NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

GRADUATION PROJECT

EE-400

Students: Şerafettin Çağlar (20040507)

Özgür Tüylü (20020097)

Supervisor: Assist.Prof.Dr. Özgür C. Özerdem

Nicosia - 2008

ACKNOWLEDGEMENT

To begin with, we would like to say thanks to Mr.ÖZGÜR ÖZERDEM, who was the supervisor of our project. When we asked him any question about installation or anything, he explained or questions patiently with his endless knowledge. And so when we will graduate we are sure he will help as again whenever we need help.

Also we want to say thanks to all of our teachers, who helped and thought as anything during our education. In addition to these, we also want to say thanks to our teachers in the faculty of engineering for giving us lectures with a good computational enviroment. Furthmore, of course we also want to say thanks to all of our class mates as well.

Finally we would like to say thanks to our parents who helped as to get this education. They always motivated as with there endless support, so thank you too much.

ABSTRACT

The electrical installation is one of the most impotant subject of an electrical engineering. According to this, the thesis is about an electrical installation of a factory.

The main objective of this thesis is to provide an electrical installation with AutoCAD. For this thesis AutoCAD is very important. Also, with the help of AutoCAD, you can easily draw the part of you installation project.

According to this thesis you can learn to use AutoCAD and also learn to make cost calculation and other calculations for electrical installation as well.

TABLE OF CONTENTS

INTRODUCTION

The thesis is about an electrical installation, electrical installation is very important for an engineering. So we decided to choose this subject, because we believed, it will help us in future carrier as well.In this thesis firstly we learned how we can design an electrical installation of the building. In addition to thesis, we also tried to provide an electrical installation with an AutoCAD. The thesis divide into three part .These are introduction, seven chapters and conclusion.

The first chapter is about historical review of installation work.

The second chapter is presents electrical materials. Electrical material is consist three mainly parts. One of them is insulators, conductors and cables.

Third chapter is about the electrical safety this is about electrical safety, protection and earthing.

Chapter four is circuit control devices, in this chapter consist circuit conditions contacts, switches and switch fuses, special switches.

Chapter five supply distribution and control, in this chapter consist overhead lines supply control and supply distribution.

Chapter six is about final circuits, this chapter consist installation planning circuit ratings, choosing cable sizes and lighting circuits, its about how can you make installation planning and where which type cable will used

Chapter seven is about practical application. This chapter is consist of calculations and how can prepare a project file, when will you brought for visa what you need for visa.

CHAPTER 1: HISTORICAL REVIEW

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 define practical future. Arc lamps were the first form of lighting, particularly for the elimination of main streets. When the incandescent-filament lamps, shop windows continued for some time to be lighted externally by arc 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. Dear 1900 has been regarded as a time when industrialist awakened to the potential of the new form of power.

Electricity was first use 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 process was operated by electric motor power for punching, shearing, drilling machines and would working machinery.

The first electric motor drivers 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 and speed by mechanical means.The development of integral electric drivers, with provisions for starting stopping and speed change, let to the extensive use of the motor in small kw ranges to drive and associated single machine, e.g. a late. One of the pioneers of the in the use of the motors was the film of Bruce pebbles, Edinburgh. The firm supplied, in the 1890s a number of weatherproof, totally enclosed motors for quarries in Dumfuries 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 installation in the early days were quiet 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 conversations. Many names of the early electric pioneers survive today. Julius sax begun to make electric bells in 1855, and later supplied the telephone with which Queen Victoria spoke between Osborne, in the isle Wight , and Southampton in 1878.He founded one of the earliest pearly electric manufacturing firms, which exist 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 Stadelmann & Co. Ltd begun by marketing improved designs of oil lamps , then Gas Fittings , and ultimately electric 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 still wires for the then fashionable crinolines. From this type of wire it was a natural step to the production of the insulated conductors for electrical purpose. 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) begun with making telegraphic equipment ,extended to generators and arc lamps, and then to power supply.

The coverings for the insulation provisions for cable were made when vulcanized rubber was introduced, and it is still used today. The first application of a lead sheath to rubber - insulated cables were made by Siemens Brothers. 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. Cable sizes were also generally known by the Standard Wire Gauge. For many years ordinary VRI cables made up about 95 percent of all installations. They were used first in wood casing, and then in conduit. wood casing was a very early invention. It was introduce to separate conductors, the 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 catalog alone, one could choose from 58 sizes of wire, with no less than 14 different grades of rubber insulation. The gades were describe 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 establish. One of the earliest makers was the company, which later becomes 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 cables. 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 effected 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.

At the time the lead-sheathed system made its first appearance, another rival wiring system also came onto the scene. This was the CTS system (cab-tire sheathed). It arouse out of the idea that if a rubber product could be used to stand up to the wear and tear of motor-car tires on roads, then the material would well be applied to cover cables. The CTS name eventually gave way to TRS (tough-rubber sheath) , when the rubber-sheathed cable system came into general use.

The main competitor to rubber as an insulating material appeared in the late 1930s. This material was PVC (polyvinyl chloride), a synthetic material which 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 experienced increased with the use of TRS cables, it was made the basis of modified wiring system. The first of these was the Calendar farm-wiring system introduced in 1937. This was though rubber sheathed cables with a semi-embedded braiding treated with a green-colored compound. This system combined the properties of ordinary TRS and HSOS (house-service over headed 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 large commercial scales since about 1980s. Over head lines of aluminum were first installed in 1878. 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 wining of the staff quarters at Kinlochleven in Argyll shire. Despite the fact that lead and lead alloy prove to be of great value in the sheathing of cables, aluminum was looked to for a sheath of, in particular, light weight. Many experiments were carried out before a reliable system of aluminum sheathed cable could be put on the market.

Perhaps one of the most interesting systems of wiring to come into existence was the MICS (mineral-insulated copper-sheathed cable) which is used compressed magnesium oxide as the insulation, and had copper sheathed and copper conductors. The cable was first developed in 1897 and was first produced in France. It has been made in Britain since 1937, first by Pyrotenax LTD, and later by other firms. Mineral insulation has also been used with conductors and sheathing of aluminum. One of the first suggestions for steel used for conduits was made in 1883. It was then called "small iron tubes". However, the first conduits were being bitumised paper. Steel for conduits did not appear on the wiring scene until about 1895. The revolution in conduit wiring dates from 1987, 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 is iron bedstead. In 1989 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 wiring of the Rayland's library in Manchester in 1886. Aluminum conduit, though suggested during the 1920s, did not appear on the market until steel become 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 unusual practice to make an inefficient contact to produce an arc to "dim" the lights. Needless to say, the misuse of the early switches, in conjunction with their wooden construction, led to many fires. Tumbler Pigeons. Many accessory names, which are household words to the electricians of today, appeared at the turn of century: verity's Mcgeoch, Tucker and Crabtree.
Further developments to produce the semi-recessed, the flush the ac only, and the "silent" switch proceeded space. 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 following 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 has got the idea from the stoppers fitted to kerosene cans of the time. Like much another really good idea, it superseded all its competitive lamp holders and its use extended through America and Europe. In Britain, however, it was not popular. The bayonet-cap type of lamp-holder was introduced by the Edison &Swan Co. about 1886. 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 come out in the early 1900s, introduced by Dorman & Smith LTD.

The first patent for a plug-and-socket was brought out by Lord Kelvin, a pioneer of electric wiring systems and wiring accessories. 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, shuttered sockets were designed by Crampton in 1983.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 plugand-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 natural 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 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 "Kant ark" 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 cloud be tapped wherever required; this idea caught on and designs were produced and put onto the market by Marryat & Place, GEC and Otter mill.

Trunking came into fashion mainly because the larger sizes of conduit proved to be expensive and troublesome to install. One of the first trunking types to be produced was the spring conduit of the Manchester firm of key engineering. They showed it for the first time at an electrical exhibition in 1908. it was semi circular steel toughing with edges formed in a such way that they remained quite secure by a spring action after being pressed into contact. But it was not until about 1930 that the idea took root and is now established as a standard wiring system.

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 weekly worth nothing; 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).

Any comparison of manufacturers catalogues of, say, ten years ago, with those of today will quickly reveal how development of both wiring systems and wiring accessories have changed, not only physically, in their design and appearance but in their ability to meet the demands made on them modem electrical installations, both domestic and industrial. What were once innovations, such as dinner switches, for :nstance, are now fairly common place where clients require more flexible control of domestic circuits. The new requirements of the regulations for Electrical installations will no doubt introduce more changes in wiring systems and accessories so that installations became safer to use with attendant reductions in the risk from electric shocks and fire hazards. New developments in lightning, for instance, particularly during the last decade or so, herald changes in the approach to installation work. innovative changes in space and water heating using solar energy and heat pumps, will involve the electrician in situations which can offer exciting challenges in installation work, not least in keeping up with the new face of old technology. More and more is the work of the electrician becoming an area of activity where a through grasp of the technology involved is essential if one is to offer the client a safe, reliable and technically competent installation.

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 an 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 long before arc lamps, sparking commuters, 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 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 a high incidence of electrical fires in the USA and the comparative freedom from fire of electrical origin in Britain.

Three months after the issue of the Phoenix Rules for firing 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 preventation 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 day: Lord Kelvin, Siemens and Crampton. 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 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, they cannot be enforced by the law of the land. 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, though the London District Committee, in a letter to the Phoenix Assurance CO, said"... they view the 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 upload 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 letter act it was recognized for the first time that the generation, distribution and use of electricity in the industrial premises could be dangerous. To control electricity in factories and other promises a draft set of regulations was later to be incorporated into statutory requirements.

While the IEE and the statutory regulation were making their positions stronger, the British Standards Institution brought out, and is still issuing. The position of the six 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 fulfills the requirements of the Electrical Supply Regulations. This means that a supply authority can insist upon all electrical work to be carried out to the standard of the IEE regulations, but cannot insist on a standard which is in excess of the IEE requirements.

The position of IEE regs, as they are popularly called, is that of being the installation engineers "bible". Because the regulations cover the whole field of installation work, and if they are complied with, it is certain that the resultant electrical installation will meet the requirements of the all interested parties. There are, however, certain types of electrical installations, which require special attention to prevent fires and accidents. These include mines, cameras, theatres, factories and places where these are exceptional risks.

The following list gives the principal regulations, which cover electricity supply and electrical installations:

Non-Statutory Regulations:

1.Institute of Electrical Engineers Regulations of Electrical installations - this covers industrial and domestic electrical installations work in the buildings.

2.The Institute of Petroleum Electrical Code, 1963 - this indicates special safety requirements in the petroleum industry, including protection from lighting and static. It is supplementary to the IEE regulations.

3.Factories Act, 1961. Memorandum by the Senior Electrical Inspector of Factories- deals with installations in factories.

4.Explanatory Motes on the Electricity Supply Regulations, 1937. - These indicate the requirements governing the supply and use of electricity.

5.Hospital Technical Memoranda no.7 - Indicates the electrical services, supply and distribution in hospitals.

All electrical contractors are most particularly concerned with the vanous requirement laid down by Acts of Parliament (or by orders and regulations made there under) as to the method of installing electric lines and fittings in various premises, and so to their qualities and specifications.

Statutory Regulations:

1. Building (Scotland) Act, 1959- provides for minimum standards of construction *and* materials including electrical installations.
2. Building Standards (Scotland) Regulations, 1981. - contains minimum requirement for electrical installations.
3. Electrical Supply Regulations, 1937 - indicates the requirements governing the supply and use of electricity and deals with installations generally, subject to certain exemptions.
4. Electricity (Factories Act) Special Regulations, 1908 and 1944 - deals with factory installations, installations on construction sites, and installations of non-domestic caravans such as mobile workshops. These regulations come under the authority of the Health and Safety Commission.
5. Coal and Other Mines (electricity) Regulations, 1956 - deals with coalmine installations.
6. Cinematograph (safety) Regulations, 1952 - deals with installations in cinemas.
7. Quarries (electricity) Regulations, 1956 - deals with installations at quarry operations.
8. Agriculture (Stationary Machinery) Regulations, 1959 - deals with agricultural and horticultural installations.

Though these statutory regulations are concerned with electrical safety in the respective type of installations listed, there are Statutory Regulations, which are also concerned with electrical safety when equipment and appliances are being used. Included in these is the electricity at Work Regulations, which come into force in1990. They are stringent in their requirements that all electrical equipment used in schools, colleges, factories and other places of work is in a safe condition and must be subjected to regular testing by competent persons.

Because of the rather legal language in which many of the Statutory Regulations are written, a number of them are made the subject of Guides and Explanatory Notes so that the electrical contractor and his employees are better able to understand requirements.

It should be noted that in addition the list above, there are guite a number of Statutory Regulations which deal with specific types of installations such as caravans and petrol stations. While it may seem that the electrician is completely surrounded by Regulations, it should be remembered that their purpose is to ensure not only the safety of the public, but work persons also. And it is also worth nothing that in the UK the record for the lowest number of electrical accidents is among the best in the world.

It is requirement of the current edition of the IEE Regulations for electrical .I1stallations that good workmanship and the use of approved materials contribute to the high level of safety provided in any electrical installations. The British Standard

Institution is the approved body for the preparation and issue of standards for testing the quality of materials and their performance once they are installed in buildings. A typical s:.andard is BS 31 Steel conduit and Fittings for electrical wiring. The BSI also issues Codes of Practice, which indicate acceptable standards of good practice and takes the form of recommendations. These codes contain the many years of practical experience of electrical contractors. Some of the Codes of interest to the practicing electrician include:

BS 1003: electrical apparatus and associated equipment for use in explosive .lmlosphere of gas or vapor.

BS 7375: distribution of electricity on construction and building sites

BS 1018: electric floor-warming systems for use with off-peak and similar supplies of electricity.

Almost a century after the first wiring Regulations were issued a complete revision was made in 1981 with the appearance of the 15th edition under the title Regulations for electrical installations. This edition differed from previous editions in its highly technical approach to the provision of electrical installations, based on the need for a high degree of quality of both materials and workmanship to ensure safety from fire, shock and burns. The technical content of the 15th edition of the Regulations placed a degree of responsibility on practicing electricians to become familiar with the electrical science principles and the technology which the installer must have in order to provide a client with an installation which is well designed and safe to use.

The 16th edition is now published with yet more changes and differences in approach from the 15th edition. The major changes include the smaller number of explanatory notes and fewer appendices. The 16th edition is also accompanied by a number of other publications: Guidance Notes and an ON-Site Guide. The Guidance notes give detailed information on such topics as protection against electric shock, protection against over current, initial and periodic testing and special installations and locations. The On-Site Guide provides guidance on the construction of the smaller installations such as domestic; commercial and small three phase installations without ilie need for the considerable amount of calculations, which the 15th edition required in the design of an installation. The Guidance in fact offers information, which will ensure :hat an installations has a high degree of built-in safety without taking economic cost into consideration. The guide also contains much need-to-know information, thus making the technical aspects of an electrical installation more accessible to the practicing electrician.

In short, the new 16th edition of the Regulations still places responsibilities on the electrician to fully understand the technical aspects of the work he carries out which only to be expected from a skilled and qualified work person.

While the IEE wiring Regulations have, since 1882, become a widely recognized St3.Ildard for electrical installations, they have not had any legal status except when they are quoted for contractual purposes. With the creation of the Single Common Market :md the hannonization of, among many other things, electrical standards among the member countries of the Common Market, the Regulations, from 1992, have been given will enhanced status by being allotted a British standard number.

CHAPTER 2: ELECTRICAL MATERIALS

2.1 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 rise in temperature is imposed in the applications of insulting materials, otherwise the insulation 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 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 are 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.

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.

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 insulations and sheathing against mechanical damage.

Paper

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

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.

Mica

This material is used between the segments of commutators of the machines, and under slip rings of ac machines. Used where high temperatures are involved such as the heating elements of electronic 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. Form includes tubes and washers.

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.

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.

Insulating oil

This is a mineral oil used in transformers, and oil filled circuit-breakers where j}ey are drawn out when the contacts separate, is quenched by the oil. It is used to .mpregnate wood, paper and press board. This oil breaks down when moisture is present.

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.

Textiles

This group of insulating includes both natural (silk, cotton, and jute) and synthetic (nylon, terylene). They are often found in tape form for winding-wire coil insulation.

Gases

Air is 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 insultants and coolants.

Liquids

Mineral oil is the most common insultant in liquid form. Others include carbon tetrachloride, silicon fluids and varnishes. Semi liquid materials included wax, bitumen 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. Bitumen is used for filling cable-boxes; some are used in paint form. Resins of a synthetic nature from 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.

2.2 Conductors

In electrical work, a conductor means a material which will allow the free passage of an electric current along it, and which presents negligible resistance to the current. If the conducting material has an extremely low resistance (e.g. a copper cable) there will, normally, be no effect when the conductor carries a current. If the conducting material has a significant resistance (e.g. iron wire) then the conductor will show the effects of an electric current passing through it usually in the form of a rise in temperature to produce a heating effect. It should be remembered that the conduction of electric current is offered not only by metals, but by liquids (e.g. water) and gasses (e.g. neon). Conductors by nature differ so enormously from insulators in their degree of conduction that the material which offer high resistance to electric current are classed as insulator.Those materials which fall in between the two are classed as semiconductors (e.g. germanium).

Copper

This metal has been known to man since the beginning of recorded history. Copper was connected with the earliest electrical effects such as, for instance, that made by Galvani in 1786 when he noticed the curious behavior of frogs legs hung by means of a cooper hook from an iron railing (note here the two dissimilar metals). Gradually copper became known as an electrical material; its low resistance established it as a conductor. One of the first applications of copper as a conductor was for the purpose of signaling; afterwards the commercial generation of electricity looked to copper for electrical distribution. It has thus a prominent place and indeed is the first metal to come to mind when an electrical material is mentioned. As a point of interest, the stranded cable, as we know it today has an ancient forebear. Among several examples, a bronze cable was found in Pompeii (destroyed AD 79); it consisted of three cables, each composed of fifteen bronze wires twisted round each other.

Copper is a tough, slow tarnishing and easily worked metal. Its high electrical conductivity marks it out for an almost exclusive use for wires and cables, contacts, and terminations. Copper for electrical purposes has a high degree of purity, at least 99.9 per cent. This degree of purity results in a conductivity value only slightly less than that of silver (106 to 100). As with all other pure metals, the electrical resistance of copper varies with temperature. Thus, when there is a rise in temperature, the resistance also increases. Copper is available as wire, bar, rod, tube, strip, and plate. Copper is a soft metal; to strengthen it certain elements are added. For overhead lines, for instance, copper is required to have a high tensile strength and is thus mixed with cadmium. Copper is also reinforced by making it surround a steel core, either solid or stranded.

Copper is the basis of many of the cuprous alloy found in electrical work. Bronze is an alloy of copper and tin. It is fairly hard and can be machined easily. When the bronze contains phosphorus, it is known as phosphor-bronze, which is used for spiral springs. Gunmetal (copper, tin, zinc) is used for terminals. Copper and zinc become brass, which is familiar as terminals, cable legs, screws and so on, where good conductivity is required, coupled with resistance to wear. Copper oxides slowly at ordinary temperatures, but rapidly at high temperatures; the oxide skin is not closely adherent and can be removed easily.

Aluminum

The use of aluminum in the electrical industry dates back to about the turn of this century when it was used for overhead line conductors. But because in the early days no precautions were taken to prevent the corrosion, which occurs with, bimetallic junctions (e.g. copper cable to aluminum bus bar) much trouble was experienced which discouraged the use of the metal.Generally speaking, aluminum and its alloys are used today for electrical purposes because of (a) weight; (b) resistance to corrosion; (c) economics (cheaper than copper); (d) ease of fabrication; (e) non-magnetic properties. Electrical applications include cable conductors, busbars, casting in switchgear, and cladding for switches.The conductor bars used in the rotor of squirrel cage induction ac motors are also of aluminum on account of the reduced weight afforded by the metal. Cable sheaths are available in aluminum.When used as conductors, the metal is either solid or stranded.

An oxide film is formed on the metal when exposed to the oxygen in the atmosphere.This film takes on the characteristics of an insulator, and is hard enough to withsand some considerableabrasion. The film also increases the corrosion-resisting properties of aluminum. Because of this film it is important to ensure that alt electrical contacts made with the metal are initially free from it; if it does form on surfaces to be mated,the film mustbe removed or broken before a good electrical contact can be made in a joint. Because the resistivity of aluminum is greater than that of cooper, the crosssectional area of the conductor for a given current-carrying capacity must be greater than that for a copper conductor.

Zinc

This metal is used mainly as a protective coating for steel and may be applied to the steel by galvanizing, shearardising or spraying. In electrical work it is found on switchgear components, conduit and fittings, resistance grids, channels, lighting fittings and wall brackets. Galvanizing is done by dipping iron or steel objects into molten metal after fluxing. Mixed with copper, the zinc forms the alloy brass.Sherardising is done by heating the steel or iron object to a certain temperature in zinc dust,to result in an amalgamation of the two metals, to form a zinc-iron alloy.

Lead

Lead is one of the oldest metals known to man. Lead is highly resistant to corrosion. So far as the electrical application of lead is concerned, apart from its use in primary and secondary cells, cable sheathing in lead was suggested as early as 1830-45.this period saw the quantity production ofelectrical conductors for inland telegraphs, and thoughts turned to the possibility of prolonging the life of the conductors: the earliest suggestion were that this could be done by encasing them in lead.Today lead is used extensively.Lead is not used pure; it is alloyed with such metals as tin, cadmium, antimony and Cooper. Its disadvantage is that it is very heavy; it is also soft, even though it is used to give insulated cables a degree of protection from mechanical damage. One of its principle properties is its resistance to the corrosive effects of water and acids.It has a low melting point;this fact is made use of in the production of solder, where it is alloyed with tin for cable-jointing work. Lead alloyed with tin and copper is used as white metal for machine bearings.

Nickel

The metal is used in conjunction with iron and chromium to form what is known as the resistive conductors as heating elements for domestic and industrial beating appliances and equipment. The alloy stands up well to the effects of oxidation. Used with chromium only the alloy is non-magnetic; with iron it is slightly magnetic. It has a high electrical resistivity and low temperature coefficient. The most common alloy names are Nicnrome and Bright ray and Pyromic.Pure nickel is found. in wire and strip forms for wire leads in lamps, and woven resistance mats, where resistance to corrosin is essential.

Carbon

This material is used for motor brushes (slip-ring and commutator), resistors in radio work. It has a negative temperature characteristic in that its resistance decreases with an increase in temperature.

Ferrous metals

These metals are based on iron and used for the construction of many pieces of equipment found in the electrical field (switches, conduit, cable armoring, motor field poles and so on). Because iron is a magnetic material, it is used where the magnetic effect of an electrical current is applied to perform some function (e.g. in an electric bell).

The choice of magnetic materials today is extremely wide. F or practical purposes magnetic materials fall into two main classes: permanent (or hand) and temporary (or soft).Permanent magnetic materials include tungsten and chromium steel and cobalt steel: when magnetized they retain their magnetic properties for a long time. Cobalt-steel magnets are used for measuring instruments,telephone apparatus and small synchronous motors. Soft magnetic materials do not retain their magnetism for any appreciable time after the magnetizing force has been withdrawn. In a laminated sheet form they're found in transformer cores and in machine poles and armatures and rotors. Silicon-iron is most widely used material fore cores.

Rare and precious metals

In general, precious metals are used either for thermocouples or contacts. Among the metals used are silver, gold, platinum, palladium and iridium. Sometimes they are used as pure metals, otherwise as an alloy within the above group or with iron and copper, where special characteristics are required. For instance, a silver-iron alloy contact has a good resistance to sticking and is used in circuits which are closed with a high inrush (e.g. magnetizing currents associated with indicators, electromagnets and transformer). It is used also for small motor-starter contacts; the alloy maintains low contact resistance for very long periods. The following are some applications are rare and precious metals in contacts:

Circuit Brakers; silver, silver-nickel, silver-tungsten.

Contactors; silver, silver-tungsten. Relays. Silver, platinum, silver-nickel.

Relays. Silver, platinuim, silver-nickel

Starters. Platinum, rhodium, silver, coin silver. Silver is used for the fuse-element in HRC fuses.

Mercury, this material is used almost exclusively for mercury switches. In a vapor form it is used in fluorescent lamps (low-pressure lamps) and in the high-pressure mercury-vapor lamp.

Semiconductors

Oxides of nickel, copper, iron, zinc and magnesium have high values of resistance; they are neither conductors nor insulators, and are called semiconductors. Other examples are silicon and germanium. When treated in certain ways, these materials have the property of being able to pass a large current in one direction while restricting the flow of current to a negligible value in the other direction. The most important application for these materials is in the construction of rectifiers and transistors.

Conducting liquids

Among the liquids used to conduct electric currents are those used as electrolytes: sulphuric acid (lead-acid cells); sal ammoniac (Leclanche cells); copper sulphate (in simple cells); caustic potash (nickel-cadmium cells). When salts are introduced to water the liquid is used as a resistor.

Conducting gases

In electrical work, so far as the practical electrician is concerned, conducting gases are, those used for electric discharge lamps: neon, vapor, sodium vapor, helium.

2.3 Cables

The range of types of cables used in electrical work is very wide; from heavy lead-sheathed and annored 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 not regarded as such. Into this category fall for these rubber and PVC insulated conductors drawn into a 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.

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).

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 said by side.

Three-core: these cables are the same in all respects to single and two-core cables except, of course, they carry three cores.

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.

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

Power cables: heavy cables, generally lead sheathed and annored; 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.

Ship-wiring cables: these cables are generally lead-sheathed and annored, and mineral-insulated, metal-sheathed. Cables must comply with Lloyd's Rules and regulations and with Admiralty requirements.

Overhead cables: bare, lightly insulated and insulated conductors of copper, copper vadmiuim 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.

Communication cables: this group includes television down-leads and radio relay cables; radio frequency cables; telephone cables.

Welding cables: these are flexible cables and heavy coeds with either copper or aluminum conductors.

Electric-sign cables: PVC and rubber insulated cables foe high voltage discharge lamps able to withstand the high voltages.

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

Appliance wiring cables: this group includes high temperature cables for electric radiators, cookers and so on. Insulated used includes nylon, asbestos and varnished cambric.

Heating cables: cables for floor warming, road heating, soil warming, ceiling heating and similar applications.

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:

1) **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.

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

3) **Three-core (circular):** generally as twin-core circular except that the third conductorcolored green and yellow for earthling purposes.

4) **Four-core (circular):** generally as twin-core circular. Colors are brown and blue.

5) **Parallel twin**: these are two stranded conductors laid together in parallel and insulatedto form a uniform cable with rubber or PVC.

6) **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.

7) **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 silicon. Cord is made in the twisted form (two and three-core).

8) **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.

CHAPTER 3: ELECTRICAL SAFETY-PROTECTION-EARTHING

3.1 Electrical safety:

The most common method used today for the protection of human beings against the risk of electrical shock is either:

1) The use of insulation (screening live parts, and keeping live parts out of reach).

2) Ensuring, by means of earthling that any metal in electrical installation other than the conductor, is prevented from becoming electrically charged. Earthing basically provides a path of low resistance to earth for any current, which results from a fault between a live conductor and earthed metal.

The general mass of earth has always been regarded as a means of getting rid of unwanted currents, charges of electricity could be dissipated by conducting them to an electrode driven into the ground. A lighting discharge to earth illustrates this basic concept of earth as being a large drain for electricity. Thus every electrical installation, which has metal work, associated with it (the wiring system, accessories or the appliances used) is connected to earth. Basically this means if, say the framework of an electric fire becomes live. The resultant current will if the frame is earthed, flow through the frame, its associated circuit protective conductor, and then to the general mass of earth. Earthing metalwork by means of a bonding conductor means that all that metalwork will be at earth potential; or, no difference in potential can exist. And because a current will not flow unless there is a difference in potential, then that installation is said to be safe from the risk of electric shock.

Effective use of insulation is another method of ensuring that the amount of metalwork in an electrical installation, which could become live, is reduced to a minimum. The term double insulated means that not only are the live parts of an appliance insulated, but that the general construction is of some insulating material. A hairdryer and an electric shaver are two items, which fall into this category.

Though the shock risk in every electrical installation is something which every electrician must concern him, there is also the increase in the number of fires caused not only by faults in wiring, but also by defects in appliances. In order to start a fire there must be either be sustained heat or an electric spark of some kind. Sustained heating effects are often to be found in overloaded conductors, bed connections, and loosefining contacts and so on. If the [illegible] are really bad, then arching will occur which could start a fire in some [illegible] material, such as blackboard, chipboard, sawdust and the like. The [illegible] is to cut off the faulty circuit in the event of an excessive current flowing [illegible] the fuse-protection is not always a guarantee that the circuit is safe from the [illegible] use of fuse, for instance 15 A wires instead of 5 A wires, will render the [illegible]

[illegible] can also be caused by an eat-leakage current causing arcing between live [illegible] say, a gas pipe. Again, fuses are not always of use in the protection of a [illegible] against the occurrence of fire. Residual-current (RCD) are often used instead of fuses to detect small fault currents and to isolate the faulty circuit from the supply.

To ensure high degree of safety from shock-risk and fire risk, it is thus important that every electrical installation to be tested and inspected not only when it is new but at periodic intervals during its working life. Many electrical installations today are anything up to fifty years old. And often they have been extended and altered to such an extent that the original safety factors have been reduced to a point where amazement is expressed on why the place has not gone up in flames before this. Insulation used as it is preventing electricity from appearing where it is not wanted, often deteriorates with age. Old, hard and brittle insulation may, of course, give no trouble if left undisturbed and is in a dry situation. But the danger of shock and fire risk is ever present, for the cables may at the some time be moved by electricians, plumbers, gas fitters and builders.

It is a recommendation of the IEE regulations that every domestic installation be tasted at intervals of five years or less. The completion and inspection certificates in the IEE regulations show the details required in every inspection. And not only should the electrical installation be tested, but all current-using appliances and apparatus used by the consumer.

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 csa 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)Alljoints 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.

3.2Protection

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.

Reasons for protections

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 whit 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)

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)

3.2.1 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.

3.2.2 Over current: Overcurrent, 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 a live conductor

a-)Neautral condactor. (Fuse)

b-)Earthed metal vork (Operators)

3.2.3 Protectors of overcurrent

a-)Fuses

b-)Circuit Breakers

FUSE:

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

There are three types of fuses.

a-)Rewireable

b-)Cartridge

c-)HBC (High Breaking Copacity)

REWIREABLE FUSE:

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

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

Table 1:Fuse current rating and color codes

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.

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

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.

Miniature Circuit Breakers (MCB): These protective devices have to elements, one thermal and one electro-magnetic. The fir, a bi-metal strip, operates for over loads and the second, a sensitive solenoid, detects short circuits. These types of fuses most useful in todays. They have good advantages for example, after breaking circuit. The fuse may be reset and it has not got any damage after they have operated. Faulty circuit can be identified easily whit an ON or OFF position of device.

More useful values of fuses;

6A, 10A, 16A, 32A, 45A, 60A, 100A, 200A, 500A.

Protection for Earth Leakages: This type of protection is done by using ELCB, which stands for Earth Leakage Circuit Breaker. There are two types of earth leakage circuit breaker.

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 todays.

3.3 Earthing

3.3.1 Earthing terms

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

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

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

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.

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.

Three main Important Point Of Earthing:

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

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

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

3.3.2.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 are 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.

CHAPTER 4: CIRCUIT CONTROL DEVICES

4.1 Circuit Conditions Contacts

All electrical circuits are required to have some means whereby they can be energized and disconnected from their supply source. This is done by switches, of which there is a very wide variety of types available. A 'switch' is defined as a mechanical device capable of making, carrying and breaking current under normal circuit conditions, which may include specified overload conditions. Switches in domestic installations are familiar devices used to control the supply to lighting, cooker and water-heating circuits. Socket-outlets may have switches incorporated. In a consumer unit, the main switch isolates the whole installation from the supply.

Certain types of circuit controls do not qualify as switches. These include thermostats for water-heaters and heating equipment, and touch switches, or electronic switches. Some switches are used as isolators, which are designed to disconnect a circuit usually when the circuit has no current flowing in it.

Some switches are operated by an electromagnet; these include contactors used for switching heating loads, large lighting loads and are also incorporated in motor starters. A more specialized type of electromagnet-operated device is the relay.

Although circuit-breakers tend to be regarded as devices used for protection of circuits against over current (overload and short-circuit), they also perform a duty as switches.

Circuit conditions

Electrical circuit has its own characteristics, which means that it will show some peculiar electrical property depending on the type of load connected to it. For instance, a circuit which has a purely resistive load (a resistor used as a lamp filament, or heater element) will show a current, which rises when the circuit is first switched on and then falls as the element reaches its normal operating condition. This means that the switch or other circuit-control device must at least be able to break the full-load current taken by the resistor. This applies particularly if the circuit has a de supply. 11 however, the supply is ac, when the switch contacts separate there may be a small arc drawn out between the contacts. This characteristic is even more noticeable when the resistor is in the form of a coil (e.g. in a fire bar element). This effect is caused by the electrical property, which a coil has in an ac circuit. It is called the 'inductive effect'.

If, instead of a resistive conductor wound in the form of a coil, a low-resistance conductor is wound round a soft-iron core, the item is then known as a 'choke' or inductor, and the circuit is said to have 'inductive characteristics', which lead to switching problems. A fluorescent circuit is an inductive circuit, as is a motor circuit.

If the circuit has a capacitor included in it, it will also show certain characteristics, which may be shown as arcing between switch contacts as they separate. The most pronounced effects of the inclusion of an inductor or a capacitor in a circuit is seen when an ac supply is used. However, small capacitors are often used connected across switch contacts to absorb the sparking caused by contact separation. Used in this way they are sometimes called 'radio-interference suppressors' (e.g. in fluorescent lamp switch starters)

Thus, before a circuit-control device is chosen the circuit to be controlled must be studied so that the device can handle, without damage to itself or the associated circuit wiring, the conditions in the circuit when it is connected or disconnected from its supply. The sections in this chapter, which follow, indicate the type of control for a circuit which various devices offer.

Contacts

There is in existence an extremely wide range of electrical-contact types used to control the flow of an electric current in a circuit. The action of any pair or pairs of contacts is (a) to 'make', to allow the current to flow, and (b) to 'break', to prevent the current flow. When this action is contained in a specially designed wiring accessory or apparatus it becomes one of the many forms of devices used to control circuits: switches, contactors, circuit-breakers and the like.

The basic requirements of any pair of contacts are (a) low resistance of the contact material and (b) low resistance between the two contact surfaces when they meet to make the circuit.

When these requirements are satisfied, the two main factors, which lead to switch troubles, are very much reduced. Though one can choose a low-resistance contact material (e.g. copper), one cannot always control the amount of pressure required to keep the two contact surfaces closed sufficiently to reduce what is called 'contact resistance'. A switch, for instance, which is operated many times, will eventually reach a state when its springs become weakened, with the result that pressure of the contacts is lost to such an extent that heat is generated and a breakdown of the switch follows.

The higher the resistance of contact material the more heat (12R walls) there will be when a current passes along it. The second factor involved in the design of switch contacts is the amount of pressure needed to keep the two contact surfaces together. All circuit-control devices, which meet the relevant specifications of the BSI, are tested very rigorously to ensure that they stand up to more wear and tear than they would meet with in normal use. Even so, most contact troubles met with in practice involving the use of circuit-control devices can be traced to insufficient contact pressures.

The material most often used for contacts is copper; this is because it is available in commercial quantities and it has a very low resistance. The terminals associated with the contacts, to which cables and wires are attached, are most often made from brass or phosphor bronze. These two metals are much harder than copper and so can withstand a certain amount of rough handling with screwdrivers when wiring is being carried out.

The insulating materials used in circuit-control devices include vitrified ceramic (for the bases of switches), bakelite (for switch covers and cases), nylon and mica (for carrying the moving contacts of switches), and insulating oil (used in oil-break circuitbreakers)

In many circuit-control devices silver is used, either as a contact facing, or as the contact itself the material has a resistance lower than that of copper; it also has high heat-dissipation characteristics and is, for this application, economical to use. Motorcontrol switches sometimes have contacts of silver-cadmium oxide to reduce thetendency to weld together with heat.

Liquid mercury is also used in special switches called mercury switches. This material has a low contact resistance and a high load-Carrying capacity, and can be used in situations with ambient temperatures from about - 17 to 204 *DC*.

Because the contacts are the bean of the circuit-control device; it follows that their surfaces must be kept clean at all times. Cleaning fluids are available for this purpose. Other maintenance points are the periodic tightening up of conductor terminals and connections, and ensuring that springs have not weakened through use, or that cam surfaces have not become worn.

There are two classes of *duty for circuit-control devices: (a) light current and (b)* heavy current. Into the first class fall generally lighting switches, relays and bell pushes; the second class includes contactors and circuit-breakers.

4.2 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 circuitbreaker 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 overcurrent 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 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 oftime. 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 ın increasing use for modem electrical installations is the miniature circuitbreaker (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 IIBC or rewirable fuses. Miniature circuit-breakers are available in distribution-board units for final circuit protection.

One main disadvantage of the MCB is the initial cost, although it has the longterm 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.

Contactor

When a switching device has one or more switches in the form of pivoted contact arms, which are actuated automatically by an electromagnet, the device is known as a contactor. The coil of the electromagnet is energized by a small current, which is just sufficient to hold the pivoted contact arm against the magnet core, and in turn so hold the contacts (fixed and moving) together. Contactors are used in an extremely wide range of applications.

They fall into two general types: (a) 'maintained' and (b) 'latched-in'. In the first type, the contact arm is maintained in position by the electromagnet. In the latched-in type, the contact arm is retained in the closed position by mechanical means.

Contact design and material depend on the size, rating and application of the contactor. Contactors with double-break contacts usually have silver cadmium-oxide contacts to provide low contact-resistance, improve arc interruption and anti- welding characteristics. Large contactors with single-break contacts use copper contacts for economy. Usually single-break contacts are designed with a wiping action to remove the copper-oxide film which readily forms on the copper tips. Since copper oxide is not a good conductor, it must be eliminated in this way for good continuity.

When the contacts open, an arc is drawn between them. The longer the arc remains, the more the contact material is consumed, and so the shorter is the contact lift. The arc can be extinguished by two means: long contact travel, or by use of arc interrupters.

The typical arc interrupter is called a 'blow-out' coil. This uses magnetic means to force the arc and its products away from the surfaces of the contacts, thus lengthening and weakening the arc so that it is eventually extinguished.

Contactors are used to control heating loads, and are often used in conjunction with time switches and thermostats, which close or open the electromagnet current as required. With the contactor, a small current (for the electromagnet) can be used to control a relatively large current in another circuit.

Thermostat

The thermostat is used to control an electric heating appliance or apparatus so that a definite temperature is maintained. it is, therefore, a switch, which operates with a change in temperature and is used in the temperature control of rooms, water-heaters, irons, cooker ovens and toasters. It *maintains* a temperature within defined *limits* by switching off the appliance when a higher temperature is attained, and switching it on again when a lower temperature has been reached.

The methods used to operate the switch contacts of a thermostat include the expansion of a metal rod, expansion of a liquid or a gas or the bending of a bimetallic strip. Applications ofthese methods are, respectively, water-heaters, ovens and irons. The illustrations show the basic elements of each type of thermostat.

The speed of response of a thermostat to a change in temperature depends to a large extent on the material used to convey the heat, called the controller. A thermostat whose thermally sensitive elements are directly opposed to the heat transfer medium will respond faster than one whose elements are shielded by a housing. Liquid-filled systems respond more quickly than gas-filled systems.

4.3 Switches and switch fuses

A switch is a device for controlling a circuit or pan of a circuit. The control function consists of energizing an electrical circuit, or in isolating it from the *supply.* The type of switch generally indicates the form, which this control takes. For instance, a single-pole switch (usually called 'one-way') controls the Jive pole of a supply. A double pole switch controls two poles.

A common type of switch in use today is the micro-gap with a rating of 5 A, to control lighting circuits. Switches with a 15 A rating are also used to control circuits, which carry heavier currents on both power (socket-outlet) and lighting arrangements.

Switches are designed for use on de and/or ac. In a de circuit, when the switch contacts separate, an arc tends to be drawn out between the separating surfaces. This arc is extinguished only when the contacts are for enough apart and when the breaking movement is quick.

Investigation of a de switch will indicate the length of the gap required when the switch is open. Compare this gap with the gap length on an ac-only switch it will be found that the latter is very much smaller. The reason for this is that ac tends to be what is called self-extinguishing. In an ac circuit, during the time taken for the contacts to open, the voltage, which is alternating, varies between zero and a maximum. It is at the zero position of the alternating voltage that the arc drawn between the parting contacts of an ac only switch is extinguished - and it does not establish itself again in normal circuit conditions. Thus, a switch designed for use only on an ac system need have only a small gap and, furthermore, the con-tact movement does not require to he operated so rapidly as is the case with do switches.

Quick-make-and-break switches are used for de circuits. Quick-make, slow-break switches are recommended for ac circuits, particularly where the load is an inductive one, for instance where fluorescent lamps are being used.

The most common lighting circuits are controlled by using one-way and two-way switches, double-pole switches and intermediate switches.

The single-pole, one-way switch provides the ON and OFF control of a circuit from one position only. When the switch is closed, the lamp is on; when the switch is open, the lamp is off One-way switches are mounted with the word TOP', which appears on the back of the switch plate, at the top. This is to ensure that when the switch rocker is in the up position, the circuit is disconnected from the supply. The switch is, of course, connected in connected in the phase conductor only. The double-pole switch is used in any situation where the voltage of the neutral conductor of a supply system is likely to rise an appreciable amount above earth potential: use of the double-pole switch means that a two-wire circuit can be completely isolated from the supply. The usual application is for the main control of sub-circuits and for the local control of cookers, water-heaters, wall-mounted radiators, and other fixed current using apparatus. The double-pole switch is often used for the 'master' control of circuits, the switch being operated by a 'secret key' attachment, and in consumer units for the complete isolation of an electrical installation from the supply.

The two-way switch is basically a single-pole changeover switch offering two alternative routes for the passage of the circuit current. These switches are sometimes known as 'landing' switches from the days when their application in the electrical installation was virtually limited to 'one in the hail, and one on the landing upstairs'

Though the two-way switch is still used extensively for stair lighting, it is also to be found wherever it is necessary to have one or more lights controlled from anyone of two positions. They are nowadays to be found in bedrooms (door and bedside), long hails (at each end) and particularly in any room with two entry doors (one at each door). In design, the switch has four terminals, two of which are permanently connected
together inside the switch by a small copper bar on what is called the 'bar' side. One of the bar terminals is blanked off 40 form a non-separable contact. The switch feed is taken to the other open terminal on the bar side. The two other terminals are connected to the 'strapping wires'. Two-way switches are used in pairs, interconnected so that the switch wire of the light circuit is taken from the open terminal on the bar side of the second switch.

The intermediate switch offers control of a circuit from anyone of three positions, the other two positions being at the two two-way switches with which the intermediate switch is most often used. The intermediate wiring circuit is basically a two-way circuit in which the strapping wires are cross connected by the two ON positions of the intermediate switch.

There are two different kinds of intermediate switch, one of which is in common use. It is thus advisable to check the type with an ohmmeter, or bell-andbattery set, because the method of connecting up differs. Shows the two common forms of connection made within each type of switch.

The application of the intermediate switch in electrical installations has so far been very limited. But there is no reason why it should not be used more extensively. Long balls, corridors and passageways with many doors are stilt wired up for two-way control. For reasonable convenience the light or lights should be controlled from every door and entrance. Thus, the user of this type of circuit can make his way through a house, switching on lights before him, and switching off behind him without have to grope about in the dark. Two or more intermediate switches can be inter-connected into the basic two-way circuit to offer control from an almost unlimited number of positions.

The switch fuse is often found as the 'main switch', near the supply-intake position. It is a unit in which the main switch (for installation control) and the main fuses (for the protection of the installation) are combined. In all instances, the switch of the switch fuse cannot be operated when the cover is open, nor can the cover be removed or opened while the switch fuse is closed. The switch fuse, which usually controls a separate distribution board, is of the double or triple-pole type, depending on the supply system.

Double and triple-pole switches are found in metal-clad units called isolators. An example is the fireman's emergency switch, painted red and found beside high-voltage gas-discharge lamps such as neon. Isolators are also used to isolate the supply from motors, and heating and non-portable appliances.

The consumer control unit is the most common means used to isolate a complete domestic installation from the supply. It incorporates a double-pole switch and a 'live' busbar to which the fmal circuits' protection are connected, and either semi-closed fuses, cartridge fuses, or miniature circuit-breakers the latter becomeing increasingly popular because of their definite action in the event of overloading and circuit faults, coupled with safety in their operation. Allthough originally intended for domestic installations, these units are being used in commercial and industrial installations where small lighting and power loads are involved.

The extremely wide range of switchgear types available today can be found in makers' trade literature, study of which is advised so as to become familiar with what is offered for use in electrical installations. All circuit-control devices, whether switches or other types, must conform to the relevant BS specifications, which thus ensure a minimum guarantee of quality and suitability for use.

4.4 Special switches

With the extensive use of electricity today, it is not surprising to find that there is a great variety of switches and other circuit-control devices with special applications. It is possible to indicate here only some of the most common types.

Three-heat switch

This type of switch is most often associated with the grill-plate of an electric cooker, though it is also used for the heat control of boiling plates The circuit controlled by the switch consists of two elements of equal resistance. The three-heat switch then offers low, medium and high heat values by its three positions.

The three-heat switch is essentially a rotary or turn switch. The positions are OFF, LOW, MEDIUM, HIGH. The switches are available as a single-pole type (four terminals) or a double-pole type (five terminals).

Time switch

As indicated by its definition, the time switch introduces a time element' into an electrical circuit, so that automatic control of the circuit is available at predetermined times. Time switches fall into two general groups: spring-driven and motor-driven. The former uses a mechanism similar to that found in clocks The latter group uses as the driving unit a small electric (synchronous) motor whose speed is constant and varies only with the 50 Hz frequency of the mains supply. Similar motors are used in electric clocks.

There are many applications for time switches: shop-window lighting, driveway lighting, street lighting, staircase lighting in multi-tenanted buildings and heating loads, the latter being switched on during 'off-peak' periods when a cheaper tariff is available.

The time-switch control of lighting circuits is often found in such particular applications as poultry houses, where banks of switches control the lighting to simulate summer-daylight conditions and so introduce a 'longer-day'. The same technique is also used in horticulture, to hasten the growth of seedlings and plants, particularly during off-season periods of the year.

For normal work, the contacts (either single- or double-pole) are silvered copper, or entirely silver. For heavy currents, mercury-contact time switches are used.

Mercury switch

This is basically a sealed glass tube with a small amount of liquid mercury inside it The leads are fused into the glass. When the tube is tilted, mercury flows over a second tenninal (the first being in pennanent contact with the mercury). Thus, contact is made to make the circuit. Mercury switches are made in a very wide variety of types, each type being designed with a particular duty and application in mind.

Switches of this type have many advantages: low force required to operate them, low contact-resistance, high load-carrying capacity, low cost, and a long life because of the -no wear' characteristic of the contacts. it is also relatively insensitive to ambient temperature conditions; a range from _4°C to over 204°C has been specified for some switches. Because the glass is hennetically sealed, the mercury switch is effectively immune to dust, oil and condensation, and can be used where corrosive fumes are present.

Contact connections to the switch are made through flexible leads, or 'pigtails', attached to the embedded electrodes or contacts. Some switches are filled with a reducing gas to keep the surface of the mercury pool free from tarnish. Because glass is used as the switch container, the contacts are always visible for inspection; and mercury tends to resist heat and arc effects. The materials used for the contacts include tungsten, iron or iron alloys (e.g. nickel-iron) and Mercury pools.

Mercury switches are operated by a tilting motion; the method of mounting a switch depends on its application, shape of the actuating member, and the motion produced by it. In the case of a single-throw switch, the glass tube is tilted from the horizontal. Mountings include bimetallic strips, cams and rotating levers. A time-lag element can be introduced by restricting the flow of mercury from one position to another; this is done by a wall placed inside the tube. The wall contains a hole, the diameter of which detennines the amount of rime-delay.

Rotary switch

The rotary or turn switch offers the facility of controlling a large number of circuits from a local position by using one switch. The three-heat switch is one of the most common examples of the rotary switch. Others include the switches used on switchboards in conjunction with ammeters and voltmeters on three-phase systems to indicate phase-to-phase currents and voltages.

Many banks of contacts can be fitted to a rotary switch so that complete control of circuits is available. Generally the currents are not large: 15 A is the usual limit.

Micro-gap switch

This switch derives its type name from the fact that when its contacts (usuaUy silver) are open they are separated by an extremely smaU gap: anything up \0 3 rom. A.s indicated earlier in the section on contacts, such switches can be used only on ac circuits. They have many applications apart from 'ac only' lighting circuits.

Thermostats using a 'snap-acting' bimetallic element are in effect micro-gap switches and are to be found in the temperature control of irons, toasters, and cooker heating elements. One industrial application is where a motor overheats and a bimetallic, snap-acting device will switch off the energizing current to stop the motor and so protect its winding.

The snap action is always positive in these switches, no matter how rapidly or how gently the force is applied to the operating button. The button can be moved by a plunger, a leaf spring, or a roller and a lever.

Starter switch

Starter switches are used for starting fluorescent lamps. The glow-type starter switch consists of two separated bimetallic contact strips contained in a glass bulb filled with helium gas. The contacts are connected to the fluorescent lamp filaments. When the circuit-control switch is closed, the mains voltage appears across the two contact strips. This voltage is sufficient to cause a small gas discharge. The heat generated by the discharge affects the bimetallic contact strips, which bend forward to meet each other. When they make contact, the current flows through the fluorescent lamp filaments to heat them. The gas-discharge glow in the starter switch now disappears. After a few seconds the bimetallic contact strips cool down and separate. This sudden interruption of the circuit causes a high-voltage surge to appear across the ends of the main lamp electrodes to start the gas discharge.

The voltage which now appears across the contact strips in the starter switch is, during running conditions, insufficient to cause further discharge in the helium gas, and so the contacts remain open while the main lamp is burning.

Two-way-and-off switch

This is a single-pole changeover switch with an OFF position. It is to be found in hotels, ships and hospitals where it is required to have two lamps in circuit while so arranging their control that both cannot be used at the same tune.

The two-way-and-off switch can be used as a dimmer control, when in one ON position of the switch only one lamp is lit; in the other ON position, two lamps are connected in series to give a 'dim' light. Other lamp-control arrangements are available when this type of switch is used with other types such as the two-way.

Series-parallel switch

This is a three-position switch with an OFF position when the switch knob or dolly is central the switch is used to control two points, or two groups of points. In one ON position, the lamp or lamps are connected in series (dim). In the other ON position, the lamp or lamps are connected in parallel (bright). These switches are to be found in hotel corridors, hospital wards and in railway carriages.

Low-voltage contacts

The most common type of low-voltage contact is the bell push, which is operated by the direct pressure of a finger on a push-button: the contacts are copper or brass. One is fixed to the base of the bell push, the other is fixed at one tenninal end, its other free end being raised. Pressure on the push-button depresses the contact's free end to complete the circuit. The contacts are usually natural copper, though they are sometimes given a coating of non-oxidisable metal. Other low-voltage contacts use steel springs and phosphor-bronze springs, and are associated with various alarm circuits: burglar, fire, frost, water-level and smoke-density.

Relay

The most common relay is a switch operated by an electromagnet. It consists of an iron-cored coil and a pivoted armature. When the coil is energized, one end of the armature is attracted to the electromagnet and the other end presses two or more contacts together contacts may also be opened by this movement of the armature.

Relays are either nonnally closed (NC) or nonnally open (NO). In the first type, when the coil is energized the contacts are open; the contacts close when the coil is reenergized.

In the NO relay, the contacts are closed when the coil is energized, and open when it is de-energized. In effect, the relay is an automatic switch. Relays are nonnally designed to operate when a very small current flows in the coil. Thus, a small current can be made to switch a larger current on or off just as a contactor functions from a distant point (remote control). They are also used in bell and telephone systems, and have a wide application in industry.

Other types of relays use a solenoid for their operation. In this instance a plunger is attracted when a predetennined value of current flows in the coil. A time-lag element can be introduced by the addition of an oil- or air-dashpot to delay the movement of the plunger. Induction and impedance relays operate by the movement of a pivoted disc in the field of an electromagnet; the protective device (usually a circuit-breaker) with which these types are associated is operated by small contacts on the moving disc which, when they close, trip the circuit-breaker. They are used in the protective systems for supply systems, motors, generators and transformers.

The thermal relay consists of a bimetallic strip, which heats up when the operating or circuit current flows through it or through an adjacent heating coil. The bending of the strip causes the contacts to either make or break.

Fireman's switch

This switch is used to isolate high-voltage lighting circuits usually found on the exterior walls of buildings, such as neon signs. The switch, which is painted red, is mounted on the outside of the building adjacent to the sign lamps. A label Fireman's switch' is required to be mounted close to the switch. The OFF position of the switch is at the top and there must be a catch (spring-loaded) to prevent its inadvertent return to the ON position. The mounting height should be not more than 2.75 m from ground level.

Emergency switching

This is a requirement of the Wiring Regulations. The switches take the form of large mushroom-head buttons, which can be knocked in the event of an emergency, say, in a workshop. The switch then disconnects the circuit or machine.

General requirements

Directly operated switches are not allowed in bathrooms or shower rooms where switches are within reach of a person in contact with the bath or shower. Pull-cord switches are recommended in these situations.

When time switches are being connected up, it is essential to ensure that a CPC is also connected to the earth terminal provided. From time to time the consumer may need to make adjustments to the switch settings, thus coming into contact with metal parts such as the switch-operating levers. Correct use of the earthing terminal will prevent shock risks.

All lighting switches must be connected m the phase conductor only and the correct color coding of the connecting wires is required by the Wiring Regulations. Any exposed metalwork (such as a metal switch plate) must be earthed. The switch must be of an adequate current rating. If they are used for inductive loads such as fluorescent circuits, they must be filly rated for the value of inductive current taken. If they are not, then they must not carry any more than half their rating, e.g. 2.5 A in the case of a 5 Arated switch.

Where switches are used as isolators for motor circuits, they should be located close to the motor position. If this is not possible, the switch handle should be able to be padlocked in the OFF position so that work can be carried out without fear of the circuit becoming live.

CHAPTER 5: SUPPLY DISTRIBUTION AND CONTROL

5.1 Overhead Lines

The cheapest method of carrying power is by overhead line, particularly where light loads are concerned, as might be the case in a farm installation. Overhead line Qoles for low-and medium-voltage services are of wood, generally 8m in length some 7 m out of the ground. There are regulations, which govern the minimum lengths of span and minimum heights above ground for consumers' overhead wiring between buildings. In ordinary ground, the erection of poles presents no difficulty. The pole should be dug as narrow as possible in the direction of line. The pole should be positioned in one comer of the hole, so that in two directions it bears against undisturbed soil. Preferably, the butt of the pole should rest on a few inches of concrete or hard core, and be well rammed. In loose ground, cross-braces are necessary below ground level to present a larger area to the yielding soil.

Copper, owing to its high electrical conductivity, being second only to silver, and because it has good mechanical properties and resistance to corrosion, has for long been the most commonly used conductor for overhead lines. One limitation to its use is the excessive sag that is necessary on long spans. In such instances, conductors with a higher tensile strength are used e.g.- a composite conductor employing copper or aluminum strands round a steel wire; or a conductor of cadmium-copper alloy. Overhead lines are subject to the requirements of the Overhead Lines Regulations, where a public supply is being carried. A conductor must have a breaking load at least 560 kg. Thus the minimum size for a copper conductor is 8 SWG. The minimum permissible size of service line must be such as to have an actual breaking load of not less than 370 kg.

Conductors may be bare or insulated PBJ, VR or PVC, Line conductors are attached to insulators carded on supports of wood, iron, steel, or reinforced concrete. All wooden supports other oak or hardwood cross-arm must be impregnated with creosote. Two forms of insulators are used; the pin-type and the disk insulator for tension positions.

5.2 Supply control

It is a requirement of the Wiring Regulations that every consumer's installation shall be adequately controlled by switchgear which is readily accessible to the consumer and which shall incorporate:

1) Protection against electric shock.

2) Protection against over current.

3) Isolation and switching

The type and size of main switchgear to be installed depends on the type of premises and anticipated load. For the average domestic premises, the service cable (underground) is two-core and PILC- or PVC-insulated. This is suitable for a load of about 20 k W at 240V, single phase and 25 mm squared csa, it is sufficient for the electrical requirements of most households. Industrial installations, unless they are very small workshops, are provided with three phases, four-wire services, usually 415V between phases, higher voltages are supplied where the load is large. The size of cable for an industrial load must cater for any future additions to the load or extensions to the factory. It is usual practice to install cables of sufficient capacity with appropriate switchgear; to save additional installation expense and outage time at a later date extensions are projected.

The location of the switchgear of a medium-voltage installation is at the main switchboard. This is situated in a substation or in a separate room on the premises to which any authorized persons have access and which is always kept clean and dry. The Switchgear, fuse gear and circuit breakers should have adequate breaking capacity current obtainable from the supply system. For medium-sized installations, the switchgear is in the form of manually operate switch fuses. These units are available as metal clad, double or triple-pole and neutral switches with HRC fuses. Capacities are up to 300A, and can safely handle faulty currents up to 25MV A at voltages up to 660V ac. Large industrial loads are handled by circuit-breakers which, of course, incorporate the facilities for handling large amounts of short-circuit automatically. A typical switchboard fur a large installation usually consists of a main circuit breaker with a bus bar chamber from which are fed the various sub circuits of the installations, each having its own small-rated circuit breaker. It is a requirement of the IEE Wiring Regulations th.at all switchgear be labeled to identify their functions and the circuits they control. In addition, switches controlling emergency services such as fire alarms, firemen's lifts and sprinkler systems should be distinctively marked, for example, by painting them red.

The memorandum by the Senior Inspector of Factories indicates the adequate passageways should be allowed to give access to al switchboards. Adequate means must also be provided for isolating the equipment to allow access for maintenance and other purposes. Where more than one phase is brought into a building, as in the case of industrial loads, special precautions must be taken to avoid the risk of shock. The Regulations insist that all live terminals between which low voltage exists should be shrouded with an insulating material or be enclosed in earthed metal. Single-phase boards, which are connected to different phases, must be 2 m apart from each other.

The position of distribution fuse boards is important, and should be near the center of the load they are intended to serve. This reduces of the cost circuit cables, though the length between the supply-intake position and particular distribution board should be taken into consideration so that the volt drop does not exceed the permitted maximum of 4 % of the nominal voltage of the supply.

Sub-main distribution in industrial premises is generally by cables or by busbar strunking systems. For machine shops and other parts of a factory where alterations in machines layout may occur frequently, the plug-in tap-off system is recommended. Separate sub-mains should be installed for special electrical services such as passenger and goods lifts and ventilating systems. Sub-main circuits should not be run within lift shafts. In small domestic and commercial installations, the distribution board is at the meter position. With the usual two-pan tariff; one-meter records the energy used for lighting, heating and cooking, and only one main control switch or switch fuse is necessary. If a different tariff is applied, for example, for peak-off loads, a separate meter and switch must be provided. The off-peak loads are controlled by time switches and contractors.

5.3 Supply Distribution

With few exceptions, the types of electricity supply normally available are alternating current single-phase-two-wire, and three-phase-four-wire. In large factories involved in certain kinds of processes as steel mills, the internal works supplies for much of the rotating plant are dc. Direct current supplies outside industry are rarely available from a supply company, although they are, of course, in wide use of emergency lighting, battery charging and similar applications where the power requirement involved is small. Where the amount of power is large as in metal refining, the voltage is small (e.g. 10 V) and the current is correspondingly is large (e.g. 10,000 A).The dc system in general use until the gradual changeover to ac supplies was the three-wire system. This consisted of a dc generator supplying a voltage of 500 V between two outer conductors known respectively as the 'positive outer' and the negative outer'. A middle wire, generally of smaller cross-sectional area, was earthed and thus provided a voltage of 250 V between any of the outer conductors and the neutral or mid-wire. Thus, a 500 V motor could be supplied across the outers, while a domestic requirement of 250 V was met by connecting the mid-wire and the positive or negative-outers. This two-voltage facility was developed from the older single-voltage systems evolved before the turn of this century.

The ac systems came into their own because it was found possible to transmit large amounts of ac electrical power over long distances provided high voltage was used. AC is generated in the power station usually at 25,000 V. This generated voltage is transformed by generator-transformers to transmission-line voltages of 132,275 and 400 kV. The transmission line from apart of what is known as the NATIONAL GRID, which is an interconnected system of conductors (overhead lines and underground cables), which carry electrical power to points of use. All these points, the transmission voltage is reduced by transformers to 33 kV and 11 kV for large consumers. The voltage is farther reduced to 415/240 V for small consumers.

The single phase, 240V, 50 Hz systems is the normal supply for small dwellings, and other single-occupier premises where the load demand is relatively small. The three-phase systems derived from a star-connected winding of a transformer, the star point being earthed. From this point a fourth conductor, the neutral, is taken to form a three-phase, four-wire system.

The voltage between any phase conductor and the neutral is 240 V. This system is the normal supply for commercial and industrial premises of medium size: schools, hotels, blocks of flats, hospitals and the like. The lighting and heating circuits of individual tenements in blocks of flats are normally supplied from low-voltage circuits derived from this system, the load across the three phases being balanced as far as practicable. High-voltage three phase supplies are fed to very large consumers where total electrical load exceeds 100 kW. The voltages are either **11** or 33 kV. The consumer is offered a cheaper tariff if he takes a higher voltage. A balance-load on a three-phase system is usually available only where three-phase motors are used. Heating loads, in most instances, can be connected across three phases and the neutral conductor omitted unless required for control purposes.

Cable sizes are dictated by the amount of electrical power to be carried. If a large power is to be taken to a consumer, high-voltage cable is use, to reduce the current and so the cross-sectional area csa of the cable conductors. Because of the high voltage, however, the cable must be of necessity cost more to insulate. Despite this, there are sound economic reasons for carrying as much power as possible at a high voltage, leaving the larger csa cables to carry larger currents associated with individual circuits in an installation at low and medium voltages. The main economic reason is to reduce the amount of power loss in a conductor. There is also the important aspect of the loss in voltage along the length of the conductor as it caries the load current.

Underground cables are used where there is a visual objection to overhead lines to where it would not be convenient to use lines. Both paper and PVC insulated cables are used, with copper and aluminum conductors. The latter has now come into favor because it costs less than copper and has its lightweight requires a smaller cable-laying labor force. Copper conductors are stranded. Aluminum conductors are found in both stranded and solid forms. Belted cables are cheaper than careened types and are used for systems up to 11 kV.

Protection of underground cables against mechanical damage is provided for by steel-wire or steel-tape armoring. Steel-tape armoring cables are cheaper in first cost than the wired-armored types, but the bending radius is less and they cannot be left 'bright', that is, with the jute serving removed to present a clean appearance n surface work. Also, tape armoring cannot be taken over plumbed or cone gland to the Armor clamp as in wire-armored cables.

There are three methods of laying underground cables: direct lying, draw-in and solid. The direct-laying method involves the cable being placed in a trench and taken covered with soil. In most instances, the cable is protected in wood planks, bricks, tiles or concrete slabs. Such cables should be armored, though if the risk of mechanical damage is small, bare-sheath cables can be used. Subsidence of the soil is an important factor in the installation of buried cables. And if the soil contains harmful chemicals, precautions must be taken to prevent the cable from being damaged by corrosion and electrolysis.
Direct lying is cheap, but replacement or renewal of the cable involves completely new excavation, which could be costly in the long terms. In the draw-in system, a line of conduits is glazed stoneware, cement or concrete. The tubes can be of earthenware or iron.

After the ducts are laid, the cables are pulled into position from manholes or brick pits. Armoring is not necessary, but the cables are usually given a covering of Hessian tape or use to protect them while drawing in. Ducts are usually multi-compartmented. In the solid system, the cable is laid in thronging in an open trench filled in.

CHAPTER 6: FINAL CIRCUITS

A final circuit is defined as 'A circuit connected directly to current-using equipment, or to a socket-outlet or socket-outlets or other outlet points for the connection of such equipment.' In addition, the regulations require that where an installation comprises more than one final circuit, each circuit shall be connected to a separate way in a distribution board. They also require that the wiring of each final circuit shall be electrically separate from that of every other final circuit. To facilitate disconnection of each final circuit for testing, the neutral conductors shall be connected at the distribution board in the same order as that in which the live conductors are connected to the fuses or circuit-breakers.

Final circuits make up the greater part of electrical installations and can vary from a pair of 1 mm2 cables feeding one lamp, to a heavy three-core PILC cable feeding a large motor from a circuit-breaker located at a factory switchboard. The main important regulation which applies to final circuits is No.27 of the Electricity Supply Regulations:

All conductors and apparatus must be of sufficient size and power for the work they are called on to do, and so constructed, installed and protected as to prevent danger'. There are five general groups of final circuits:

1. Rated at not more than 16A.
2. Rated over 16K
3. Rated over 16A but confined to feeding 13A socket-outlets with fused plugs.
4. Circuits feeding fluorescent and other discharge lamps.
5. Circuits feeding motors.

An industrial installation may have all five types; a domestic installation may have only 1, 2 and 3. Whatever the type of installation and the uses to which electrical energy is put, it is essential that some significant element of planning be introduced at any early stage in the design of an installation. Before indicating the factors, which are involved in the choice of final circuit types, a few brief notes on planning aspects will be relevant.

6.1 Installation Planning

a) Domestic installations seem to be the simplest to plan, but there are a number of points, which are worth considering. And though these might seem obvious at first sight, a close survey of existing installations will reveal rather too many lapses in efficient planning, even for a dwelling house. For example, a room which can be entered from two points should be wired for two-way switching; a two-landing staircase should be wired for intermediate switching; and a large house should have two or more lighting circuits. A note in an older edition of the IEE Regulations is still relevant: in the interests of good planning ills undesirable that the whole of the fixed lighting of an installation should be supplied from one final sub circuit. The reason for this is not far to seek. If an installation has two lighting circuits and one circuit fails, the house is not plunged into darkness. It is often a good point to consider a slight 'overlap' of lighting circuits: to wire one lighting point from one circuit within the wiring area of the other circuit. If this is done, there should be a note to this effect displayed at the distribution board.

The lighting in houses should be regarded as an important aspect of interior decoration, as well as supplying lighting on a purely functional basis. In living rooms and bedrooms, wall-mounted fittings can be used, controlled by multi-point switches at the entrance doors. Thought should be given to the provision of 13A socket-outlets for supplying table and standard lamps. The use of local lighting over working surfaces in kitchens is an aspect of good planning. External lighting should not be overlooked, either to light up the front and back doors or to light the way to outhouses such as detached garages, coal stores and greenhouses. In very large houses, driveway lighting may have to be considered.

To facilitate the interchange of fittings and appliances throughout the house, it is recommended that 13A three-pin socket-outlets to BS 1363 should be used exclusively. Where it might be inconvenient to withdraw plugs from the associated socket-outlets when appliances are out of use, switched socket-outlets should be used. Because the past few years have seen a rapid increase in the use of electrical appliances, it is essential that an ample number of socket-outlets be provided, and situated wherever there might arise the need for an electrical outlet The table below shows the provision of socket-outlets, both the desirable number and the minimum provision that can be considered as acceptable:

Parr of dwelling	Desirable provision	Maximum provision
Working area of a kitchen	4	4
Dining area	2	1
Living area	5	3
First (or only) double bedroom	3	2
Other double bedrooms	2	2
Single bedrooms	1	1
Hall or landing	1	-
	20	15
Store/workshop/garage		
Single study-bedrooms	2	2
Single bed-sitting rooms in family dwellings	3	3
Single bed-sitting rooms in self-contained bed sitting room dwellings	5	5

It can thus be seen that the average house should have an adequate number of socket-outlets. In the living room, there should be a two-gang socket-outlet on each side of the fireplace. Additional socket-outlets should be located less than 2 m from the opposite comers of the room, where they are least likely to he hidden by furniture, In bedrooms, at least a single socket-outlet should be provided at each side of a bed; twogang units can be used to good advantage (e.g. to supply a bedside lamp and an electric blanket). Additionally, there should be socket-outlets for dressing-table lamps, a heating appliance or a portable television set.

The kitchen probably places the greatest demand on the electrical servIce. Outlets are required for such varied appliances as washing machines, refrigerators, waste-disposal units, food mixers, can-openers, flat irons, coffee percolators and toasters. As far as possible, the outlets should be located above working surfaces and two-gang units are recommended.

In the dining room, small plate-warmers may be required. In halls and on landings the outlet is generally used for a vacuum cleaner or floor polisher, and perhaps a bail heater. No *provision is made for the use of portable appliances in a room containing a fixed bath or* shower. However, an electric shaver unit to BS 3052 may be installed out of reach of a person in the bath or shower. Additionally, a bathroom heater (of the enclosed-element type) or towel rail should be permanently connected through a fixed control switch out of reach of the bath or shower position.

b)Commercial installations are often difficult to design because frequently the buildings are built as basic shells with the final requirements for lighting and other circuits not known until the office tenants sign their leases. The lighting in such buildings is general, special, and building services'. The general lighting is supplied by a flexible wiring system which will allow for a specific area in a new building to be sectioned or partitioned off into smaller areas for offices, stores and the like. Special lighting may include external lighting, wall points, etc. The service lighting is that associated with lifts, corridors, stairs, and landings and is usually the responsibility of the landlord. Where a tenant's specific lighting requirements are not known when the building is being erected, the lighting outlets are laid out on a · grid' system, in which the outlet points are sited at regular intervals usually related to the module of the building (that is, the basic size, multiples of which are

...construction of the building). Generally, about 3 m are allowed between outlets. ... be left on the ceiling for ceiling switches. They may also be fined on structural ... or on the ceiling along the line of future corridors from which extensions to switch ... can be made on future partitions.

The provision of adequate socket-outlets is a particular problem, for should the ... load increase (e.g. an office may go over to all-electric typewriters or install a ... or data-processing system), it is often difficult to extend or alter an inflexible ... Thus, the electrical services provisions should allow for the possibility of ... new outlets or revising the positions of existing outlets without difficulty or ... disturbance to the building and its occupants. Where a tenant's requirements for ...-outlets are not known, it is usual practice to install one socket-outlet on the external ... in each building bay and make provision for spur connections to two further outlets to ...installed on internal partitions as may be required. Only a limited number of bays, not more than three, should be connected to each ring circuit.

c) Industrial premises require lighting installations, which cater for the intensity of lighting required for the process to be carried out. In addition, local lighting at reduced voltages is often a requirement on machines or for portable inspection lamps. The lighting installation within the factory area should be wired with a system, which will allow for extensive alteration and significant addition with ease of maintenance and rewiring when necessary.

d) Special types of premises include hospitals, theatres, cinemas, hotels, schools and buildings of historic interest. Some of these, such as hospitals, have specific codes of practice laid down by the Ministry of Health. In places of entertainment, secondary lighting installations are required.

6.2 Circuit Ratings

Circuits rated under 16A

A final circuit rated at not more than 16A may feed an unlimited number of points provided that the total 'current demand' does not exceed 16A. They include IS, \3,5 and 2A socket-outlets, lighting outlets, stationary appliances and certain loads which may be neglected because their current demand is negligible (e.g. clocks, belltransformers, electric shaver supply units), provided that their rating is not greater than SV A. No diversity is allowed on fmal circuits. The current rating of the cable must not be exceeded. An important point to note is that if a cable size must be increased to avoid excessive voltage drop in the circuit, the rating of the fuse or circuit-breaker protecting the circuit must not be increased correspondingly. The same condition would apply if the ambient temperature of a cable were to be taken into consideration. The reason for this is that the larger cables are not being chosen for the current that they can carry under favorable circuit conditions, but to provide for the special conditions in which they are being installed. The lighting circuits of domestic installations are rated at 5A.Industrial lighting circuits are usually rated at 15-16A because of the higher wattage of the lamps used.

Circuits rated over 16A

With two exceptions, circuits rated at over 16A should not serve more than one point. The exceptions are circuits, which feed \3A socket-outlets, and cooker circuits. Final circuits for cooking appliances are assessed for current demand as follows.

The first l0A of the total rated current of the connected cooking appliances, plus 30% of the remainder of the total rated current of the connected cooking appliances, plus SA, if the cooker control unit has a socket-outlet.

Thus, a cooker with a total load of 11 kW at 240V (46A) would in fact be supplied by cables rated to carry about 26A, depending on the distance the cooker is away from the distribution board. If a large cooker, which exceeds 30A, is to be installed in domestic premises, and where the protection is offered by fuses, a supply service of more than the nonnal 60A rating may be required. In this instance, the supply authority should be consulted. Water-heater circuits are tenninated in a 20A double-pole isolating switch, fitted with an earthing tenninal and a neon pilot lamp.

Circuits rated for 13A socket-outlets

Final circuits which supply I3A socket-outlets with fused plugs and I3A fused (switched or unswitched) connection units are provided by two types of circuit: ring and radial. Ring circuits serve a maximum floor area of 100 m2 derived from a 30A protective device. Radial circuits serving a maximum area of 50 m2 are also protected by a 30A device, while if the area served is no more than 20 m2 a 20A device provides the protection. The following is a summary of the requirements relating to 13A socket-outlet circuits:

Each socket-outlet of a two-gang or multiple socket-outlet is to be counted as one socket-outlet.

Stationary appliances, pennanently connected to a radial or ring circuit, must be protected by a fuse not exceeding I3A rating and controlled by a switch or a circuitbreaker.

It is important to realize that the conductor sizes recommended for ring circuits are minima. They must be increased if necessary where circuits are installed in groups, or in conditions of high ambient temperature, taking into consideration the class of excess-current protection provided.

The method of properly connecting circuit conductors of a ring circuit involves correct polarity and security of the terminals.

Except where a ring circuit is run throughout in metallic conduit, ducts or trunking, the CPC shall be run in the form of a ring, having both ends connected to earth at the distribution board (or its equivalent).

The total number of spurs shall not exceed the total number of socket-outlets and stationary appliances connected directly to the ring.

Fused spurs from ring circuits must be connected through fused spur boxes, and the rating of the fuse must not exceed the current rating of the cable forming the spur, and in any event must not exceed 13A.

One socket-outlet or one two-gang socket outlet unit, or one stationary appliance fed from a connection unit, can be connected to each non-fused spur.

Circuits feeding motors

Final circuits, which supply motors, require careful consideration. In particular, cables which carry the starting, accelerating and load currents of a motor must be rated at least to the flill40ad current rating of the motor It; however, the motor is subjected to frequent starting and stopping, the csa of the cables should be increased to cater for the consequent increase in conductor temperature. More than one motor may be connected to a 16A fmal circuit, provided that the aggregate hill-load rating of the motors does not exceed 16A. If a motor takes more than 16A hill-load current, it should be fed from its own final circuit.

Cooker circuits

These are derived from (usually) a 30 A or 32 A way, but can be higher depending on the kW rating of the cooker. The control units need not have a socket-outlet incorporated in them, but if one is provided the protective device must be able to disconnect the circuit in the event of a fault within 0.4 second (it would he 5 seconds otherwise). The control unit must be located within 2 m of the appliance (this also applies to 'split-level' cooking appliances).

Water-heater circuits

Generally derived from a 15 A or 16 A way, the circuit must incorporate a doublepole switch (usually of 20 A rating), with an aaoitional switch recommenoeo in dose proximity to the immerser unit which should be connected by using heat-resisting flexible cable or cord.

6.3 Choosing cable sizes

The selection of the size of a cable to carry a load current involves the consideration of the rating and type of the protective device, the ambient temperature and whether other cables are run alongside the cable (grouping). There are many situations in which cables can find themselves being overheated. The more obvious are the conditions set up when over currents are carried due to overloading and when a short-circuit occurs. Others include the increase in temperature when a number of current carrying cables are bunched together, for instance in conduit and trunking, which is a situation in which each cable contributes its heat to that of others and which, because of tile enclosed situation, produces an environment, which can quickly lead to the deterioration of the cable insulation (particularly when PVC is involved) and lead to a possible source of fire. At about 80°C, PVC becomes very son, so that a conductor can migrate or travel through the insulation and eventually make contact with earthed.

This produces a shock-risk situation, with an increase in the leakage current which could prove fatal if the installation earthing arrangement is faulty. Eventually, when the insulation breaks down completely, a short-circuit occurs and the circuit is now dependent on the ability of the over-current protection device to operate to disconnect the circuit from its supply. As is probably realized, the time of operation of the protective device is crucial: a semi-enclosed fuse will take longer to operate than would a miniature circuit-breaker. In some circumstances, particularly where PVC insulated cables are used, the time taken by a semi-enclosed fuse to operate may be long enough for the cables to burn out and create a fire hazard.

Another problem, which has occurred in recent years, concerns the use of thermal insulation in buildings, with cables being installed in conditions where the natural heat produced by even their normal load currents cannot be dissipated easily. The TEE Regulations recognize the fact that, in these circumstances, the ratings of cables have to be reduced quite considerably. These classifications are used in the tables, which give the current-carrying capacities of cables. The installation conditions include 'enclosed (e.g. in conduit, trunking and ducts); 'open and clipped direct' (e.g. clipped to a wall, to a cable tray, embedded direct in plaster which is not thermally-insulating, and suspended from a catenary wire); 'defined conditions', which include cables in free air; and cables 'in enclosed trenches'.

From this, it can be seen and appreciated that the selection of a cable to feed a circuit is now required to be undertaken with a number of factors to be considered carefully. Situations which were formerly taken for granted must now be investigated so that the cable I sinstalled in the best conditions which will allow the cable to carry its load current with the safety of the user of the installation in mind.

The IEE Regulations require that the choice of a cable for a particular circuit must have due regard for a number of factors, and not just the circuit current. These factors include:

a) The ambient temperature in which the cable is installed;

b) The installation condition e.g. whether grouped or bunched with other current carrying cables, enclosed or installed open;

c) Whether the cable is surrounded by or in contact with thermal insulating material;

d) Whether the circuit is protected by semi-enclosed (rewirable) fuses to BS 3036. The method of choosing the correct size of conductor for a particular load condition, as recommended by the IEE Regulations, is based on the rating of the over current protective device. All factors affecting the cable in its installed condition are applied as divisors to the rating of the device. In general, the size of every bare conductor or cable conductor shall be such that the drop in voltage from the origin of the installation to any point in that installation does not exceed 4% of the nominal voltage when the conductors are carrying the full load current. It should be noted that conductors of large cross-sectional area have different volt drops per ampere per meter for ac circuits than those operating from dc supplies. This is because of the reactance inherent in conductors carrying ac.

The following process for working out the correct size of cables is as follows:

1. First find the load current of the circuit (Is).

2. Determine the correction factor for the ambient temperature, which of course does not include the heat generated in the cable itself but is more concerned with the maximum temperature of the medium through which the cable runs.

3. Determine the correction factor for grouping.

4. Determine the correction factor if the cable is in contact with or is surrounded by thermal insulation material. Two factors are given: 0.75 if only one side of the cable is in contact with the material (e.g. a cable clipped to the side of a joist) and 0.5 if the cable is completely surrounded by the material.

5. Select the rating of the over current device. If this is offering what used to be called 'close' protection, the correction factor is 1. If, however, protection is by means of a semi-enclosed fuse, the factor is 0.725. The rating of the device must at least equal the load current.

6. Determine the size of the circuit conductor by calculating its current rating.

7. Check that the volt drop does not exceed the maximum permissible allowed.

If Iz represents the current rating of the conductor and In the rating of the protective device, then

$$Iz = \frac{In}{Cg \times Ca \times Ci \times Cf} \text{ amperes}$$

Where Cg is the factor for grouping;

Ca is the factor for ambient temperature;

Ci is the factor for thermal insulation (0.5 if cable is surrounded and 0.75 if the insulation is in contact with only one side of the cable;

Cr is the factor for the over current device. This factor is 1 for all devices except semi-enclosed fuses, when the factor is 0.725.

6.4 Lighting Circuits

Final circuits

Electrical apparatus is connected by cables to the electricity supply, and to the associated protective and controlling devices (usually fuses and switches). This arrangement of cables is known as a circuit and circuits which connect current, using apparatus to the consumer unit or distribution board, are called final circuits.

Lighting tinal circuits

One of the earliest commercial uses for electricity was for the lighting of premises; indeed, some of the early installations had only lighting installed, as the number of electrical appliances were few.

The simplest lighting circuit is one lamp controlled by one switch and is known as a one-way circuit. The circuit commences at the protective device in the consumer unit, which is connected to the phase conductor of the supply. From here it goes to the switch controlling the circuit and from there to the lamp. From the lamp the cable returns to the consumer unit where it is connected to the neutral terminal of the consumer unit, so completing the circuit.

Two-way lighting circuits

For independent control from two positions, for example on a staircase, two-way switches are required. These switches have three terminals, one of which is called the common and is marked with a letter C; the other two arc called the strippers and are usually marked Li and L2 respectively. The neutral conductor is taken to the lamp position. From the other side of the lamp, a conductor known as the switch wire is taken to the common of the second switch, and the two switches are linked by a -pair of conductors known as the strippers. From the common of the first switch, a conductor known as the switch feed is taken to the phase.

With the switches in the positions shown in drawing (a); the current travels from the common of the first switch across the switch contacts to L2. From L2 it travels along the L2 strapper to the L2 terminal of the second switch; here it cannot go any further because the contacts of the second switch are open, so that the lamp does not light.

To make the lamp light, it would be necessary for someone to operate switch one so that the common is in contact with Li, as shown in drawing (b), or to operate switch two so that its common was in contact with L2. Either of these actions would complete the circuit and the lamp would light.

Intermediate lighting circuits

If it is desired to have control from three or more positions, intermediate type switches are necessary as well as the two two-way switches. Intermediate switches have four terminals and although the switch action of different makes of switch end up with the same results, the connections vary, so it is advisable to check the switch action before connecting up. The intermediate switches should be connect to the two strapping cables. This means that the circuit must always start and finish with the two-way switches. When using the commonest type of intermediate switch for three-way control, the circuit is wired as shown. The switch action in position one is shown with the solid line, and in position two with the dotted line. Operation of the two-way switches is carried out as normal and the lamp can be turned on or off from any of the three positions.

In another often used type, the Ll strappers from the two-way switches are connected into the nearest of the top terminals, but the L2 suappers are taken into the furthest of the bottom terminals (i.e. the cables are crossed over).

Conversion of a one-way circuit into a two-way circuit

On occasions, the electrician is called upon to make alteration to existing circuits. One of the more popular requests is to make a one-way circuit into a two-way. The conversion can be carried out quite simply by running a piece of three core and CPC cable from the existing switch position to the new position.

Methods of wiring lighting circuits

The loop-in method of wiring

For circuits wired in single core PVC insulated cable and are suitable for wiring carried out in conduit wiring systems. Much of the wiring done today, however, is carried out in composite cables such as PVC insulated, PVC sheathed, twin and earth cable. The technique used for this type of cable is essentially different for that of the singles cables, and the first method we are going to look at is the loop-in method.

This is probably the most common method of wiring domestic premises in use today. All the connections are made at the electrical accessories. A cable containing phase neutral and CPC conductors is run from the consumer unit to the first lighting point; a second cable is run down to the switch position. The connections are made inside the ceiling rose at the terminals provided and it should be noted that it is a requirement of the IEE Wiring Regulations that the phase terminal in the ceiling rose shall be shrouded. The reason for this is that, even with the switch in the off position, this terminal is still live until the power is switched off at the consumer unit.

If a further lighting point is required, an additional cable is run from the first lighting point to the new position. The phase, neutral and CPC conductors are connected into the corresponding connections on the first ceiling rose. At the new position, another ceiling rose is fitted and a cable taken down to the new switch position. The connections at the second position arc made off in exactly the same way as before. This procedure is known as looping in and out of the accessories, hence the name loop-in system. If any of the current carrying conductors are colored black, then they must be identified with a red sleeve or piece of red tape, both at the ceiling rose and at the switch.

The joint box method of wiring

There are a number of different types of joint box, but the most popular pattern consists of a circular molded plastic box in which is fixed four or more brass pillar terminals.

The joint box is sired in a position as near to the center of the area to be wired as possible, and fixed with wood screws to a suitable timber bearer nailed between the or ceiling joists. A composite cable, which contains the phase, neutral and CPC conductors, is run from the consumer unit and terminated in the joint box. Care should be taken to see that the cable sheath enters into the joint box, so no conductors are exposed on the outside. The CPC conductor is bare in composite cables, so it will be necessary to insulate this from the other cables in the joint box. This is done by fitting over it a plastic sleeving, colored green and yellow in accordance with the IEE Wiring Regulations. To complete the circuit, further cables are run from the light position and the switch position.

IEE Regulations Concerning Lighting circuits

We have already seen a number of the regulations applicable to the installation of lighting circuits; however, there are several other points, which must be noted.

· Where conductors or flexible enter a luminaries, as, for example, when a bulkhead fitting or batten lamp holder is used, the conductors should be able to withstand any heat likely to be encountered, or sleeved with heat resistant sleeving.

· A ceiling rose, unless specially designed for the purpose, should have only one flexible cord.

· The flexible cord used to make up a pendant (the ceiling rose, flex and lamp holder assembly) should be capable of withstanding any heat that is likely 7-to be present in normal use.

· Where a flexible cord supports or partly supports a luminary, the maximum mass supported shall nor exceed the values.

· A ceiling rose shall not be used on a voltage exceeding 250V.

· Parts of lamp holders, installed within 2.5 m of a fixed bath or shower, shall be constructed or shrouded in insulating material. Bayonet-type (B22) lamp holders shall be fitted with a protective shield to BS 5042 (Home Office skirt), or a totally enclosed luminary installed.

· Lighting switches shall be installed, so as to be normally inaccessible to persons using a fixed bath or shower.

· For circuits supplying equipment in a room containing a fixed bath or shower that can be touched at the same time as exposed conductive or extraneous conductive parts, the protective device shall disconnect the circuit within 0.4 of a second.

· For circuits on TN or TT systems, where an Edison screw lamp holder is being used, the outer contact shall be connected to the neutral conductor.

· Final circuits for discharge lighting (this includes fluorescent luminaries) shall be capable of carrying the total steady current, via the lamp's associated gear and its harmonic currents. Where this information is not available, the demand in volt-amperes can be worked out by multiplying the rated lamp watts by 18. This is based on the assumption that the power factor is not less than 0.85 lagging.

· Semi-conductors may be used for functional switching (not isolators) provided that they comply with sections 512 and 537 of the Regulations.

· When installing lighting circuits, the current is equivalent to the connected load with a minimum of 100 W per lamp holder. It should be noted, however, that diversity can be applied to lighting.

CHAPTER 7: PRACTICAL APPLICATION

7.1 CALCULATİONS :

7.1.1 -Lighting Calculations:

BODRUM:

DİMENSİONS	MAİNTENANCE FACTOR=1.25	LİGHT İNTENSİTY	ARMATÜR TYPE: Fluoresan
A=22 m	CEILING=0.8	E=150 LUX	Lamp type: 2x65/80w
B=26.13 m	WALLS=0.5		Armatur light flux: Φ_L=2x5600=11200Lm
H=3.35 m	SURFACE=0.1		

Working plane =h1=0m

* $h = H - h1 = 3.35 - 0 = 3.35$ m

* $k = (a \times b)/ h \times (a + b) =(22 \times 26.13) / 3.35 \times (22 +26.13) = 3.56$

* $\eta =$

* İnterpolation

k =3.0	η =0.52
k = 4.0	η =0.55
1.0	0.03
0.56	x

x = 0.0168 $\eta = 0.52 + 0.0168 = 0.5368$

* d = 1.25
* A = 603 m²

* $\Phi_T =(E \times A \times d) / \eta = (150 \times 603 \times 1.25) / 0.5368$

$= 246395.95$ lm

* $n = \Phi_T / \Phi_L = 246395.95 / 11200$

$=$ <u>22 adet</u>

OTO SERVİS BÖLÜMÜ (SENDE 1'İN ALTI) :

DİMENSİONS	MAİNTENANCE FACTOR=1.25	LİGHT İNTENSİTY	ARMATÜR TYPE: Fluoresan
A=5.29m	CEILING=0.8	E=250 LUX	Lamp type: 2x65/80w
B=10.18m	WALLS=0.5		Armatur light flux: Ql=2x5600=11200Lm
H=2.47m	SURFACE=0.1		

Working plane =h1=0 m

* $h = H - h1 = 2.47 - 0 = 2.47$m

* $k = (a \times b)/ h \times (a + b) =(5.29 \times 10.18) / 2.47 \times (5.29 + 10.18) = 1.40$

* $\eta =$

* İnterpolation

$k = 1.25 \qquad \eta = 0.38$

$k = 1.50 \qquad \eta = 0.41$

$0.25 \qquad 0.03$

$0.15 \qquad x$

$x = 0.018 \qquad \eta = 0.38 + 0.018 = 0.398$

* $d = 1.25$

* $A = 48.46\ m^2$

* $\Phi_T = (E \times A \times d) / \eta = (250 \times 48.46 \times 1.25) / 0.398$

$= 38049.62$

* $n = \Phi_T / \Phi_l = 38049.62 / 11200$

= 3 adet

OTO SERVİS BÖLÜMÜ (ÜSTÜ AÇIK BÖLÜM) :

DİMENSİONS	MAİNTENANCE FACTOR=1.25	LİGHT İNTENSİTY	ARMATÜR TYPE: Fluoresan
A=5.50m	CEILING=0.8	E=300 LUX	Lamp type: 2x65/80w
B=10.14m	WALLS=0.5		
H=4.15m	SURFACE=0.1		Armatur light flux: Ql=2x5600=11200Lm

Working plane =h1=0.85 m

* $h = H - h1 = 4 - 0.85 = 3.15$ m

* $k = (a \times b)/ h \times (a + b) = (5.50 \times 10.14) / 4.15 \times (5.50 + 10.14) = 0.85$

* $\eta =$

İnterpolation

*

$k = 0.80 \qquad \eta = 0.29$

$k = 1.00 \qquad \eta = 0.33$

$0.20 \qquad 0.04$

$0.05 \qquad x$

$x = 0.01 \qquad \eta = 0.29 + 0.01$

$= 0.30$

=1.25

* $A = 55.77\ m^2$

* $\Phi_T = (E \times A \times d) / \eta = (300 \times 55.77 \times 1.25) / 0.30$

$= 69712.5$

* $n = \Phi_T / \Phi_l = 69712.5 / 11200$

= <u>6 adet</u>

OTO YEDEK PARÇA DEPOLAMA (ÜSTÜ AÇIK BÖLÜM) :

DİMENSİONS	MAİNTENANCE FACTOR=1.25	LİGHT İNTENSİTY	ARMATÜR TYPE: Fluoresan
A=9.19 m	CEILING=0.8	E=200 LUX	Lamp type: 2x65/80w
B=5.49 m	WALLS=0.5		
H=4.17 m	SURFACE=0.1		Armatur light flux: Ql=2x5600=11200Lm

Working plane =h1=0m

* $h = H - h1 = 4.17 - 0 = 4.17$ m

* $k = (a \times b) / h \times (a + b) = (9.19 \times 5.49) / 4.17 \times (9.19 + 5.49) = 0.82$

* $\eta =$

* İnterpolation

k = 0.80 $\eta = 0.29$

k = 1.00 $\eta = 0.33$

0.20 0.04

0.02 x

x = 0.004 $\eta = 0.29 + 0.004$

$= 0.294$

* $d = 1.25$
* $A = 50.45\ m^2$

* $\Phi_T = (E \times A \times d) / \eta = (200 \times 50.45 \times 1.25) / 0.294$

$= 42899.6\ lm$

* $n = \Phi_T / \Phi_l = 42899.6 / 11200$

$=$ <u>4 adet</u>

OTOSTOP LAMBALARI İMALAT ATÖLYESİ:

DİMENSİONS	MAİNTENANCE FACTOR=1.25	LİGHT İNTENSİTY	ARMATÜR TYPE: Fluoresan
A=10.2 m	CEILING=0.8	E=300 LUX	Lamp type: 2x65/80w
B=22.3 m	WALLS=0.5		
H=4.50 m	SURFACE=0.1		Armatur light flux: Ql=2x5600=11200Lm

Working plane =h1=0.85m

* $h = H - h1 = 4.50 - 0.85 = 3.65\ m$

* $k = (a \times b) / h \times (a + b) = (10.2 \times 22.3) / 3.65 \times (10.2 + 22.3) = 1.91$

* $\eta =$

* İnterpolation

$k = 1.50 \qquad \eta = 0.41$

$k = 2.00 \qquad \eta = 0.46$

$0.50 \qquad 0.05$

$0.41 \qquad x$

$x = 0.041 \qquad \eta = 0.41 + 0.041$

$= 0.451$

* $d = 1.25$
* $A = 227.4\ m^2$

* $\Phi_T = (E \times A \times d) / \eta = (300 \times 227.4 \times 1.25) / 0.451$

$= 189500\ lm$

* $n = \Phi_T / \Phi_l = 189500 / 11200$

$=$ <u>18 adet</u>

OTOSTOP LAMBALARI İMALAT ATÖLYESİ (DİNLENME BÖLÜMÜNÜN ALTI) :

DİMENSİONS	MAİNTENANCE FACTOR=1.25	LİGHT İNTENSİTY	ARMATÜR TYPE: Fluoresan
A=5.00 m	CEILING=0.8	E= 300 LUX	Lamp type: 2x65/80w
B=18.21m	WALLS=0.5		
H=2.32 m	SURFACE=0.1		Armatur light flux: Ql=2x5600=11200Lm

Working plane =h1=0.85m

* $h = H - h1 = 2.32 - 0.85 = 1.47m$

* $k = (a \times b) / h \times (a + b) = (5.00 \times 18.21) / 1.47 \times (5.00 + 18.21) = 2.66$

* $\eta =$

* İnterpolation

k = 2.50 $\eta = 0.49$

k = 3.00 $\eta = 0.52$

0.50 0.03

0.16 x

$x = 0.009$ $\eta = 0.49 + 0.009$
$= 0.499$

* $d = 1.25$
* $A = 91.05\ m^2$

* $\Phi_T = (E \times A \times d) / \eta = (300 \times 91.05 \times 1.25) / 0.499$

$= 68424.34$

* $n = \Phi_T / \Phi_\iota = 68424.34 / 11200$

= <u>6 adet</u>

DTB

L1=4(2x80) flo+1(1x100)	=740 w
L2=4(2x80) flo	=640 w
L3=4(2x80) flo+1(1x100)	=740 w
L4=3(2x80) flo	=480 w
L5=3(2x80) flo	=480 w
L6=4(2x80) flo+1(1x100)	=740 w
L7=3(1x100w)	=300 w
P1=4(2x13) A	=2400 w
P2=3(2x13) A	=1800 w
P3=3(2x13) A	=2400 w
P4=4(2x13) A	=2400 w
P5=4(2x13) A	=2400 w
Total power	=14,920 kw

DTI

L8=5(2x80w) flo	=800w
L9=4(2x80w) flo	=640 w
L10=5(2x80w) flo	=800 w
L11=4(2x80w) flo	=740w
L12=3(2x80w) flo	=480 w
L13=3(2x80w) flo	=480 w
L14=6(1x100w) flo	=600w

P6=4(2x13) A	=2400 w
P7=3(2x13) A	=2400 w
P8=5(2x13) A	=3000 w
HEATER	=3000w
Total Power	=14.640 kw

DTD

L24=6(1x80w) flo		=480 w
L25=4(1x100w) lamb + 1(1x80w) flo		=480 w
P13=1(1x13)A +3(2x13)A + BD		=2100 w
P14=3(1x13)A +3(2x13)A		=2700 w
Cooker		=6000 w
Water pump	0.5hp x746 w	=373 w
Total power		=12.133 kw

DTO

L15=3(2x80w)	=1800 w
L16=3(2x80w)	=1800 w
L17=3(2x80w) flo + 2(1x100w)	=2000 w
L20=3(2x80w) flo	=1800 w
L26=2(1x100w)	=200 w
P9=2(1x13)A +3(2x13)A	=2400 w
P11=2(2x13)A	=1200 w

Total Power of System

ADT = DTB + DTI + DTD + DTO + DTY + DTM1 + DTM2 + DTM3 + DTM4 + DTM5

=(14920 + 14640 + 12133 + 13920 + 8580 + 30000 + 30000 + 30000 +30000 +30000) w

=214193 w

Demand power

DTB + DTI + DTD + DTO + DTY we are using for the system % 60

=(14920 + 14640 + 12133 + 13920 + 8580) w =64193 w

% 60 = 64193 x 60 /100 =38515.8 w

DTM1 + DTM2 + DTM3 + DTM4 + DTM5 we are using for the system % 100

=30000 + 30000 + 30000 +30000 +30000) w

% 100 = 150000 w

For the system demand power is

150000 + 38515.8 = 188515.8 w

for the Wye connection

P = 3 x Vø x Iø x pf ; Vø = V L-L / 1.73 ; Iø = I L-L

For the one phase current calculation

Iø = P / 1.73 x V L-L x pf

=188515.8 / 1.73 x 415 x (0.8) = 188515.8 / 574.36

= 328.21 A for phase

DTB

Total power of DTB 14920 watt

% 60 = 14920 x 60 / 100 = 8950 watt

Iø = P / 1.73 x V L-L x pf

=8950 / 1.73 x 415 x (0.8) = 8950 / 574.36

= 15.6 A

DTI and DTD

Total power of DTI 14640 watt

power of DTD 12133 watt

For DTI % 60 = 14640 x 60 / 100 = 8784 watt

For DTD % 60 = 12133 x 60 / 100 = 7280 watt

Total power = 16064 watt

For DTI

Iø = P / 1.73 x V L-L x pf

=16064 / 1.73 x 415 x (0.8) = 16064 / 574.36

= 27.9 A

For DTD

Iø = P / 1.73 x V L-L x pf

=7280 / 1.73 x 415 x (0.8) = 7280 / 574.36

= 12.7 A

DTO and DTY

Total power of DTO 13920 watt

power of DTY 8580 watt

For DTO % 60 = 13920 x 60 / 100 = 8352 watt

For DTY % 60 = 8580 x 60 / 100 = 5148 watt

Total power = 13500 watt

For DTO

Iø = P / 1.73 x V L-L x pf

=13500 / 1.73 x 415 x (0.8) = 13500 / 574.36

= 23.5 A

For DTY

Iø = P / 1.73 x V L-L x pf

=5148 / 1.73 x 415 x (0.8) = 5148 / 574.36

= 8.9 A

For DTM1

Iø = P / 1.73 x V L-L x pf

Iø = 30000 w / 1.73 x 415 x (0.8) = 30000 / 574.36

= 52.23 A

DTM1 = DTM2 = DTM3 = DTM4 = DTM5 =We are using same value for all the motors.

For one phase cross sectional area DTB

L1= 740 w / 240 V = 3.1 A

L2= 640 w / 240 V = 2.7 A

L3= 740 w / 240 V = 3.1 A

L4= 480 w / 240 V = 2 A

L5= 480 w / 240 V = 2 A

L6= 740 w / 240 V = 3.1 A

L7= 300 w / 240 V = 1.25 A

P1= 2400 w / 240 V = 10 A

P2= 1800 w / 240 V = 7.5 A

P3= 2400 w / 240 V = 10 A

P4= 2400 w / 240 V = 10 A

P5= 2400 w / 240 V = 10 A

DTI

L8= 800w / 240 V = 3.3 A

L9= 640 w / 240 V = 2.5 A

L10= 800w / 240 V = 3.3 A

L11= 740w / 240 V = 3.08 A

L12= 480 w / 240 V = 2 A

L13= 480 w / 240 V = 2 A

L14= 600w / 240 V = 2.5 A

P6= 2400 w / 240 V =10 A

P7= 2400 w / 240 V =10 A

P8= 3000 w / 240 V = 10 A

HEATER = 3000w / 240 V = 12.5 A

DTD

L24= 480 w / 240 V = 2 A

L25= 480 w / 240 V = 2 A

P13= 2100 w / 240 V = 8.75 A

P14= 2700 w / 240 V = 11.75 A

Cooker = 6000 w / 240 V = 25 A

Water pump 0.5hp x746 w =373 w / 240 V = 1.55 A

DTO

L15= 480 w / 240 V = 2 A

L16= 480 w / 240 V = 2 A

L17= 680 w / 240 V = 2.8 A

L20= 480 w / 240 V = 2 A

L26= 200 w / 240 V = 0.8 A

P9= 2400 w / 240 V = 10 A

P11= 1200 w / 240 V = 5 A

Extra= 1000 w / 240 V = 4.1 A

Extra= 2000 w / 240 V = 8.3 A

Extra= 5000 w / 240 V = 20.8 A

DTY

L18= 740 w / 240 V = 3.1 V

L19= 800 w / 240 V = 3.3 A

L21= 740 w / 240 V = 3.08 A

L22= 600 w / 240 V = 2.5 A

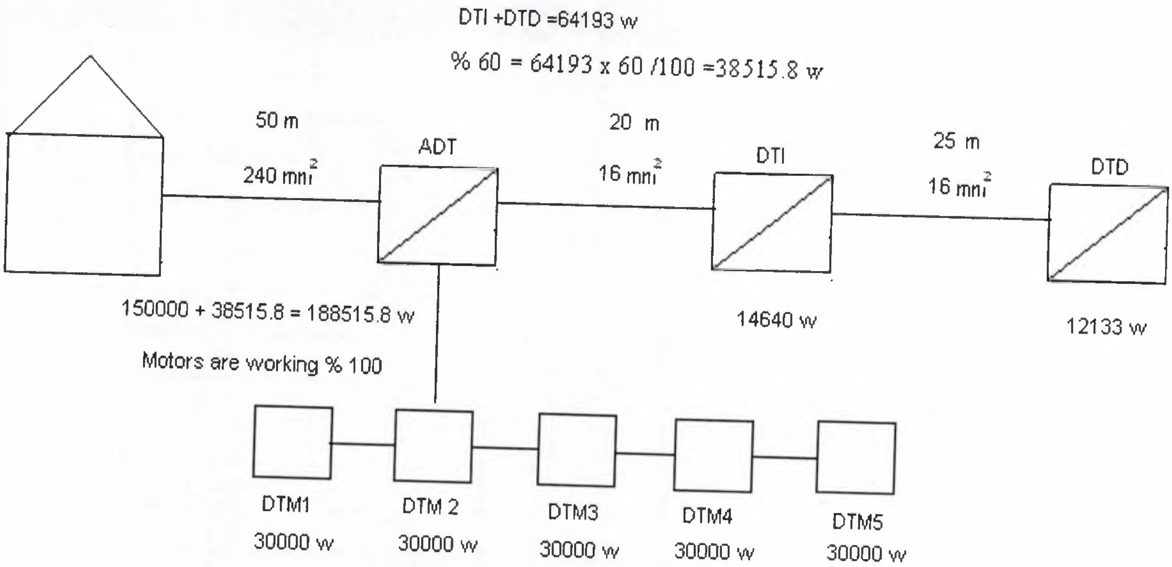
L23= 300 w / 240 V = 1.25 A

P10= 2400 w / 240 V = 10 A

P12= 1800 w / 240 V = 7.5 A

P15= 1200 w / 240 V = 5 A

Voltage Drop Calculation



$\%e1 = 1.24\times10^{-5} \times P \times L / S = 1.24\times10^{-5} \times 188515.8 \times 50\,m / 240$ V = 0.486 V %

$\%e2 = 1.24\times10^{-5} \times P \times L / S = 1.24\times10^{-5} \times 14640\,w \times 20\,m / 16\,mm^2 = 0.22$ V %

$\%e3 = 1.24\times10^{-5} \times P \times L / S = 1.24\times10^{-5} \times 12133\,w \times 25 / 16\,mm^2 = 0.23$ V %

Total Voltage Drop (3 phase)

= e1 + e2 + e3=0.486 V + 0.22 V + 0.23 V = 0.936 V

% 0.936 V

% 0.936 < % 3 That means all the crossectional areas are suitible.

Table of the cross section area,

Kesit S= mm^2	1.Grup A	2.Grup A	3.Grup A
0,75		13	16
1	12	16	20
1,5	16	20	25
2,5	21	27	34
4	27	36	45
6	35	47	57
10	48	65	78
16	65	87	104
25	88	115	137
35	110	143	168
50	140	178	210
70	175	220	260
95	210	265	310
120	250	310	365
150	-	355	415
185	-	405	475
240	-	480	560
300	-	555	645
400	-	-	770
500	-	-	880

7.1.2 Cost calculation report :

Sn.XX's Company ofElectric Project ;

S. NO	MALZEME CİNSİ	BİRİM	MİKTAR	BİRİM FİYAT(YTL)	TOPLAM FİYAT(YTL)
1	Tavan Globu Tes.	adet	5	60,00	300,00
2	Duvar Globu Tes.	"	11	60,00	660,00
3	1x80W Flo. Tes.	"	7	110,00	770,00
4	2x80W Flo. Tes.	"	71	152,00	10.792,00
5	Aplik	"	6	125,00	750,00
6	Mutfak aspiratörü tes.	"	1	130,00	130,00
7	Tel. Prizi Tes.	"	6	88,00	528,00
8	T.V. Anten Prizi Tes.	"	4	90,00	360,00
9	1x13A Priz Tes.	"	6	67,00	402,00
10	2x13A Priz Tes.	"	50	80,00	4.000,00
11	Cooker Kontrol Tes.	"	1	146,00	146,00
12	Semaver Tes.	"	1	164,00	164,00
13	Su Motoru Tes.	"	1	168,00	168,00
14	1X6 Yollu dağıtım taplosu	"	1	385,00	385,00
15	1X8 Yollu dağıtım taplosu	"	1	494,00	494,00
16	3X4 Yollu dağıtım taplosu	"	3	735,00	2.205,00
17	Akım otomatiği (C/O)63A	"	2	182,00	364,00
18	3X8 YOLLU MCCB'Lİ ADT	"	1	5.476,00	5.476,00
19	3X400A MCCB	"	1	1.474,00	1.474,00
20	Akım otomatiği (C/O)3X63A	"	3	330,00	990,00
21	MCCB+ELCB 3X400A	"	1	1.134,00	1.134,00
22	2x16+6mm2 PVC	Metre	30	18,00	540,00
23	4x10+6mm2 PVC	Metre	40	20,90	836,00
24	4x16+6mm2 PVC	Metre	30	30,00	900,00
25	(4X25+6)mm2 PVC	Metre	120	35,00	4.200,00
26	(3X240+120)mm2 ÇZ XLPE	Metre	30	379,00	11.370,00
27	Topraklama Tes.	Adet	11	50,00	550,00
				TOPLAM	**48.358,00**

7.2 HOW TO PREPARE A PROJECT FILE

In this chapter preparation of a project file is discussed. In any project file consist of the followings:

i-Contract

ii-Agreement

iii-Cost Calculation

iv-Land Plan

v- Installation of a project

To begin with, the drawing part of this project could be done. After that, cost calculation could be done as well. In this thesis, the aim of the cost calculation is to learn how much the engineering will learn.

According to this, we have to take the unit price list from KIBRIS TORK MiMARLAR MUHENDİSLER ODASI BİRLIGI (KTMMOB) for doing this calculation. Depend on this price list the cost calculation can be done. How this calculation can be done?

First of all, if we suppose that we have a house, we have to count how many materials and which materials this house has got in it. After that, when we will found them, we are going to find the prices of the materials in the price list. Then, we will multiply number of the materials with price. The total which we will find in here is going to show us the price of the materials. According to the table of the KTMMOB, the total price which we found should be equal to the percentages in the list of KTMMOB, so these percentages will show us how much money we are going to get from here. Then we can easily learn how much we can get from this project. 7 percent of the money should be taken for drawing. Also, 3 percent money will be taken for controlling.

The materials of the underground part of this thesis need nearly 2.700.00 YTL. According to list of the KTMMOB, this money is equal to 9 percentages.

CONTRACT

Contract paper is between the working person and costumer, aim of this paper, both of side writes what does want to from opposite side. And if any side can change decided other side can get money back or get money depends on the conversation between costumer and engineering. This paper should be in the project file.

AGREEMENT

Agreement paper is before starting at work about what is the conversation between engineer and costumer, and you have to make one piece of paper for writing what decided get for this work and both sides have to use that rule. And also they have to put this piece of paper in project file.

COST CALCULATIONS

Cost calculations is making as we write calculations part in chapter seven. And you can see there the cost calculations

LAND PLAN

Land plan is it will show you where you land is and how you can go there also we have to put this piece of paper in Project file

INSTALLATION OF A PROJECT

End of all this work we have prepared one project file as KTMMOB want put all document in this file and bring to visa. All we should them for this work.

CONCLUSION

The thesis is electrical installation of a Factory. This part is the one most important part for engineering. Beginning of this thesis about history for installation, its about what did happen and when did happen is about that.

The thesis is information about Electrical Materials, Electrical Safety protection Earthing, Circuit control devices, supply distribution and control final circuits and finally practical application were given. In the final circuit is about which cable size used and where, which cable size can use.

In the practical part for drawing installation project by using AutoCAD is prepared. The calculation part is by using excel is prepared.

REFERANCES:

1) Electrical Installation Theory and Practice by E.L.Donelly

2) Electrical Installation practice book 15th edition by H.A.Miller

3) Electrical Installation Technology 3rd volume 3rd
edition by F:G:Thompson-J.H.Smith

4) Electrical Installation Workshop and Technology 1st volume
5th edition by F:G:Thompson-J.H.Smith

5) Electrical Installation Workshop and Technology 2nd volume
4th edition by F:G:Thompson-J.H.Smith

6) Proje Diizenleme Esasları ve yardımcı bilgiler kitabı-K.T.M.M.O.B (E,M.O)

7) Binalann Elektirik Tesisatlan için Yonetmenlik-K.T.M.M.O.B (E.M.O)

8) www.ktemo.org