and results in the complete failure of the electrode.

The current density of the electrode is found by:

Current density = I / A = $92 \times 10^3 / \sqrt{t}$

Where I = short-circuit fault current, A = area (in cm2), t = time in seconds (duration of the fault current).

The formula assumes a temperature rise of 120^0C, over an ambient temperature of 25^0C, 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. Because 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 aluminium 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.

5.3. 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.

5.4. 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.

5.5. 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.

5.5.1. 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.

5.5.2. 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 aluminium, the maximum value is one ohm.

5.5.3. 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 aluminium).

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.

5.5.4. 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'.

5.5.5. 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 5.1 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: **Resistance = Voltage / Current**

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 do 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.

5.5.6. 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.

5.5.7. 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 6: CABLES

6.1. Types of Cables:

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

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.

6.1.1. Single-core.

These are natural or tinned copper wires. The insulating materials include butyl - rubber, 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 rather than for use as single conductors in conduit or trunking wiring systems. But that are available from the cable manufacturers for specific insulation requirements. Sizes vary 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 are those used for single-core cables. The circular cables require cotton filler threads to gain 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 course, they carry three cores.

6.1.4. Composite cables.

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

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

6.1.5. Wiring cables

Switchboard wiring; domestic at workshop flexible cables and cords. Mainly copper conductors.

6.1.6. Power cables

Heavy cables, generally lead sheathed and armored; control cables for electrical equipment. Both copper and aluminum conductors.

Mining cables

In this field cables are used for trailing cables to supply equipment; shot-firing cables; roadway lighting; lift -shaft wiring; signaling, telephone and control cables. Adequate 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-sheathed. Cables must comply with Lloyd's Rules and Regulations, and with Admiralty requirements.

6.1.8. Overhead cables

Bare, lightly-insulated and insulated conductors of copper, copper-cadmium and aluminum generally. Sometimes with steel core for added strength. For overhead distribution cables are PVC and in most cases comply with British Telecom requirements.

6.1.9. Communication cables

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

6.1.10. Welding cables

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

6.1.11. Electric-sign cables

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

6.1.12. Equipment wires

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

6.1.13. Appliance-wiring cables

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

6.1.14. Heating cables

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

6.1.15. Flexible cords

A flexible cord is defined as a flexible cable in which the csa of each conductor does not exceed 4 mm squared. The most common types of flexible cords are used in domestic and light industrial work. The diameter of each strand or wire varies from 0.21 to 0.31 mm. Flexible cord come in many sizes and types; for convenience they are groups as follows:

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

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

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

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

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

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

NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

ELECTRICAL INSTALLATION PROJECT FOR APARTMENT AND BUSSINESS CENTER

Graduation Project
EE-400

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ABSTRACT

In life nearly all equipments requires electrical energy for their operation. Therefore, in order to satisfy this requirements electrical installation should be well designed and applied with professionally knowledge. This emphasizes the impotance of the electrical engineers.

My project is about electrical installation of an apartment and bussiness center, and this project needs well knowledge about electrical installation and also researcing the present systems.

This project consists the installation of lighting circuits, the installation of sockets, illumination, loudspeaker, tv and telephone systems. For all of these, there are some regulations that has to be applied.All projects are drawn in AutoCAD 2007.

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INTRODUCTION

Drawing electrical installation projects is one of the most important aspect of electrical engineering. All of the drawings should be based on the principles of the IEE standards and T.R.N.C. standards and also has to include the regulations. Before starting the drawing all of the details has to be considered and applied very carefully

The first chapter introduces with some brief information about the historical development of electricity, changes in the life, industrial attacts and historical review of wiring installations.

Chapter two presents the generation transmission distribution from the power station step by step until it reaches to the costumer use.

Chapter three gives information about the protection. Why we use protection, what is the protection methods, faults that may occur, risks,corrosion and leakages.

Chapter four presents the insulators which is used in all types of installations including high voltage transmission.

Chapter five is concerned on the most impotant aspect of elctrical installation which is the earthing process. It gives information about the earthhing terms, systems, important points, electric shock and testing the earthing system.

Chapter six is devoted to the types of cables, and how to identify cables.

Chapter seven gives information about some special installations that is applied to the buildings such like suond, TV, telephone, etc.

Chapter eight is about illumination of buildings

The appendix is found illumination calculation.

The conclusion presents important results obtained by the author and the important points that has to be considered in engineering life.

CHAPTER 1: GENERALS

1.1 Historical Review of Installation Work

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 bean regarded as a time when industrialists awakened to the potential of the new form of power.

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. 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.

Electrical installations in the early days were quite primitive and often dangerous. It is on record that in 1881, the installation in Hatfield House was carried out by an aristocratic amateur. That the installation was dangerous did not perturb visitors to the house who'... when the naked wires on the gallery ceiling broke into flame... nonchalantly threw up cushions to put out the fire and then went on with their conversation'...

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.

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.

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. 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.

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.

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. 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, aluminium was looked to for a sheath of, in particular, light weight. Many experiments were carried out before a reliable system of aluminium-sheathed cable could be put on the market.

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 aluminium.

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.

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. Aluminium 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.

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. 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.

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 many 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.

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 H'. 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.

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.

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).

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.

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.

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 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'.

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.

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.

CHAPTER 2: GENERATION AND TRANSMISSION

The generation of electric is to convert the mechanical energy into the electrical energy. Mechanical energy mean that motors which makes the turbine turn.

Electrical energy must be at definite value. And also frequency must be 50Hz or at other countries 60Hz. The voltage which is generated (the output of the generator) is 11KV. After the station the lines which transfer the generated voltage to the costumers at expected value. These can be done in some rules. If the voltage transfers as it is generated up to costumers. There will be voltage drop and looses. So voltage is stepped up. When the voltage is stepped up, current will decrease. That is why the voltage is increased. This is done as it is depending on ohm's law. Actually these mean low current. Used cables will become thin. This will be economic and it will be easy to install transmission lines. If we cannot do this, we will have to use thicker cable.

To transfer the generated voltage these steps will be done. Generated voltage (11KV) is applied to the step-up transformer to have 66KV. This voltage is carried up to a sub-station. In this sub-station the voltage will be stepped-down again to 11KV. At the end the voltage stepped-down to 415V that is used by costumers. As a result the value of the voltage has to be at definite value. These;

a-) line to line – 380 V

b-) line to neutral – 220V

c-) line to earth – 0V

d-) earth to neutral – 0V

2.1 Electricity Generation

Electricity generation is the first process in the delivery of electricity to consumers. The other processes are electric power transmission and electricity distribution which are normally carried out by the Electrical power industry.

Centralized power generation became possible when it was recognized that alternating current electric power lines can transport electricity at low costs across great distances by taking advantage of the ability to transform the voltage using power transformers.

Electricity has been generated for the purpose of powering human technologies for at least 120 years from various sources of energy. The first power plants were run on wood, while today we rely mainly on coal, nuclear, natural gas, hydroelectric, and petroleum power and a small amount from solar energy, tidal harnesses, wind generators, and geothermal sources.

Electricity demand

The demand for electricity can be met in two different ways. The primary method thus far has been for public or private utilities to construct large scale centralized projects to generate and transmit the electricity required to fuel economies. Many of these projects have caused unpleasant environmental effects such as air or radiation pollution and the flooding of large areas of land.

Distributed generation creates power on a smaller scale at locations throughout the electricity network. Often these sites generate electricity as a byproduct of other industrial processes such as using gas from landfills to drive turbines.

2.2 Methods of Generating Electricity

2.2.1. Turbines

Rotating turbines attached to electrical generators produce most commercially available electricity. Turbines are driven by a fluid which acts as an intermediate energy carrier. The fluids typically used are:

steam - Water is boiled by nuclear fission or the burning of fossil fuels (coal, natural gas, or petroleum). Some newer plants use the sun as the heat source: solar parabolic troughs and solar power towers concentrate sunlight to heat a heat transfer fluid, which is then used to produce steam.

water - Turbine blades are acted upon by flowing water, produced by hydroelectric dams or tidal forces,

wind - Most wind turbines generate electricity from naturally occurring wind. Solar updraft towers use wind that is artificially produced inside the chimney by heating it with sunlight.

hot gases - Turbines are driven directly by gases produced by the combustion of natural gas or oil.

Combined cycle gas turbine plants are driven by both steam and gas. They generate power by burning natural gas in a gas turbine and use residual heat to generate additional electricity from steam. These plants offer efficiencies of up to 60%.

2.2.2. Reciprocating engines

Small electricity generators are often powered by reciprocating engines burning diesel, biogas or natural gas. Diesel engines are often used for back up generation, usually at low voltages. Biogas is often combusted where it is produced, such as a landfill or wastewater treatment plant, with a reciprocating engine or a microturbine, which is a small gas turbine.

2.2.3. Photovoltaic panels

Unlike the solar heat concentrators mentioned above, photovoltaic panels convert sunlight directly to electricity. Although sunlight is free and abundant, solar electricity is still usually somewhat more expensive to produce than large-scale mechanically generated power due to the cost of the panels. Low-efficiency silicon solar cells have been decreasing in cost though, and multijunction cells with close to 30% conversion efficiency are now commercially available. Over 40% efficiency has been demonstrated in experimental systems.[3], (Until recently, photovoltaics were most commonly used in remote sites where there is no access to a commercial power grid, or as a supplemental electricity source for individual homes and businesses. Recent advances in manufacturing efficiency and photovoltaic technology, combined with subsidies driven by environmental concerns, have dramatically accelerated the deployment of solar panels. Installed solar capacity is growing by 30% per year in several regions including Germany, Japan, California and New Jersey.

2.2.4. Other generation methods

Various other technologies have been studied and developed for power generation. Solid-state generation (without moving parts) is of particular interest in portable applications. This area is largely dominated by thermoelectric (TE) devices, though thermionic (TI) and thermophotovoltaic (TPV) systems have been developed as well. Typically, TE devices are used at lower temperatures than TI and TPV systems. Piezoelectric devices are used for power generation from mechanical strain, particularly in power harvesting. Betavoltaics are another type of solid-state power generator which produces electricity from radioactive decay.

Fluid-based magnetohydrodynamic (MHD) power generation has been studied as a method for extracting electrical power from nuclear reactors and also from more conventional fuel combustion systems.

Electrochemical electricity generation is also important in portable and mobile applications. Currently, most electrochemical power comes from closed electrochemical cells ("batteries") [4], which are arguably utilized more as storage systems than generation systems, but open electrochemical systems, known as fuel cells, have been undergoing a great deal of research and development in the last few years. Fuel cells can be used to extract power either from natural fuels or from synthesized fuels (mainly electrolytic hydrogen) and so can be viewed as either generation systems or storage systems depending on their use.

2.3. AC Power Transmission

AC power transmission is the transmission of electric power by alternating current. Usually transmission lines use three phase AC current. In electric railways, single phase AC current is sometimes used in a railway electrification system. In urban areas, trains may be powered by DC at 600 volts or so.

Today, transmission-level voltages are usually considered to be 110 kV and above. Lower voltages such as 66 kV and 33 kV are usually considered sub-transmission voltages but are occasionally used on long lines with light loads. Voltages less than 33 kV are usually used for distribution. Voltages above 230 kV are considered extra high voltage and require different designs compared to equipment used at lower

voltages. Overhead transmission lines are uninsulated wire, so design of these lines requires minimum clearances to be observed to maintain safety.

2.4. Losses

Transmitting electricity at high voltage reduces the fraction of energy lost to Joule heating. For a given amount of power, a higher voltage reduces the current and thus the resistive losses in the conductor. Long distance transmission is typically done with overhead lines at voltages of 110 to 1200 kV. However, at extremely high voltages, more than 2000 kV between conductor and ground, corona discharge losses are so large that they can offset the lower resistance loss in the line conductors.

Transmission and distribution losses in the USA were estimated at 7.2% in 1995 [2], and in the UK at 7.4% in 1998. [3]

In an alternating current transmission line, the inductance and capacitance of the line conductors can be significant. The currents that flow in these components of transmission line impedance constitute reactive power, which transmits no energy to the load. Reactive current flow causes extra losses in the transmission circuit. The ratio of real power (transmitted to the load) to apparent power is the power factor. As reactive current increases, the reactive power increases and the power factor decreases. For systems with low power factors, losses are higher than for systems with high power factors. Utilities add capacitor banks and other components throughout the system — such as phase-shifting transformers, static VAR compensators, and flexible AC transmission systems (FACTS) — to control reactive power flow for reduction of losses and stabilization of system voltage.

Electrical power is always partially lost by transmission. This applies to short distances such as between components on a printed circuit board as well as to cross country high voltage lines. Power lost is proportional to the resistance of the wire and the square of the current.

For a system which delivers a certain amount of power, P, over a particular voltage, V, the current flowing through the cables is given by $I = \frac{P}{V}$. Thus, the power lost in the lines, $P_{loss} = RI^2 = R(\frac{P}{V})^2 = \frac{RP^2}{V^2}$.

Therefore, the power lost is proportional to the resistance and inversely proportional to the square of the voltage. A higher transmission voltage reduces the current and thus the power lost during transmission.

CHAPTER 3: PROTECTION

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

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

3.1. Reasons For Protection

3.1.1. Mechanical Damage

Mechanical damage is the term used to describe the physical harm sustains by various parts of electrical sets. Generally by impact hitting cable with a hammer by obrasing. Cables sheath being rubbed against wall corner or by collision (e.g. sharp object falling to cut a cable prevent damage of cable sheath conduits, ducts tranking and casing)

3.1.2. 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)

3.1.3. Corrosion:

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

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

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.

3.1.4. 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 the short-circuit. Short circuit is a direct contact between live conductors

a-) Neutral conductor. (Fuse)

b-) Earthed metal work (Operators)

3.2. Protectors of over current

a-) Fuses

b-) Circuit Breakers

3.2.1. 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-) Rewire able

b-) Cartridge

c-)HBC (High Breaking Capacity)

3.2.1. 1. Rewire able Fuse:

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

Table 3.1. 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.

3.2.1.2. 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 rewire able fuse of not deteriorating, of accuracy in breaking at rated values and of not arcing when interrupting faults. They are however, expensive to replace.

3.2.1.3. 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.

3.2.2. 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 of its rated normal current, the circuit-breaker can make and break a circuit, particularly in abnormal conditions such as the occasion of a short-circuit in an installation. It thus disconnects automatically a faulty circuit.

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

following. (a) The normal current it will have to carry and (b) the amount of current which the supply will feed into the circuit fault, which current the circuit-breaker will have to interrupt without damage to itself.

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

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

In certain circumstances, circuit breakers must be used with 'back-up' protection, which 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 rewire able 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.

3.3. Values of fuses;

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

3.4. 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.

3.5. 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 in case 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 4: INSULATORS

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 E - Polyvinyl acetyl resin. Class H - Silicon-glass.

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

4.1. Rubber

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

4.2. 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.

4.3. Paper

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.

4.4. Glass

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.

4.5. Mica

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.

4.6. Ceramics

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.

4.7. Bakelite

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.

4.8. 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.

4.9. Epoxide Resin

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

4.10. Textiles

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.

4.11. Gases

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.

4.12. Liquids

Mineral oil is the most common insulant 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 fibers 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 5: 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 earthing 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.

5.1. Earthing Terms

5.1.1 Earth

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

5.1.2 Earth Electrode

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

5.1.3 Earthing Lead

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

5.1.4 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.

5.2 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.

5.2.1. 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. 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.

5.2.2. 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).

5.2.3. Earthing practice

5.2.3.1. 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 100^0C and results in the complete failure of the electrode.

The current density of the electrode is found by:

Current density = I / A = $92 \times 10^3 / \sqrt{t}$

Where I = short-circuit fault current, A = area (in cm2), t = time in seconds (duration of the fault current).

The formula assumes a temperature rise of 120^0C, over an ambient temperature of 25^0C, 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. Because 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 aluminium 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.

5.3. 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.

5.4. 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.

5.5. 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.

5.5.1. 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.

5.5.2. 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 aluminium, the maximum value is one ohm.

5.5.3. 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 aluminium).

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.

5.5.4. 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'.

5.5.5. 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 5.1 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: **Resistance = Voltage / Current**

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 do 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.

5.5.6. 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.

5.5.7. 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 6: CABLES

6.1. Types of Cables:

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

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.

6.1.1. Single-core.

These are natural or tinned copper wires. The insulating materials include butyl - rubber, 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 rather than for use as single conductors in conduit or trunking wiring systems. But that are available from the cable manufacturers for specific insulation requirements. Sizes vary 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 are those used for single-core cables. The circular cables require cotton filler threads to gain 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 course, they carry three cores.

6.1.4. Composite cables.

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

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

6.1.5. Wiring cables

Switchboard wiring; domestic at workshop flexible cables and cords. Mainly copper conductors.

6.1.6. Power cables

Heavy cables, generally lead sheathed and armored; control cables for electrical equipment. Both copper and aluminum conductors.

Mining cables

In this field cables are used for trailing cables to supply equipment; shot-firing cables; roadway lighting; lift -shaft wiring; signaling, telephone and control cables. Adequate 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-sheathed. Cables must comply with Lloyd's Rules and Regulations, and with Admiralty requirements.

6.1.8. Overhead cables

Bare, lightly-insulated and insulated conductors of copper, copper-cadmium and aluminum generally. Sometimes with steel core for added strength. For overhead distribution cables are PVC and in most cases comply with British Telecom requirements.

6.1.9. Communication cables

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

6.1.10. Welding cables

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

6.1.11. Electric-sign cables

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

6.1.12. Equipment wires

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

6.1.13. Appliance-wiring cables

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

6.1.14. Heating cables

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

6.1.15. Flexible cords

A flexible cord is defined as a flexible cable in which the csa of each conductor does not exceed 4 mm squared. The most common types of flexible cords are used in domestic and light industrial work. The diameter of each strand or wire varies from 0.21 to 0.31 mm. Flexible cord come in many sizes and types; for convenience they are groups as follows:

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

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

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

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

v. Parallel twin: These are two stranded conductors laid together in parallel and insulated 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. Coaxial cables (antenna cable):

Antenna cables is a special cable which is used to transfer high frequency. This 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. This cables are very slim. Telephone cables are not same as electric cables. There are a lot of size 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/green.

In Turkey Standards;

Red	Phase
Black	Neutral
Green	Earth

We have some methods to identify the conductors.

1.Colouring of the conductor insulation

2.Printed numbers on the conductor

3.Colorued 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.

Table 6.2 Cable Sizes

Cable size
$0.75\ mm^2$
$1\ mm^2$
$1.5\ mm^2$
$2.5\ mm^2$
$4\ mm^2$
$6\ mm^2$
$10\ mm^2$
$16\ mm^2$
$25\ mm^2$

$35\ mm^2$
$50\ mm^2$
$70\ mm^2$
$95\ mm^2$
$120\ mm^2$
$150\ mm^2$
$185\ mm^2$
$240\ mm^2$
$300\ mm^2$
$400\ mm^2$
$500\ mm^2$

CHAPTER 7: SPECIAL INSTALLATIONS

Though the bulk of electrical installation work carried out in this country does not involve the consideration of special factors in the context of the wiring systems, accessories and the equipment to be used in an installation, there are some types of installation conditions which call for special consideration. These conditions create the need for what are called in this chapter 'special installations', which tend to fall out with the general run of installations and require their special and particular requirements to be satisfied. These special installations are dealt with in the IEE Regulations in a rather general way and the electrician must therefore consult other sources of information as to installation procedures, techniques, and recommended types of equipment. These sources include BS Codes of Practice and manufacturers' instructions, and IEE Regulations.

7.1 Damp Situations

In general terms a 'damp situation' is one in which moisture is either permanently present, or intermittently present to such an extent as to be likely to impair the effectiveness of an installation conforming to the requirements for ordinary situations. These situations create a hazard from electric shock (particularly from surface leakage over otherwise healthy insulation) and the risks, which attend a gradual deterioration of the metalwork of the installation as the result of corrosion.

The IEE Regulations require that every cable installed in a damp situation, and where it is exposed to rain, dripping water, condensed water, and accumulations of water, shall be of a type designed to withstand these conditions. In addition all metal sheaths and armor of cables, metal conduit, ducts or trunking, and clips and their fixings, shall be of corrosion-resisting material. In particular, they should not be placed in contact with other metals with which they are liable to set up electrolytic action. If steel conduit is involved in such damp installations, it must be of heavy gauge. Conduit threads should be painted over with a bituminous paint immediately after erection Cables, which are armored and destined for installation in a damp situation, are required to have further protection in the form of an overall PVC sheath.

Even though an installation is not classed as 'damp', there may occasionally arise a situation, which could place it in this category. This is one result of condensation, which, though it might occur intermittently, may well appear in the form of a considerable quantity of condensate. Condensation exists where there is a difference in temperature, for instance, where equipment is installed inside a room in which the ambient temperature is high, the equipment being controlled by switchgear outside the room in a lower ambient temperature. If the switchgear and the equipment are connected by trunking or conduit, then condensation is likely to occur. It will also occur where a room has a high ambient temperature during the day and where the temperature subsequently falls when the room is unoccupied during the night.

Generally, whenever dampness, whatever its source, is present, galvanized or sherardised metalwork is recommended. In addition, site conditions may be such that fixing accessories and materials may also he required to withstand any corrosive action that might occur. If conduit is used, drip points should be provided so that water can drip away. Long runs of conduit should be slightly off level to allow any accumulated condensate to run to a drain point at the lowest level.

The problem of condensation occurs frequently in cold-store installations and around refrigeration plant. Switchgear and other control equipment should be installed outside the cold rooms in a position some reasonable distance away from blasts of cold air and clear of door openings where changes in temperature are likely to occur. Cables of the MICS and lead-sheathed types should be glanced into totally enclosed lighting fittings and run into the cold chambers on wood battens. Cable entries into cold rooms should be sealed with some bituminous material. It is important to recognize that working PVC cables in low temperatures will injure the cables. At temperatures below $0^{\circ}C$, PVC has a 'cold-shatter' characteristic and may crack if hit sharply. There is also a warning note regarding the use of cables with bituminous-compounded beddings or servings.

7.2 Corrosion

Wherever metal is used there is the attendant problem of corrosion. Two conditions are necessary for corrosion: a susceptible metal and a corrosive environment. Nearly all of the common metals in use today corrode under most natural conditions; the bulk of all anti-corrosive measures have thus been attempts either to isolate the metal from its environment, or to changing the environment chemically to render it less corrosive In installation work, the problems of corrosion tend to be more acute in certain types of installation. Chemical works, salt works, cow byres and other ammonia-affected areas, all require special consideration in their design and the work executed to produce the installation. Corrosion, in a normal installation condition, may affect earth connections.

The corrosion of metals in contact with soil or water is an electrochemical reaction; that is, the corrosion reaction involves both the chemical change (e.g., from iron to rust) and a flow of electric current. It is this principle, which is used in the dry cell, where the corrosion of the zinc case provides the cell's electrical output. The current flows from the metal into the soil or water (called the electrolyte) at the anode and then from the electrolyte into the metal at the cathode. Corrosion occurs at the point where the current flows from tile metal into tile electrolyte. Every metal develops its own particular electrode potential when placed in an electrolyte or similar medium. If two different metals are coupled together in the same electrolyte, tile difference between their potentials will be sufficient to produce a current of electricity. The metal with the more negative potential will suffer corrosion. It follows that the more compatible the metals are, the less will be the rate of progress of any corrosive action which takes place between them, because the amount of potential difference between them is reduced.

In general there is a 'natural' potential of -0.3 to - 0.6 V between a buried mass of metal and its surrounding soil. This potential is measured by using a very-high-resistance voltmeter and a device called a half-cell, which consists of a copper rod immersed in saturated copper sulphate solution contained in a plastic tube which has a porous plug at the bottom for making contact with the soil as near as possible to the buried mass. Certain areas of the mass surface will act as anodes (where the current leaves the metal) and these will corrode. The areas, which act as cathodes (where the current enters the metal) do not corrode. This sub-division in the areas of the surface of the buried mass is due to the fact that the areas assume the roles of anodes and cathodes depending upon variations in the metal itself, its surface treatment, and the electrolyte.

Reducing the amount of current that flows from it into the surrounding medium or electrolyte can diminish the corrosion of a metal. Painting or otherwise coating the metal will increase the electrical resistance of both anodes and cathodes. But if the coating has flaws or holes in it, then the current concentrates at these points and deep pitting will occur. The corrosion current can also be reduced by lowering the electrical potential difference between the anodes and the cathodes either by controlling the purity of the electrolyte or by adding inhibitors to it.

Because only the anodes corrode, current flowing into them from an introduced external anode so as to cause the whole of the buried structure to become a cathode can prevent corrosion. This is the principle of cathodic protection. The method can be used only where the introduced anode can be accommodated within the electrolyte that surrounds the buried metal, and the soil or water must be present in bulk.

The method is widely employed as a corrosion preventive measure on underground metalwork. Two basic techniques are used to give cathodic protection: (i) the sacrificial anode system; (ii) the impressed current system.

In the first method , a mass of base metal, such as magnesium, is buried in the electrolyte and connected electrically to the structure to be protected. The natural difference in potential between the structure metal, usually steel, and the magnesium causes a current to flow from the magnesium (the new anode) through the electrolyte to the steel, which is the new cathode. The anode gradually corrodes and is thus called a 'sacrificial anode'. In practice a closely controlled magnesium-alloy is used. The main factors which govern the degree of protection, and the current output from the galvanic cell so formed by the protective system, are the surface area, volume and shape of the anodes used, the resistivity of the electrolyte and the surface area of the exposed metal being protected. The sacrificial anode system is common in congested areas since the low potentials generated by the galvanic system virtually eliminate the possibility of corrosion arising on adjacent metal structures on account of stray current. The system also needs no external electrical supply and is to a great extent self regulating in output, which latter will vary according to the resistivity of the surrounding medium (e.g., in wet or dry weather conditions). The anodes need periodical renewal. In reasonable soil conditions, the life of an anode may be up to 15 years.

The second method of protection, the impressed-current system, uses a conventionally generated direct current from rotating machinery or via a transformer/rectifier unit. The negative side of the supply is connected to the structure to be protected; the positive side is fed to an 'anode ground-bed' usually formed from high-quality graphite impregnated by resin, wax or linseed oil, silicon iron or scrap iron or steel. The buried structure then becomes the cathode. The anode may, but need not, corrode. Silicon-iron and graphite anode ground-beds are semi-inert and have a very long life. Scrap iron or scrap steel beds go into solution quite rapidly and disintegrate at the rate of about 10 kg/Ampere/year.

The metalwork associated with electrical installations, which may require cathodic protection include supporting lattice structures, armoured cables with rotted servings, metal pipes containing cables, and general structural steelwork.

Another aspect of corrosion may not be too familiar to installation installers. This concerns the continuous exposure of PVC-insulated cables to temperatures above 115°C that may cause the formation of corrosive products, which can attack conductors and other metalwork. Generally, the precautions to prevent the occurrence of corrosion in normal installations include:

1. The prevention of contact between two dissimilar metals (e.g. copper and aluminium), particularly where dampness is likely to be present.

2. The protection of cables, wiring Systems and equipment against the corrosive action of water, oil, and dampness, unless they are designed to withstand these conditions.

3. The protection of metal sheaths of cables and metal-conduit fittings where they come into contact with lime, plaster, cement and certain hardwoods such as beech and oak.

4. The use of bituminous paints and PVC over sheathing on metallic surfaces liable to corrosion in service.

7.3. Sound Distribution Systems

Sound-distribution Systems consist essentially of loudspeakers permanently installed in suitable positions in buildings or in open spaces associated with buildings - They are essentially part of the telecommunications Systems of buildings. The currents, which operate such systems, are derived from a microphone, gramophone, radio receiver, or other device, or from a wire broadcasting service. These currents are of a very small order and so require to be amplified to values suitable for the operation of loudspeakers. Sound-distribution systems are found in schools, theatres and cinemas, churches, meeting halls, factories, offices and department stores, hotels and clubs, hospitals, railway stations and sports grounds. Though these systems generally operate from mains supplies, some systems, or parts thereof, operate from batteries or from mains-supplied rectified current, producing low voltages.

7.4. Personnel call Systems

These systems are used in private dwellings, hotels, schools, factories, and other premises where it is required to attract the attention of individuals to a situation or circumstance. The simplest system is where a caller calls a person to a particular position. In a private house, the householder is called to the door. A bell push or similar device is fitted at each such position and an indicator provided to show which push has been operated. A bell or buzzer is used to provide the sound, which will attract attention to the call. Bell pushes can be of the wall-mounted, table or pendant type; the contact points are of a metal, which gives long service without becoming pitted or corroded. If the bell push is to be installed outside, protection against the ingress of moisture must be provided.

Indicators are installed in a central position in the building. In large premises, such as hotels and factories, the indicator board is located in a room in which some person is always in attendance, e.g., kitchen or reception office. The use of lamps is necessary where the sound of bells must be either objectionable or useless, e.g., in hospitals at night or in noisy workshops. Hand-setting indicators should be mounted at a height convenient for access and visibility.

Multiple-call systems are used in very large hotels where the call points are too many to be indicated conveniently on a single indicator board or panel. Pushes are fitted at each call point, but the circuits are grouped to serve a corridor or floor. Each group gives the indication in a central service room. In these systems, arrangements must be made to have attendants on duty in corridors or floors to deal with the calls. Multiple-call systems use indicators, which have to be reset by the attendant.

Time-bell systems are common in schools and factories to indicate the beginning or end of a time or period (e.g., break, class change, etc.). These systems usually have one or two pushes or other switches connected in parallel and a number of bells throughout the building, which are also connected in parallel. The bells can be controlled from a clock system, to eliminate the human element required with bell pushes.

The burglar-alarm system is also a call system. The switches in this case are sets of contacts mounted at doors and windows. There are two circuit types; open-circuit and closed circuit. The first type requires contacts to close to energies the bell circuit. In the closed circuit type, all contacts are closed. A circulating current energizes a series relay with normally open contacts. When a contact set is opened, this current ceases to flow, de-energizes the relay, and closes the relay contacts to ring an alarm bell. Some alarm systems operate from photoelectric cells, which work when an invisible light beam is broken. The large plate-glass windows of jewelers' shops often have a series length of very thin wire, which, if broken when the window is smashed in or a hole cut in it, will bring the relay into operation to ring a bell. In certain systems today, no bell rings, but a buzzer and light indication circuit is wired from the protected building and terminated at a nearby police station. Thus the intruder is not warned, and the police have the opportunity of catching the burglar red-handed.

The open-circuit system is seldom used because it can be interfered with. For instance, a cut in a wire will render the complete system inoperative, whereas such a break in the series circuit of a circulating-current (closed-circuit) system will immediately set an alarm-bell ringing. Supplies are sometimes from the mains, but in this instance a standby-battery supply is provided in the event of a power failure. Alarm bells are often installed in a place inaccessible to unauthorized persons, and outside the building.

Another type of call alarm system is the watchman's supervisory service. It is designed to provide a recorded indication of the visits of watchmen or guards to different pans of a building in the course of the duty round. The system uses a clock movement of the impulse, synchronous-time controlled a.c. or 8-day clockwork type installed at each contact station throughout the building. Each station has a box with a bell push operated by the insertion of a special key. Operation of the contacts energizes an electromagnetic ally-operated marker which records the time of the visit on a paper marked off in hours. In some systems, an alarm is given after a predetermined time if the watchman fails to 'clock in' at any contact station.

Luminous call systems are used instead of bells. These Systems use color lights, which summon staff to fulfill a service duty. They are largely used in hospitals and hotels. When the bell push is pressed in any position in the building, a small lamp lights in a duty room to indicate the general area from which the call has come. Alternatively, a lamp outside the call room lights and remains so until an attendant extinguishes it by operating a reset push located just outside the room. Some systems incorporate a single-stroke bell. Call and indicating circuitry is also incorporated in lift systems.

7.5. Fire-Alarm Circuits

A fire-alarm is defined as 'an arrangement of call points, detectors, sounders and other equipment for the transmission and indication of alarm and supervisory signals, for the testing of circuits, and where required, for the operation of auxiliary services' Section 37(7) of the Factories Act of 1937 states: where in any factory… more than 20 persons are employed… effective provision shall be made for giving warning in case of fire, which shall be clearly audible throughout the building.

A fire-alarm system consists of a number of press-buttons or call-points, which operate bells, sirens, or hooters, generally known as 'sounders'. Manually operated call-points are effective only if there are persons present to give an alarm. But if protection from fire is required when the premises are unoccupied, as at night and during weekends or during holiday periods, then automatic call-points are necessary. On very large premises, additional circuitry is included in fire-alarm systems to give an indication of the location of the fire, so that firemen can go directly to the fire and allow staff to leave the building by safe routes which by-pass the fire area.

The closed-circuit type of system is used so that circuit failure or breakage will at once be indicated by an audible alarm. Manual call-points consist of a pair of contacts kept together by a thin sheet of glass, which, if broken, in the event of a fire, or maliciously, will cause the contacts to separate and, through a relay, energies a bell or alarm circuit. All call-points are required to be colored red. The method of operation (e.g., 'Fire Alarm: in case of fire, break glass') must be clearly indicated either on the point itself or on a label beside it.

Automatic call-points are known as 'detectors' and are heat-sensitive, which means that they are sensitive to a rise in the ambient temperature of a room. They come into operation at a predetermined temperature (e.g., 80°C).

There are two types of heat detector. The more common type is the 'point' detector, which, as its name suggests, is relatively small. The other type is the 'line' detector, which has a long continuous sensitive detecting element extending over a large area of ceiling. The sensing elements used in heat detectors include:

1. Metal strips, rods, wires or coils, which expand when heated.

2. Fusible alloys.

3. Conductors whose electrical resistance changes with a rise in the ambient temperature.

4. Hollow tubes containing a fluid, which expands on heating and applies the resultant pressure to a diaphragm.

5. Thermocouples.

Some detectors ate of the light-sensitive type: photoelectric cells which operate when a beam of light illuminating the cells is scattered and absorbed by smoke particles. Heat and smoke detectors are liable to give false alarms in certain conditions:

a) Heat detectors. False alarms may be caused by abnormal increases in temperature due to space heating equipment, industrial processes, and sunshine.

b) Smoke detectors. Smoke and other fumes, dusts, fibers may cause false alarms, and steam produced by normal processes and activities, or by passing road vehicles. Those detectors, which use a beam of light to illuminate a photoelectric cell, may also give false alarms if the beam is accidentally obstructed.

Automatic call-points are sometimes designed to give an alarm and also to bring into operation an auxiliary fire service, such as a sprinkler system. Other examples of such services are the closing of windows and the closing of the covers of tanks, which contain inflammable liquids.

Some means of giving an audible warning of fire is a statutory obligation in certain premises under the Offices, Shops, and Railway Premises Act, 1963. Normally for these premises, an automatic fire alarm system must also be capable of manual operation, but this may not be necessary if the fire risk is low.

In a large installation a visual indicator panel (enunciator board) sited in a position agreed with the local Fire Authority, is normally incorporated in the system. All circuits to which detectors are fitted are connected to it. Each circuit is connected to a separate enunciator, so that when a detector actuates, it indicates on the board the area in which the fire has occurred. The panels are also provided with test facilities, by means of which the circuits can be tested and certain faults indicated. With some systems, faults are indicated automatically.

Warning devices included bells, sirens, hooters, or whistles; they may be arranged to give either local or general alarms. In either case, the warning should sound continuously once a detector has operated, until the Fire Brigade arrives. An external audible warning device is recommended for mounting near to the visual indicating panel. The device should indicate which building is involved, this being particularly necessary for premises, which comprise several buildings. In hospitals, department stores and other places where a general internal alarm is not thought desirable, an alarm may be given at a manned central point only and warning passed by telephone or light signal to other parts of the premises.

The object of an automatic fire-alarm system is to call the fire brigade. The most effective and reliable means of satisfying this requirement is the provision of a signal, which is automatically transmitted to the local fire brigade, through a direct-line connection. The line can be continuously monitored so that an immediate alarm is given as soon as a fault develops; regular testing can be arranged.

Some methods use an auto-dialing unit at the protected premises, which connects alarm calls in the form of a pre-recorded message, either via the public '911' emergency call service to the appropriate fire-control room, or direct via the automatic telephone system to a pre-selected telephone number. This method is cheaper than the direct-line method, but is less reliable. It for some reason, connection to the appropriate fire-control point is not achieved at the first attempt, it is possible for an alarm call to be lost. Also, this system cannot be continuously monitored for faults because it is not permanently connected to the point where the alarm calls are received.

Recommendations on wiring and equipment used are set out in BS Code of Practice BS 5839, which also includes recommendations on suitable power supplies.

The following bibliography contains information on fire alarm systems:

Rules for Automatic Fire Alarms - Fire Offices' Committee

BS 3116 - Heat Sensitive Detectors for Automatic Fire Alarm Systems in Buildings Automatic Fire Detection and Alarm Systems -Fire Protection Association.

Fixed Fire Extinguishing Equipment in Buildings - Fire Protection Association.

The IEE Regulations recognize fire-alarm circuits as 'Category 3' circuits, in that fire-alarm circuits, for reasons of security, should be segregated from each other as well as completely separated from any other wiring. Mains-voltage circuits (Category 1) for sounders, battery-charging and other auxiliary circuits in a fire-alarm system should also be completely separated from other (Category 2) circuits in the same fire-alarm system. If Category 3 (fire-alarm) circuits are wired in MIC's cable, the cable may be laid in a common trunking or channel, but must not be drawn into a common duct or conduit.

7.6. Radio and TV

The erection of aerials for the reception of radio and TV broadcasts is usually undertaken by the specialist. In buildings, which consist of blocks of flats, communal pick-up services are provided, being fed from a communal pre-amplifier. This unit is installed as near as possible to the aerial site so that any interference picked up by the intervening feeder is reduced to a minimum. The contractor's interest in these Services is mainly confined to the provision of conduit or socket-outlet facilities. In a multi-point television installation, Up to twenty receiver points may be connected to one cable, which is looped through the socket-outlets.

7.7. Telephone Systems

These systems are either internal or are connected to the public telephone facilities. All installations, which have public connections, are subject to the supervision and approval of the telephone companies whose engineers normally undertake the final connecting-up. The electrical contractor is generally required to install conduit or trunking to facilitate the wiring of the building for telephone outlets. In large buildings a main switchboard is installed to receive incoming calls, which are then switched to the required extension phone. There are two types of private installations: PMBX (private manual branch exchange) and PABX (private automatic branch exchange).

In the PMBX system, each extension phone is wired to the main switchboard and connection is made by sockets called jacks. There are certain disadvantages associated with this system, which usually requires an additional internal phone system. In the PABX system, all incoming calls are terminated at the manual switchboard and are answered by the telephone operator. All extension to extension calls are set up automatically and direct out dialing on certain extensions is possible. All extension phones can call the operator who can identify the extension on a lamp-per-line basis. Direct access to the local Fire Brigade can be incorporated in the system, a special code being allocated for this purpose. A cordless switchboard (PMBX 4) is a more recent development of the PABX system. It has a switchboard with a translucent screen or lamp signaling. It enables the operator to supervise and connect all calls with full control given by a few levers and keys. When a call is transferred to an extension it disappears from the switchboard and is then under the full control of the extension; this is a feature not available with the older approved system known as PABX 3.

CHAPTER 8: ILLUMINATION CALCULATION

Illumanition calculation is performed in order to find the number of armatures necessory for rooms.

The dimensions of living room kitchen and bedroom have measured sepertally. [Lenght(a) wıth(b) height (h)]

Illumination calculation is done one by one for each part.

8.1 The Calculation of Internal Illumination

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)

$$\Phi_s = \Phi_{dir} + \Phi_{end}$$

Φ_{dir} 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

$$E_o = \Phi_o / S$$

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:

$$E_o = \Phi_o \eta / S = \Phi_o / S$$

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.

$$\eta = \eta_{ayg} - \eta_{oda}$$

$$\eta = \Phi_{ayg} / \Phi_o$$

η_{ayg} represents the efficiency of device

η_{oda} represents the efficiency of room

$$\eta = \Phi_s / \Phi_{ayg}$$

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 8.1. shows belowed in same situations that are used mostly;

Table 8.1. Illumination System

Illumination system	Direct Illumination (n_{ayg}=%70)		Semi-Direct Illimination (n_{ayg}=%80)		Mixed Illimination (n_{ayg}=%80)		Semi Indirect Illimination (n_{ayg}=%80)		Indirect Illimination (n_{ayg}=%70)	
	n(%)		n(%)		n(%)		n(%)		n(%)	
Room index (a/h)	A	B	A	B	A	B	A	B	A	B
0,5	13	9	9	5	12	7	11	6	9	5
0,7	19	13	13	7	16	10	15	8	12	6
1,0	25	19	17	10	21	13	19	12	15	8
1,5	35	30	24	15	27	17	25	16	20	11
2,0	40	36	29	19	32	21	29	19	23	14
2,5	44	40	33	23	35	24	32	22	26	16
3,0	47	43	36	26	38	26	35	24	28	18
4,0	51	47	41	30	43	30	39	28	32	20
5,0	54	50	45	34	46	33	42	30	34	22
7,0	57	53	51	39	51	37	46	34	36	24
10,0	59	55	57	40	55	40	51	37	38	26

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 ;

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

While preparing the table, only two efficiency about illumination devices

(η ayg = %70 and η ayg = %80) is taken.

If another illumination device that has the efficiency η' ayg is used (η' is an aygıt different from %70, %80 efficensy level) , the efficiency that is found from table is multiplied with a factor of η' 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: $\mathbf{E_O = \Phi_s / S = \eta\ \Phi_o / S}$

If the average illumination level of plane is given and total light flow that light sources give (Φ_0) is looked for ;

$$\mathbf{\Phi_o = E_o\ S / \eta}$$

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

Table 8.2. Illumination Units

NAME	SYMBOL	UNIT	EXPLANATION
Light flow	**Φ**	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 is given 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)
Illumination intensity	**E**	lux (lux)	It is the total light flow that comes to 1 m^2 area
flashing	**L**	cd/cm2	It is th elight indensity that comes from light sources or unit surfaces that the light sources lighten.

Table 8.3. Illumination Equation

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 surface (m)
	H	Height of the light source to the floor(m)
	h1	Height of the working surfaces to the flor (m)
	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, type of armature chosen, room index

Table8.5. 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 8.4. Typical Flows of Some Lamps

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

Table 8.6.Minimum Illumination Value Table

OFFICE

Architectural and Mechanic's projects	750
Decorative and sketch drawings	500
Accountancy	500
Typewriter	500
Manager Room	250
Conference Room	200
Waiting Room, Cantine	150
File Room, Archive	100

SCOOLS

Nursery School	100
Primary School Classes	200
Middle and High School Classes	250
Middle and High School Laboratory	300
Technic School Work Classes	250
Technic School Project Room	400
Corridor	150
Show Rooms	200

SHOP

Shopwindow	1000
Shop General	500
Office	250

OUTDOOR

Long Distance Main Roads	20
City Roads	15
City-Village Roads	10

HEALTH

Birth Room	250
Waiting Room	100
Private Patient Room	50
Operating Theatre	500-750
Laboratory	300
Rehabilitation	250
Sterilization	400
Dispensary	400
X-Ray	50
Corridor, Stairs, WC	50
Examination Room	250

OTHER

Small Piece Equipment Store	200
Large Piece Equipment Store	100
Work Room, Garage	250
Lubrication and Wash Room	250
Parking Area	50
Museum General	150
Museum (statue, plastic etc.)	400
Sewing Room	500
Sewing Control	750
Packaging	150

CINEMAS

trance, Foyer, Stairs	150-200
oon	100-150

THEATERS

Entrance, Foyer, Stairs	150-200
Saloon	50-100

CONCLUSION

For an electrical engineer the most important subject is drawing electrical installation projects. Because the engineer is imagining something that is not present and he or she has to think and apply in a very unusual and complex way. We choose 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 T.R.N.C. standards have been applied very carefully.

This project indicated us nearly all critical points of drawing an electrical installation project of a building like an apartment and business center.

REFERENCES

[1] Thompson F. G., *Electrical Installation and Workshop Technology*, Volume One, 5th ed., Longman Group U.K. Limited, 1992.

[2] Thompson F. G., *Electrical Installation and Workshop Technology*, Volume Two, 4th ed., Longman Group U.K. Ltd., 1992.

[3] Theraja B. L., *Electrical Technology in S.I. Systems of Units*, 22nd ed., Niraja Construction & Development Co. (P) Ltd., New Delhi, 1987.

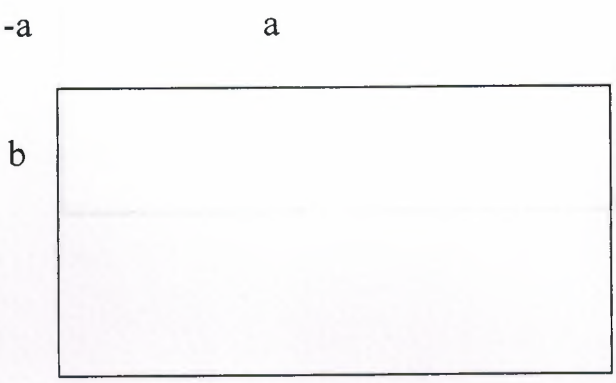
[4] Chamber of Electrical Engineers. Project Drawing Principles and Help Information's book5th ed. Nicosia, 2002

[5] http://www.wikipedia.com

APPENDIX

ILLUMINATION CALCULATION

for dükkan 1 and dükkan 1-a



$a = 7.3$ m

$b = 7.1$ m

$H = 3.5$ m

$E = 250$ lux from table

$d = 1.25$ from table

roof= 0.8

wall= 0.3

ground= 0.1

$h = H - h1 = 3.5 - 0.85 = 2.65$

$k = a.b / h(a+b)$

$k = (51.83) / (2.65)(14.4)$

$k = 1.36$

from table $\eta = 0.38$

$\Phi_T = E.A.d / \eta$

$\Phi_T = (250)(51.83)(1.25) / 0.38$

$\Phi_T = 42623.355$

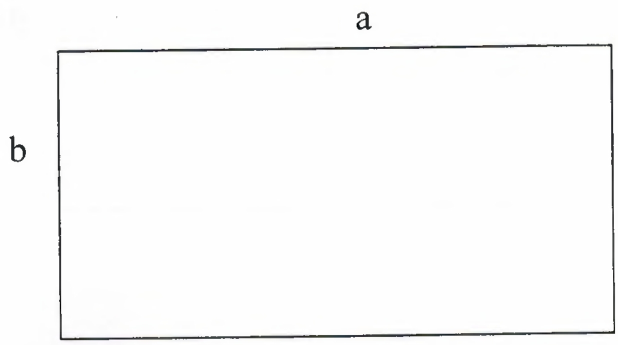
$n = \Phi_T / \Phi_L$

$n = 39504 / 11200$

$n = 3.81$

room needs 4 piece 2x65/80 W flourescent

for dükkan 2



a= 15 m

b= 7.1 m

H=3.5 m

E=250 lux from table

d= 1.25 from table

roof= 0.8

wall= 0.3

ground= 0.1

h=H- h1=3.5-0.85=2.65

k= a.b / h(a+b)

k= (106.5) / (2.65) (22.1)

k= 1.81

from table η= 0.41

Φ_T = E.A.d / η

Φ_T = (250) (106.5) (1.25) / 0.45

Φ_T = 81173.78

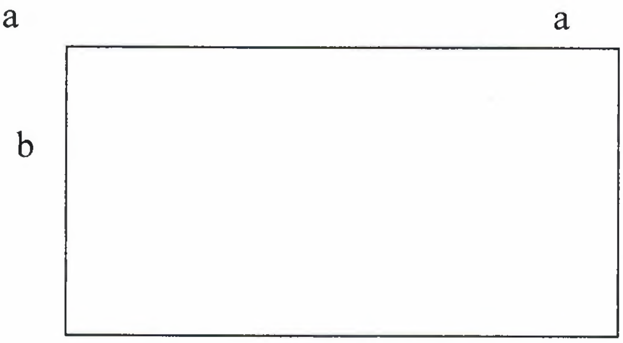
n= Φ_T / Φ_L

n= 81173.78/ 11200

n=7.25

room needs 8 piece 2x65/80 W flourescent

for right part of dükkan 2-a



a= 7.3 m

b= 7.1 m

H=3.5 m

E=250 lux from table

d= 1.25 from table

roof= 0.8

wall= 0.3

ground= 0.1

h=H- h1=3.5-0.85=2.65

k= a.b / h(a+b)

k= (51.83) / (2.65) (14.4)

k= 1.36

from table η= 0.38

$\Phi_T = E.A.d / \eta$

$\Phi_T = (250)(51.83)(1.25) / 0.38$

$\Phi_T = 42623.355$

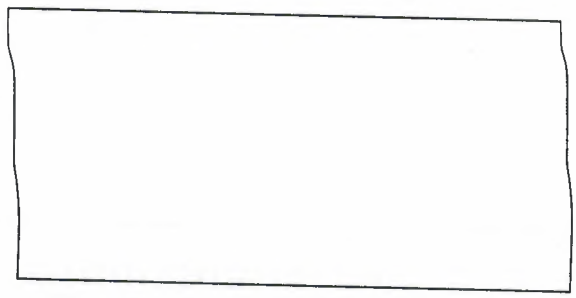
n= Φ_T / Φ_L

n= 42623.355/ 11200

n=3.81

room needs 4 piece 2x65/80 W flourescent

for left part of dükkan 2-a



a= 7.7 m

b= 3.8 m

H=3.5 m

E=250 lux from table

d= 1.25 from table

roof= 0.8

wall= 0.3

ground= 0.1

h=H- h1=3.5-0.85=2.65

k= a.b / h(a+b)

k= (29.26) / (2.65) (11.5)

k= 0.96

from table η= 0.33

$\Phi_T = E.A.d / \eta$

$\Phi_T = (250)(29.26)(1.25) / 0.33$

$\Phi_T = 27708$

$n = \Phi_T / \Phi_L$

n= 27708/ 11200

n=2.47

room needs 2 piece 2x65/80 W flourescent