NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

ELECTRICAL INSTALLATION PROJECT DRAWING

Graduation Project
EE- 400

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ABSTRACT

One of the places that are being used for electricity is our houses. We always need it. So, for using it safely and for our needs we firstly have pay great attention for the basis of the installation for the electricity. So, I examined the installation for a typical villa except some special applications in this project. I firstly examined about the wiring installation and about history. And then, I carried on examining the insulators that is so significant in electrical protection and we use everywhere in our lives nowadays. And after that, I examined the conductor that is being protected with these insulator, the wirings. And then, I gave place in my project on switch and sockets upon depending on the differences of voltage and frequency around the world. After giving all these, I went in to my main subject that is electrical installation. I finished my last chapter that is drawing Project that I have prepared with the electrical security and protection ways

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CHAPTER 1
GENERALS

1.1 Historical Review of Installation Work

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

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

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

The first electric motor drives in light industries were in the form of one motor-unit per line of shafting. Each motor was started once a day and continued to run throughout the whole working day in one direction at a constant speed. All the various machines driven from the shafting were started, stopped, reversed or changed in direction and speed by mechanical means. The development of integral electric drives, with provisions for starting, stopping and speed changes, led to the extensive use of the motor in small kilowatt ranges to drive an associated single machine, e.g. a lathe. One of the pioneers in the use of motors was the firm of Bruce Peebles, Edinburgh. The firm supplied, in the 1890s, a number of weatherproof, totally enclosed motors for quarries in Dumfries shire, believed to be among the first of their type in Britain. The first electric winder ever built in Britain was supplied in 1905 to a Lanark oil concern. Railway electrification started as long ago as 1883, but it was not until long after the turn of this century that any major development took place.

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

Siemens Brothers made the first application of a lead sheath to rubber-insulated cables. The manner in which we name cables was also a product of Siemens, whose early system was to give a cable a certain length related to a standard resistance of 0.1 ohm. Thus a No.90 cable in their catalogue was a cable of which 90 yards had a resistance of 0.1 ohm. The Standard Wire Gauge also generally knew Cable sizes.

For many years ordinary VRI cables made up about 95 per cent of all installations. They were used first in wood casing, and then in conduit. Wood casing was a very early invention. It was introduced to separate conductors, this separation being considered a necessary safeguard against the two wires touching and so causing fire. Choosing a cable at the turn of the century was quite a task. From one catalogue alone, one could choose from fifty-eight sizes of wire, with no less than fourteen different grades of rubber insulation. The grades were described by such terms as light, high, medium, or best insulation. Nowadays there are two grades of insulation: up to 600 V and 600 V/1,000 V. And the sizes of cables have been reduced to a more practicable seventeen.

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

As experience increased with the use of TRS cables, it was made the basis of modified wiring systems. The first of these was the Calendar farm-wiring system introduced in 1937. This was tough rubber sheathed cable with a semi-embedded braiding treated with a green-colored compound. This system combined the properties of ordinary TRS and HSOS (house-service overhead system) cables.

So far as conductor material was concerned, copper was the most widely used. But aluminum was also applied as a conductor material. Aluminum, which has excellent electrical properties, has been produced on a large commercial scale since about 1890. Overhead lines of aluminum were first installed in 1898. Rubber-insulated aluminum cables of 3/0.036 inch and 3/0.045 inch were made to the order of the British Aluminum Company and used in the early years of this century for the wiring of the staff quarters at Kinlochleven in Argyllshire. Despite the fact that lead and lead-alloy proved to be of great value in the sheathing of cables, 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 used compressed magnesium oxide as the insulation, and had a copper sheath and copper conductors. The cable was first developed in 1897 and was first produced in France. It has been made in Britain since 1937, first by Pyrotenax Ltd, and later by other firms. Mineral insulation has also been used with conductors and sheathing of aluminum.

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

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.

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

It was one thing to produce a lamp operated from electricity. It was quite another thing to devise a way in which the lamp could be held securely while current was flowing in its circuit. The first lamps were fitted with wire tails for joining to terminal screws. It was Thomas Edison who introduced, in 1880, the screw cap, which still bears his name. It is said he got the idea from the stoppers fitted to kerosene cans of the time. Like much another really good idea, it superseded all its competitive lamp holders and its use extended through America and Europe. In Britain, however, it was not popular. The Edison & Swan Co. about 1886 introduced the bayonet-cap type of lamp-holder. The early type was soon improved to the lamp holders we know today.

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

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

Early fuses consisted of lead wires; lead being used because of its low melting point.

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

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

1.2 Historical Review of Wiring Installation

The history of the development of non-legal and statutory rules and regulations for the wiring of buildings is no less interesting than that of wiring systems and accessories. When electrical energy received a utilization impetus from the invention of the incandescent lamp, many set themselves up as electricians or electrical wiremen. Others were gas plumbers who indulged in the installation of electrics as a matter of normal course. This was all very well: the contracting industry had to get started in some way, however ragged. But with so many amateurs troubles were bound to multiply. And they did. It was not long before arc lamps, sparking commutators, and badly insulated conductors contributed to fires. It was the insurance companies, which gave their attention to the fire risk inherent in the electrical installations of the 1880s. Foremost among these was the Phoenix Assurance Co., whose engineer, Mr. Heaphy, was told to investigate the situation and draw up a report on his findings.

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

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

Three months after the issue of the Phoenix Rules for wiring in 1882, the Society of

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

The Rules have since been revised at fairly regular intervals as new developments and the results of experience can be written in for the considered attention of all those concerned with the electrical equipment of buildings. Basically the regulations were intended to act as a guide for electricians and others to provide a degree of safety in the use of electricity by inexperienced persons such as householders. The regulations were, and still are, not legal; that is, the law of the land cannot enforce them. Despite this apparent loophole, the regulations are accepted as a guide to the practice of installation work, which will ensure, at the very least, a minimum standard of work. The Institution of Electrical Engineers (IEE) was not alone in the insistence of good standards in electrical installation work. In 1905, the Electrical Trades Union, through the London District Committee, in a letter to the Phoenix Assurance Co., said ' . . . they view with alarm the large extent to which bad work is now being carried out by electric light contractors . . .. As the carrying out of bad work is attended by fires and other risks, besides injuring the Trade, they respectfully ask you to. . Uphold a higher standard of work'.

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

While the IEE and the statutory regulations were making their positions stronger, the British Standards Institution brought out, and is still issuing, Codes of Practice to provide what are regarded as guides to good practice. The position of the Statutory

Regulations in this country is that they form the primary requirements, which must by law be satisfied. The IEE Regulations and Codes of Practice indicate supplementary requirements. However, it is accepted that if an installation is carried out in accordance with the IEE Wiring Regulations, then it generally fulfils the requirements of the Electricity Supply Regulations. This means that a supply authority can insist upon all electrical work to be carried out to the standard of the IEE Regulations, but cannot insist on a standard which is in excess of the IEE requirements.

CHAPTER 2
INSULATORS

2.1 What is the insulator

An insulator is unable to conduct electricity because its electrons are bound tightly to their nuclei, they cannot move freely from atom to atom. In conductors, electrons move freely because they are weakly bound to their nuclei. This results in the flow of electricity.

Many materials are used for the insulation of cable conductors. The basic function of any cable insulation is to confine the electric current to a insulating materials chosen for this duty must be efficient and able to with stand the stress of the working voltage of the supply system to which the cable is connected. The following are some of the more common materials used for cable insulation. Most solid materials are classified as insulators because they offer very large resistance to the flow of electric current. Metals are classified as conductors because their outer electrons are not tightly bound, but in most materials even the outermost electrons are so tightly bound that there is essentially zero electron flow through them with ordinary voltages. Some materials are particularly good insulators and can be characterized by their high resistivities

Table 2.1 Comparing of the resistivity of copper

	Resistivity (ohm m)
Glass	10^12
Mica	9 x 10^13
Quartz (fused)	5 x 10^16

	Resistivity (ohm m)
Copper	1.7 x 10^-8

2.1.1 Rubber

This was one of the most common insulating materials units it was largely replaced by PVC. In old wiring system it is found in its 'vulcanized form', which is rubber with about 5 percent sulphur. It is flexible, impervious to water but suffers (it hardens and becomes brittle) when exposed to a temperature above 55 C. Because the sulphur content in the rubber attacks cooper, the wires are always tinned. About the only application for rubber as insulation material for conductors nowadays is in domestic flexible used for hand appliances such as electric irons. The working temperature is 60C

2.1.2 85 C Rubbers

This material is a synthetic rubber designed for working temperatures up to 85 C .It is in its flexible cord format used for hot situations such as immersion heaters and night storage heaters where the heat from elements can travel into the flexible conductors. As a sheating material it is susceptible to oil and grease and thus such flexible are sheathed with chloro-sulphonated polyethylene (CSP).The type of sheath is known as HOFR (heat and oil resisting and flame retardant).Often used for heavy-duty applications, it is found in its large csa size feeding exterior equipment such as mobile cranes and conveyors.

2.1.3 Silicone rubber

This material is sometimes designated 150 C insulation and can operate in a continuous temperature up to that level. Applications of this fire-resistant cable include the wiring of fire alarm, security and emergency lighting circuits where there need for these circuit to function in fire condition. It is also useful when connections have to be made to terminals in enclosures in which heat might be considerable, such as in enclosed lamp fittings and heaters.

2.1.4 Pvc

This material is polyvinyl chloride and is now the most common insulating material used for cables and flexible at low voltages. Its insulating properties are actually less than those for rubber. However it is impervious to water and oil and can be self-colored without impairing its insulation resistance qualities. The maximum working temperature is 70 C, above which the PVC will tend to become plastic and melt. If PVC is exposed to a continuous temperature of around 115 C it will produce a corrosive substance which will attack cooper and brass terminals. At low temperatures, round 0 C, the PVC tends to become brittle and it is not recommended for PVC cables to be installed in freezing conditions. Apart from its use as conductor insulation, it is used as a sheating material. It's most common from is in the cables used for domestic wiring and for domestic flexible.

2.1.5 Paper

Paper has been use as an insulating material from the very days of the electrical industry. The paper, however, is impregnated to increase its insulating qualities and to prevent its being impaired by moisture. The cables are sheathed with lead and armoured with steel or aluminium wire or tape. Such cables are mainly used for large loads at high voltages.

2.1.6 Mineral insulation

This is composed of magnesium oxide powder and is used in the type of cable known as MIMS (mineral-insulated metal-sheathed) with the sheath usually made from cooper. It was originally developed to withstand both fire and explosion, but is now used for more general application. The cable is non-ageing and can be operated with sheath temperatures of up to 250 C .Because the magnesium oxide is hygroscopic (it absorbs moisture) the cable ends must always be seals. The temperature limits of the seal depend on the cable's application.

2.1.7 Glass Insulation

This material is very heat-resistant and is used for temperatures as high as 180 C. As glass-fibre, the insulation takes the from of impregnated glass-fibre braiding. This insulation is found commonly in the internal wiring of electric cookers or other appliances where the cable must be impervious to moisture, resistant to heat and be tough and flexible.

2.1.8 Mica

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

2.1.9 Ceramics

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.

Fig. 2.1 Ceramics

2.1.10 Strong Ceramic (Silicon Nitride: Si_3N_4)

Silicon nitride and silicon carbide are considered strong ceramics because of their characteristics.

Si_3N_4 is formed by the combination of powders or gases and a series of chemical reactions. This material is dark gray to black in color and can look very smooth when polished. Silicon nitride has excellent performance qualities: It exhibits high strength over a wide range of temperatures; it has very good wear resistance to physical and thermal stresses; and it is a good insulator.

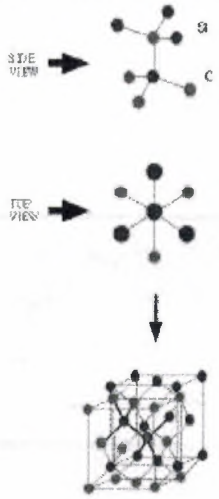


Fig.2.2 Si_3N_4, crystal structure and bonding

CHAPTER 3
CONDUCTOR & CABLES

3.1 Conductors

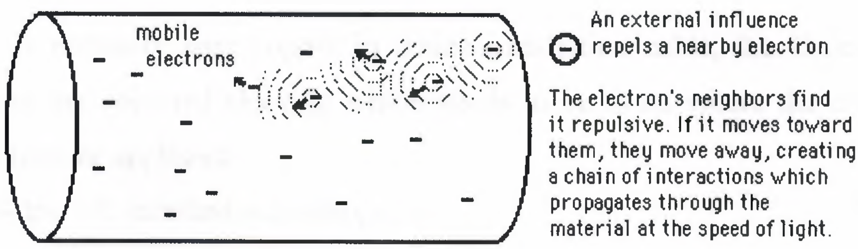


Fig 3.1 Cross section of cooper wire

In a conductor, electric current can flow freely, in an insulator it cannot. Metals such as copper typify conductors, while most non-metallic solids are said to be good insulators, having extremely high resistance to the flow of charge through them. "Conductor" implies that the outer electrons of the atoms are loosely bound and free to move through the material. Most atoms hold on to their electrons tightly and are insulators. In copper, the valence electrons are essentially free and strongly repel each other. Any external influence which moves one of them will cause a repulsion of other electrons which propagates, "domino fashion" through the conductor.
Simply stated, most metals are good electrical conductors, most nonmetals are not. Metals are also generally good heat conductors while nonmetals are not.

3.2 Domestic Electric power cable colours in the UK

March 2004 saw amendment 2 to British Standard BS 7671 (Requirements for Electrical Installations). Probably the most significant change introduced for the diyer was the change of colour coding of electric cable.

3.2.1 Core and Earth Cable

Pre March 2004 the UK standard for '2 core and earth' cable used in single phase (i.e. normal household) installation was:

Live Red

NeutralBlack

Earth Green and Yellow (see note)

The earth feed is normally bare copper in mains installation cable, the Green and Yellow applies to the coloured sleeving which needs to be fitted where the earth is connected to a fitting or appliance.

Post March 2004 the UK standard was changed to:

Live Brown

NeutralBlue

Earth Green and Yellow (no change)

These are may recognise new colour coding is the same as used for appliance flexes in the UK for many years.

3.2.2 Core and Earth Cable (two way lighting)

Pre March 2004 the UK standard for '3 core and earth' cable used in two way lighting was blue, yellow and red with a bare copper earth.

Post March 2004 the UK standard was changed to Grey, Black and Brown with a bare copper earth.

3.2.3 Reason of the changing color

As with so very much these days, the change is the result of international standardization (or harmonization) with most of Europe already using this colour coding - the new colours are sometimes referred to as 'harmonized'.

3.3 Electric power cables in the UK

Domestic electric cable is usually available to British Standard BS 6004. The standard UK domestic electricity supply is 240 volts AC. Solid core cables should never be reused - although they can be bent into shape, they are not designed to be flexed and repeated movement can weaken the cores causing then to become weak, overheat or fail.

3.3.1 Twin Core and Earth (general internal power cables)

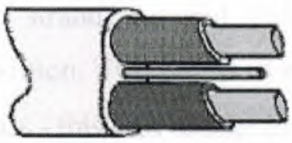


Fig 3.2 Twin Core and Earth

Consists of two insulated solid cores (brown and blue, respectively live and neutral) with a bare copper earth conductor between the inner cores and an overall PVC sheath.

Table 3.1 Cable size and their using purpose

Core size mm2	Current (A)	Wattage (kW) at 240V	Typical applications
1.0	14	3.25	Lighting
1.5	18	4.25	Lighting
2.5	24	5.75	Power circuit
4.0	32	7.75	Power circuit, shower
6.0	40	9.75	Shower, cooker
10	53	12.9	Cooker

The currents and wattages shown are for the cables in 'free air' installations, the cables should be derated if cables are run together or in such a way that the thermal rise of the cable is not free to dissipate.

Rubber insulated, two core (multi strand) covered with an outer lead sheath. If there is any of this very old wiring still installed, it should be isolated and replaced immediately. With the age of this type of cable, it is almost guaranteed that the rubber insulation will be degraded and breaking down, any failure of the insulation can cause the outer covering to become live - an installation still using this type of wiring is unlikely to have modern trips fitted in the consumer unit or a master earth leakage trip.

Rubber insulated, two or three core (multi strand) covered with an outer rubber sheath. The danger with this type of cables is the degrading of the rubber especially where a terminal has become overheated. The wiring should be considered ready for replacement.

PVC insulated, three core (multi strand) covered with an outer PVC sheath, and this may still be in good physical condition. Two points to watch for are:

1. Broken individual strands - this will reduce the current carrying capacity of the cable and can cause the wire to overheat at screw terminals.
2. Earth wires which are just twisted together - this is not a function of the cable but the method of installation common at the time this type of cable was available.

3.3.2 Core and Earth (normally used for the connections between two way switches)

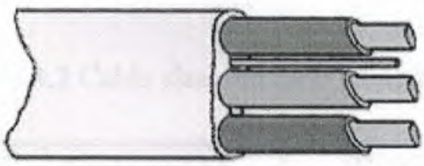


Fig 3.3 Three core cable

Consists of three insulated solid cores (blue, yellow and red) with a bare copper earth conductor between the inner cores and an overall PVC sheath. The alternative harmonized colours are grey, black and brown

Core size mm2	Current (A)	Wattage (KW) at 240V	typical applications
1.0	12	2.75	lighting double pole switching

3.3.3 Armoured cable

Fig 3.4 Armoured cable

Armoured cable is normally used to transfer power either underground or overhead. The construction is normally the inner cores (which are generally multi strand) being individually sheathed, then covered by an initial overall plastic sheath, followed by the protective wire armour with a final outer sheath to hold it all together. The inner cores may number two, three or four depending upon the application.

The wire protective armour should always be earthed at one end to ensure that it cannot become live if a fault should develop within the cable.

Installation of armour cable should be left to professional contractors, not so much because it is difficult but because of the safety implications if overhead or underground installations should fail to meet the exacting installation requirements.

The ratings below are typical for three core armoured cable but individual manufacturers will give specific ratings for their own cables which should be used in preference to the following.

Table 3.2 Cable size and their using range

Core size mm2	Current (A)	Wattage (kW) at 240V
1.5	18	4.25
2.5	24	5.75
6.0	41	9.9
10.0	56	13.5
16.0	85	20.5
25.0	104	25.25

CHAPTER 4
PLUGS & SOCKETS

4.1 History of Plugs & Sockets

When electricity was first introduced into the domestic environment, it was primarily for lighting. However, as it became a viable alternative to other means of heating and also the development of labour-saving appliances, a means of connection to the supply other than via a light socket was required. In the 1920s, the two-pin plug made its appearance.

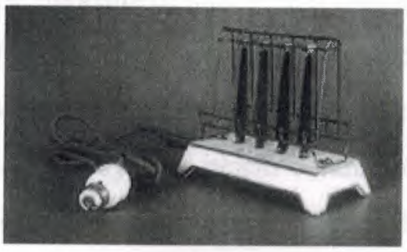


Fig.4.1 Light fitting plug with toaster

At that time, some electricity companies operated a split-tariff system where the cost of electricity for lighting was lower than that for other purposes, which led to low-power appliances (e.g. vacuum cleaners, hair driers, etc.) being connected to the light fitting.
As the need for safer installations grew, earthed three-contact systems were developed.
The reason we have over a dozen different styles of plugs and wall outlets is that many countries preferred to develop plug designs of their own, instead of adopting a common standard. In many countries, there is no single standard, with multiple plug designs in use, creating extra complexity and potential safety problems for users.
However, as shown below, most countries have settled on one of a few common de facto standards; though there are legacy installations of obsolete wiring conventions in most regions of the world. Some buildings have wiring that's been in use for almost a century and which pre-date all modern standards.

4.2 Domestic AC power plugs and sockets

They allow a connection between the mains (domestic, usually single-phase, AC electrical power) and the appliances commonly used in homes.

A power plug is a mechanical connector that fits into a power point or electrical socket. It has male features, usually brass and often tin or nickel plated, that interface mechanically and electrically to the mains. Such plugs have a live contact, a neutral contact, and an optional earth. In many types of plugs there is no distinction between live and neutral and in a few cases both main pins may be live.

A power socket (electrical socket, power point, mains socket, plug-in, outlet, receptacle, or female power connector) is a connection point that delivers mains electricity when a plug is inserted into it. It is the opposite of a plug, and usually has only female features.

Most common household power is "single phase." In some countries two (which may be split phase two phase or two phases from 3 phase) or even three phases are wired into a home. However in most places only one phase conductor along with the neutral is connected to each normal socket. Large appliances with higher power requirements may use three-phase current and have phase 1, phase 2, and phase 3 contacts, an earth contact and in some cases a neutral contact.

4.3 The three contacts

4.3.1 Live

The live contact carries an alternating current (generally in the form of a sine wave as voltage is measured relative to the neutral). The exact voltage varies by country, as set by national regulations and industry standards. In a few cases (older installations in Scandinavian countries, the outputs of British site isolation transformers and probably a few other cases) both main conductors may be live, either being two phases from a three-phase system or being from a single-phase transformer with centre-tapped output. Some socket designs do not provide for polarization and some that do are commonly wired either way round.

4.3.2 Neutral

The neutral contact is in most (but not all) cases referenced to the earth and except under fault conditions generally does not pose a danger but is nevertheless treated as live in most installation practices.

The main danger than can be posed by the neutral is it becoming live after a broken neutral in the wiring. Neutral and earth are strongly related and more info on this can be found in Ground (power)

4.3.3 Earth

The earth contact is only intended to carry current when connected to a faulty instrument (except for EMI/RFI filters which do cause a small current down the earth): if a bare live wire in a device gets loose and touches the metal casing of the appliance (called a "short"), somebody touching this part may receive an electric shock. Hence, according to the law in many countries, devices with metal outer casing must use a three-contact plug, and the metal casing must be connected to the earth contact. So, in the event of this kind of fault, the ground will carry off the current and drag the case to earth potential. Also, as this is a short circuit, the circuit breaker will open, or the fuse will blow. On first sight, it might seem that one can get the same protection by connecting the casing to the neutral instead of the earth wire but this has safety problems of its own more info on this can be found in Ground (power)

4.4 Types of Plug & Sockets

Electrical plugs and their sockets differ by country in shape and size. Figure designate each type by a letter, following US government practice, plus a short comment in parentheses giving its country of origin and number of contacts. Subsections then detail the subtypes used in various parts of the world.

Fig 4.2 Voltage/Frequency

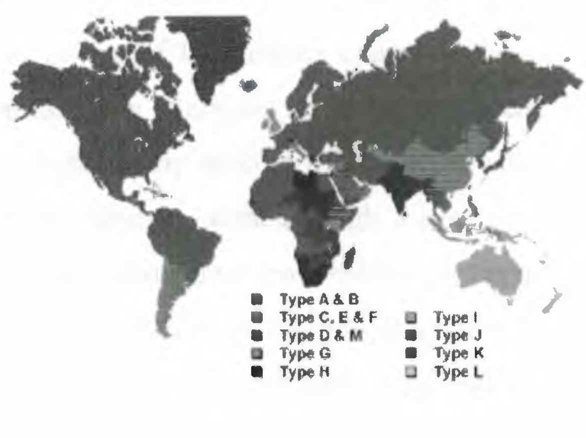


Fig 4.3 Type Switch& Sockets

4.4.1 Type A (American 2-pin)

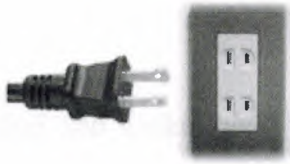


Fig.4.4 Type A (American 2-pin)

Sockets with two live connections and a neutral are also common in America but not elsewhere.

However, this article concentrates on single-phase plugs and sockets for common domestic use where three-phase power is not usually available.

Those planning to travel with electrical equipment should also review the electrical travelers guide

A polarized American class II plug and socket. This plug can only be inserted into the socket in one manner, with the wider pin — the neutral contact — being inserted on the left.

NEMA 1-15

This class II unearthed plug with two flat parallel pins is standard in most of North America and Central America on devices not requiring a ground connection, such as lamps and "double-insulated" small appliances. The corresponding sockets are now restricted in Canada and much of the U.S. in favour of the earthed class-I sockets, below, but remain in place in many older homes. Early examples were not polarized, but later ones distinguish the neutral (return) conductor by making it slightly broader than the hot one. It should be borne in mind that America went through a period of grounding appliance casings to the neutral and therefore great care should be taken about polarity when wiring such plugs and sockets and American two-pin plugs should not be changed for any unpolarised type without checking the appliance is not grounded to the neutral. Attention should also be paid to this when running American appliances off a centre-tapped supply such as British site isolation transformers.

NEMA 2-15, 2-20, and 2-30

These class II unearthed plugs with two flat parallel pins are 240 V variants of the 1-15. The 2-15 has both pins rotated 90 degrees; the 2-20 has one pin rotated 90 degrees, and the 2-30 is rotated. These are all fairly rare types.

JIS 8303, Class II

At first glance, the Japanese plug and socket seem to be identical to NEMA 1-15. However, the Japanese system incorporates tighter dimensional requirements, different marking requirements, and mandatory testing and approval by MITI or JIS. Furthermore, standard wire sizes and the resulting current ratings are different than those used elsewhere in the world.

4.4.2 Type B (American 3-pin)

Fig.4.5 Type B (American 3-pin)

An American class I plug. This type of plug has an earthing pin. Adaptors (called "cheater plugs") allow the insertion of this class of plug into a class II socket, which lacks the earth connector.

NEMA 5-15 / CS22.2, N°42

This is a class I plug with two flat parallel pins and an earthing pin (American standard NEMA 5-15/Canadian standard CS22.2, N°42). It is rated at 15 amps. This is the plug in the illustration. The earthing pin is longer than the two parallel pins so that the device is earthed before the supply is connected.

Homes in the U.S. and Canada are normally supplied with both legs and the neutral of a centre-tapped 240V transformer, making both (nominal) 120 V and 240 V readily available. Lighting circuits and general-purpose outlets, including those illustrated here, are connected to either, but not both, legs (which in common usage are referred to as "phases") and thus supply 120V.

JIS 8303, Class I

Japan uses a type B that differs from its American counterpart in the same way that the type A one does. It is, however, much less common.

Latin American type B

An unearthed version of the North American NEMA 5-15 plug is commonly used in Central America and parts of South America. It is therefore common for users who have bought North American appliances to simply cut off the earthing pin so that the plug can be mated with a two-pole unearthed socket.

4.4.3 Type C (Europlug 2-pin)

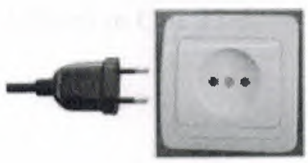


Fig.4.6 Type C (Europlug 2-pin)

The CEE 7/16 plug is the most widely used plug in much of Europe. This type of plug is not earthed.

This two-wire plug is unearthed and has two round, 19 mm pins, which usually converge slightly. It is popularly known as the Europlug which is described in It is probably the single most widely used international plug. It will mate with any socket that accepts 4.0 mm round contacts spaced 19 mm apart. It is commonly used in all countries of Europe except the UK, Ireland, and (former) UK dependencies such as Malta. It is also used in various parts of the developing world. This plug is generally limited for use in class II applications that require 2.5 amps or less. It is, of course, unpolarised. This plug is also defined in Italian standard CEI 23-5

CEE 7/17

Fig.4.7 CEE 7/17

This peculiar unpolarised plug might easily be categorized under E or F. It has two pins like 7/16 does, but they are 4.8 mm in diameter like types E and F, and also a round, plastic or rubber base that stops the plug being inserted into small sockets that 7/16 can fit into. Instead, only large round sockets such as those intended for types E and F can take it. The base has holes in it to accommodate both side contacts and socket earth pins. Class II applications. Also defined in CEI 23-5.

BS 4573

Fig. 4.8 BS 4573

In the United Kingdom and Ireland, there is a special version of the type C plug for use with shavers (electric razors) in bathrooms (where normal sockets cannot be used close to wet zones). It has 5 mm diameter pins on 16.6 mm pitch, and can often take CEE 7/16, US and/or Australian plugs. They are also often capable of supplying either 230 V or 115 V. In wet zones, they must contain an isolating transformer compliant with BS 3535.

4.4.4 Type D (Old British 3-pin)

BS 546, 5 amps

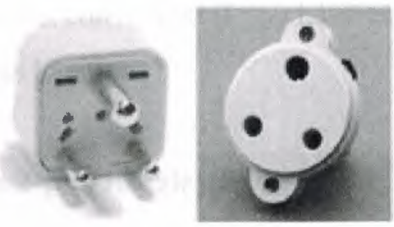


Fig.4.9 Type D (Old British 3-pin)

India has standardized on a plug which was originally defined in British Standard 546. It has three large round pins in a triangular pattern, and is now almost exclusively used in India, Sri Lanka, Nepal, Namibia and Hong Kong. However, this 5 amp plug, along with its 2 amp cousin, is sometimes used in the UK for centrally-switched domestic lighting circuits, in order to distinguish them from normal power circuits.

BS 546, 15 amps

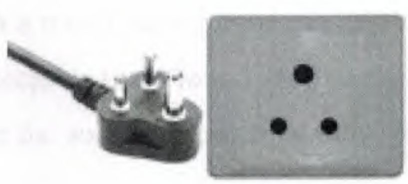


Fig.4.10 BS 546

This plug is sometimes referred to as type M, but it is in fact merely the 15 A version of the plug above, which it resembles, though its pins are much larger: 7.05 mm × 21.1 mm.

Live and neutral are spaced 25.4 mm apart, and earth is 28.6 mm away from each of them. Although the preceding type is standard in India, Sri Lanka, Nepal and Namibia, the 15 A version is also used for larger appliances. Some sockets over there can take both types of plugs. Some countries like South Africa use it as the main domestic plug and socket type. The Type M is almost universally used in the UK for dimmable theatre and architectural lighting installations. It is also often used for non-dimmed but centrally controlled sockets within such installations. The main reason for doing this is that fused plugs, while convenient for domestic wiring (as they allow 32 A socket circuits to be used safely), are not convenient if you have extension cords powering equipment indifficult-to-access locations

4.4.5 Type E (French 2-pin, female earth)

Fig. 4.11 French type E

France, Belgium and some other countries have standardized on a socket which is not compatible with the CEE 7/4 socket (type F) that is standard in Germany and other continental European countries. The reason for incompatibility is that earthing in the E socket is accomplished with a round male pin permanently mounted in the socket. The plug itself is similar to C except that it is round and has the addition of a female contact to accept the earthing pin in the socket. It has two round pins measuring 4.8 × 19 mm, spaced 19 mm apart.

The pins are slightly thicker than those of type C; as a consequence, they do not fit into type L sockets, but may be generally forced into them (care must be taken when pulling out the plug not to pull the socket as well).

4.4.6 Type F (German 2-pin,side clip earth)

CEE 7/4

Fig 4.12.CEE 7/4 Schuko

Plug F, known as CEE 7/4 and commonly called a "Schuko plug", is like E except that it has two earthing clips on the sides of the plug instead of a female earth contact. Because the CEE 7/4 plug can be inserted in either direction into the receptacle, the Schuko connection system is unpolarised (i.e. live and neutral are connected at random). It is used in applications up to 16 amps. Above that, equipment must either be wired permanently to the mains or connected via another higher power connector such as the IEC 309 system.

"Schuko" is an abbreviation for the German word *Schutzkontakt*, which means "Protective (i.e. earth) contact".

CEE 7/7

Fig. 4.13 CEE 7/7

In order to bridge the differences between sockets E and F, the CEE 7/7 plug was developed: it has earthing clips on both sides to mate with the CEE 7/4 socket and a female contact to accept the earthing pin of the type E socket. Nowadays, when appliances are sold with type E/F plugs attached, the plug is CEE 7/7 and non-rewirable. This means that the *plugs* are identical in countries like France and Germany:

only the *sockets* are now different. One is only likely to come across type E/F plugs that are not compatible with the other type if for some reason a cheap replacement plug has been attached to a cord that originally had another plug.

Note that the CEE 7/7 plug is polarized when used with a type E outlet. The plug is rated at 16 amps. Above that, equipment must either be wired permanently to the mains or connected via another higher power connector such as the IEC 309 system.

Gost 7396

The countries of the CIS use a standard plug and socket defined in Russian Standard Gost 7396 which is similar to the Schuko standard. Contacts are also 19 mm apart, but the diameter of these pins is 4.0 mm (like C) instead of 4.8 mm (E and F). It is possible to mate Russian plugs with Schuko outlets, but Russian sockets will not allow to connect type E and F plugs as the outlets have smaller hole diameters than the pins of those two plugs mentioned. Many official standards in Eastern Europe are virtually identical to the Schuko standard. Furthermore, one of the protocols governing the reunification of Germany provided that the DIN and VDE standards would prevail without exception. The former East Germany was required to conform to the Schuko standard. It appears that most if not all of the Eastern European countries generally use the Schuko standard internally but, until recently, they exported appliances to the Soviet Union with the Soviet standard plug installed. Because the volumes of appliance exports to the Soviet Union were large, the Soviet plug has found its way into use in Eastern Europe as well.

4.4.7 Type G (British 3-pin)

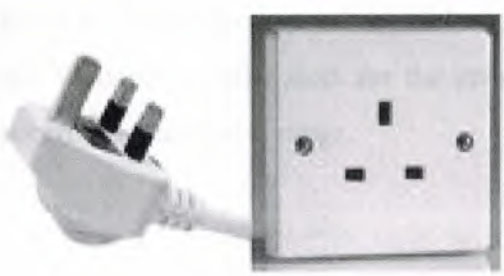


Fig.4.14 Type G (British 3-pin)

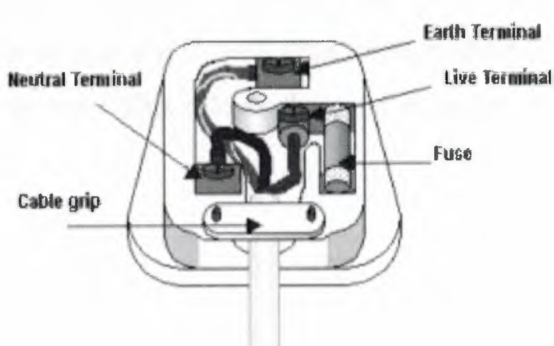


Fig.4.15 Inside of the Type G

BS 1363

This plug has three rectangular prongs that form a triangle. Live and neutral are $4 \times 6 \times 18$ mm with 9 mm of insulation (the insulation ensures that even small fingers cannot touch any live part of the prongs while unplugging an appliance), and spaced 22 mm apart. Earth is $4 \times 8 \times 23$ mm. British Standard BS 1363 requires use of a three-wire earthed and fused plug for all connections to the power mains (including class II, two-wire appliances).

The fuse in the plug is chosen to match the current taken by the appliance, from 3–13 amps. BS 1363 was published in 1962 and since that time it has gradually replaced the earlier standard plugs and sockets (type D) (BS 546).

This very safe system is used in the UK and many of its former colonies. See BS 1363 for further information on safety features, where it is used, and more.

4.4.8 Type H (Israeli 3-pin)

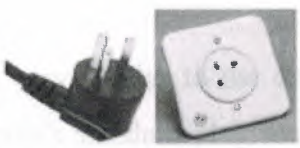


Fig.4.16 Type H (Israeli 3-pin)

SI 32

This plug, defined in SI 32, is unique to Israel and is incompatible with all other sockets. It has two flat pins like the type B plug, but they form a V-shape rather than being parallel like B plugs. Rated at 16 amps, it also has an earthing pin. Visitors to Israel will find that in practice, sockets are manufactured with widening in the middle of the V-shape-oriented slots for the energized prongs. This allows the type H socket to accommodate type C plugs.

4.4.9 Type I (Australian 2/3-pin)

AS 3112

Fig.4.17 Type I (Australian 2/3-pin)

This plug, used in Australia and New Zealand, has also an earthing pin and two flat pins forming a V-shape. There is an unearthed version of this plug as well, with only two flat V-aligned pins. These flat blades measure 6.5 by 1.6 mm and are set 30° to the vertical on a nominal pitch of 13.7 mm. It is easy to bend them straight with pliers to force them into American sockets.

Although the above plug looks very similar to the one used in Israel (type H), both plugs are not compatible. Australia's standard plug/socket system is described in SAA document AS 3112 and is used in applications up to 10 A. As of 2003, the latest major update is AS/NZS 3112:2000, which mandates insulated pins by 2005.

A variant plug with a slightly longer, wider and thicker earth pin is used for devices drawing up to 15 amperes; sockets supporting this pin will also accept 10 A plugs.

Wall sockets almost always have switches on them for extra safety, as in the UK.

New Zealand and Papua New Guinea have the same system as Australia.

CPCS-CCC

Fig.4.18 CPCS-CCC

CCC Mark

Although there are slight differences (the pins are 1 mm longer) the Australian plug mates with the socket used in the People's Republic of China (mainland China). The standard for Chinese plugs and sockets was set out in GB 2099.1–1996 and GB 1002–1996. As part of China's commitment for entry into the WTO, the new CPCS (Compulsory Product Certification System) has been introduced, and compliant Chinese plugs have been awarded the CCC (China Compulsory Certification) Mark by this system. The plug is three wire, grounded, rated at 10 A, 250 V and used for Class 1 applications.

IRAM 2073

The Argentine plug is a three-wire, earthed plug rated at 10 A, 250 V used in Class 1 applications in Argentina and Uruguay.

This plug is similar in appearance to the Australian and Chinese plugs. The pins are 1 mm longer than those of the Australian version and there are slight differences in the specified body dimensions.

The most important difference lies in how the Argentinean plug is wired: the positions of the live and neutral contact pins are reversed from those of the Australian plug. With devices conforming to current standards this should not matter too much in practice as neutral is generally treated with the same care as live in appliance design. However with older or non-complying equipment, using for example single pole switches to break only the live conductor rather than both live and neutral, this difference can be dangerous.

4.4.10 Type J (Swiss 3-pin)

SEV 1011

Switzerland has its own standard which is described in SEV 1011. This plug is similar to C, except that it has the addition of an earth pin off to one side. Swiss sockets can take europlugs (CEE 7/16). This connector system is rated for use in applications up to 10 amps. Above 10 amps, equipment must be either wired permanently to the electrical supply system with appropriate branch circuit protection or connected to the mains with an appropriate high power industrial connector.

This type of socket can also be sporadically encountered in buildings in Spain.

Switzerland also has a 2 pin plug, with the same pin shape, size and spacing as the SEV 1011's live and neutral pins, but the hexagonal form factor is more flattened. It fits into both Swiss sockets (round and hexagonal) and CEE 7/16 sockets and is rated for up to 10 amps.

4.4.11 Type K (Danish 3-pin)

Fig.4.19 Type K (Danish 3-pin)

107-2-D1

Afsnit 107-2-D1

The Danish standard is described in Afsnit 107-2-D1. The plug is similar to F except that it has an earthing pin instead of earthing clips. The Danish socket will also accept the CEE 7/4, CEE 7/7, CEE 7/16 or CEE 7/17 plugs; however, there is no earthing connection with these plugs because a male earth pin is required on the plug. The correct plug must be used in Denmark for safety reasons. A variation of this plug intended for use only on surge protected computer circuits has been introduced. The current rating on both plugs is 10 A.

4.4.12 Type L (Italian 3-pin)

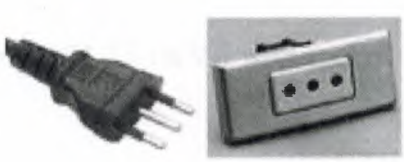


Fig.4.20 Type L (Italian 3-pin)

23-16/VII rewirable

The Italian earthed plug/socket standard, CEI 23-16/VII, includes two styles rated at 10 and 16 amps and differ in terms of contact diameter and spacing. Because they can be inserted in either direction at random, both are unpolarised. CEE 7/16 (type C) plugs are also in common use. Appliances with CEE 7/7 plugs are often sold in Italy, but not every socket can take them.

CEI 23-16/VII, 10-amp style

The 10 amp style is like C except that it is earthed by means of a central earthing pin. Italian sockets designed to accept the Schuko plugs often have an extra hole in the centre so that 10-amp type L plugs can also be inserted. These plugs are otherwise incompatible with any other socket.

This plug is relatively standardized in Libya, Ethiopia, and Chile and is found randomly throughout North Africa, and occasionally in old buildings in Spain.

CEI 23-16/VII, 16 amp style

The 16-amp style is even more idiosyncratic. The pins are a couple of mm further apart, and all three are slightly thicker. The sockets for this often have special holes that can take the

10-amp plugs and CEE 7/16 as well. The packaging on these plugs in Italy may claim they are a "North European" type.

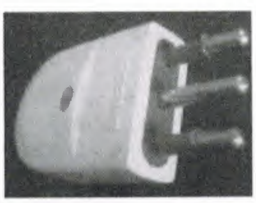


Fig.4.21 23-16/VII with socket

4.4.13 Type M

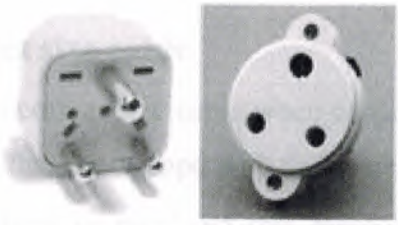


Fig. 4.22 Type M is same type D)

Type M is used to describe the 15 A version of D.

4.5. Safety notes & disclaimer

Safety note for mainland European plug types C, E, F, J, K, & L

Many European countries use the same basic two-pin plug designs but extended them to be earthed in different ways. Thus it is fairly common to find plug and socket combinations where the live and neutral pins will mate, but the earth pin will not. This also applies if a European plug is forced into a UK socket. Earth connections on European sockets are also sometimes absent or unreliable.

CHAPTER 5

DOMESTIC WIRING

5.1 Choosing the correct size cable

It is important to choose the correct size cable when connecting to the mains. The wire has to be the correct size so that it can cope with the power demands of the device. The size stated for cables is given in mm^2 and this measurement is actually the cross sectional area of the wire inside. The larger that area the higher the current it can carry. If a cable is used which is too small for the amount of current passing through, it becomes dangerous. This results in the wire overheating and causing a serious safety risk. The table below gives typical values of cable size available plus corresponding current rating and maximum power ratings.

Table 5.1 suitable cable size for wiring

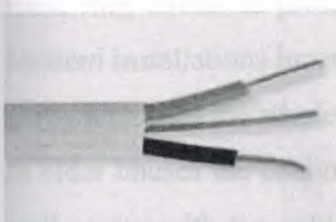


Fig. 5.1 Cord

Conductor Size	Current	Maximum power (Watts)
1.0 mm2	10 amps	Up to 2400 Watts
1.25 mm2	13 amps	Up to 3120 Watts
1.5 mm2	15 amps	Up to 3600 Watts
2.5 mm2	20 amps	Up to 4800 Watts
4.0 mm2	25 amps	Up to 6000 Watts

5.2 Type of the wiring

There are two type wiring style and these are ring circuit and radial circuit.

5.2.1 Ring circuit

The ordinary wall sockets around the house are normally connected to a ring circuit. The ring circuits of a domestic property supply the socket outlets and fixed appliances in the premises.

The 'ring' is formed by the cable going from the consumer unit to the first socket, then on to the second socket and then the next socket etc. until the cable returns to the consumer unit. This means that every socket on the ring circuit has two cable routes back to the supply. The cable of the ring circuit consists of a red (live) wire, a black (neutral) wire and a bare copper earth wire, all three being enclosed by an outer PVC sheathing. The cable used in domestic ring circuits is either 2.5 mm^2 or 4.0 mm^2 twin core and earth, these are rated (in free air) at 24amps or 32amps respectively.

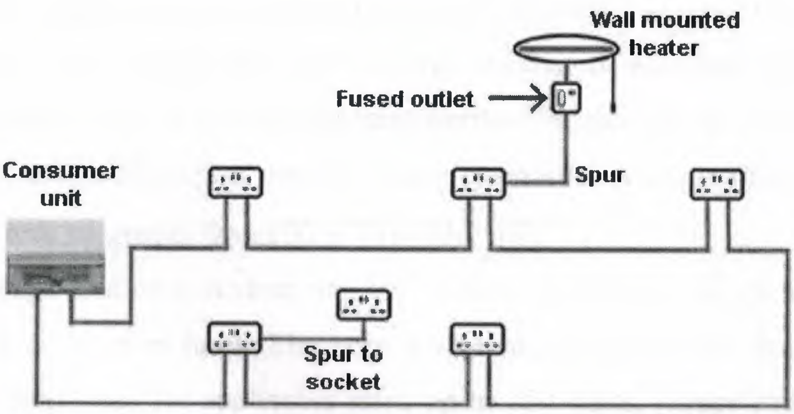


Fig 5.2 basic ring circuit configuration

Each ring circuit is protected by a 32 amp fuse or trip fitted in the consumer unit. Modern installations incorporate a Residual Current Device (RCD) before the consumer unit which trips the whole system off if a fault is detected.

In older houses the cabling for ring circuits (and other circuits) may be fed through the wall cavity with the cables coming into the back of the wall mounted socket. This is unacceptable in new premises and extensions. It is now considered that cables within the cavity may become wet causing the insulation of the cable to break down and moisture running down the cable into the socket. When rewiring older houses, new cables should not be run through the cavity, they should be run through new ducting embedded in the inner wall surfaces or under floorboards.

A ring circuit is considered to be rated at 30amps (7200 watts). A ring may serve up to 100 m^2 of floor area and, in theory, may have any number of sockets outlets or fused connection units connected to it. With each socket outlet is normally rated at 13 amps, as a 'rule of thumb', they are limited to under twenty outlets, it is unlikely that the variety of domestic appliances being used at any one time will exceed 30amps. The length of cable used in a ring circuit is limited to 50 meters for circuits protected by an MCB. The sockets are normally mounted flush with the wall although surface mounted boxes are often easier to fit when sockets are added to the circuit. .

High power electrical appliances (such as cookers, showers etc.) should not be connected to a ring main even if they use less current that the 30 amp rating of the ring circuit. Connection of such appliances will reduce the number of other appliances that can be use simultaneously and will lead to nuisance trips at the consumer unit.

It is advisable to have at least two ring circuits in all premises, in multi floor houses, one for each floor. The kitchen may have a large number of electrical appliances so a separate ring circuit for the kitchen may also worthwhile, this has the added benefit that a freezer will not be affected if there is a fault elsewhere. A single ring circuit should serve a floor area no greater than 100 m^2 (or 120^2 yd).

In the UK, plugs used on a modern ring circuit have square pins and each plug is fitted with either 3 or 13 amp fuses. The correct fuse should always be fitted to suit the appliance, 3 amp fuses for appliances rated up to 750 watts, (lamps and clock radios etc.) - 13amp fuses for larger appliances up to 3000 watts.

Spur extensions can be connected to the ring circuit. A spur is a socket connected into the ring by a single cable run so the socket does not have the full benefit of two cable routes to the consumer unit. Spurs are often used when a socket is added; it is easier to connect using a single cable rather than extending the ring circuit to include the new socket. A spur extension can be connected to the ring circuit provided that it supplies no more than two 13 amp socket outlets or one fixed appliance. Over the whole ring, the total number of spurs must not exceed the number of socket outlets directly on the main ring. No more than two separate spurs may be connected from each outlet on the ring.

Removal of the front of a wall socket will give an indication of the circuit connected to it

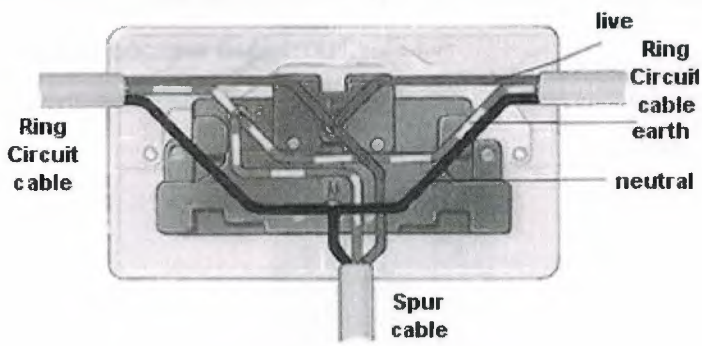


Fig. 5.3 Connection of ring circuit socket

A single cable connected to the terminals indicates that it is an existing spur.

Two cables may indicate either that it is on a main ring circuit OR that it is a spur with another spur connected to it. This is not a recognized configuration but possible if both spur sockets are single sockets.

Three or four cables normally indicate a socket on a main ring circuit with one or two spurs running from it.

If the wiring has been changed by a previous diy'er, it may be possible to identify any added cables and then deduce the original circuit.

5.2.1.1 Ring circuit fused outlet units

Where connection to a fixed appliance is required, a fused outlet unit may be fitted to the wall (rather than a plug socket) and connected into the ring main. These outlets require the correct fuse rating for the appliance and are connected to the appliance by a cable or flex. The outlet may be switched or unswitched and may be fitted with an indicator light to show when the supply is connected.

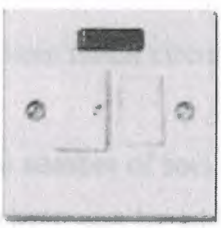


Fig 5.4 Switch with lamp

Where a flex is taken to a heater of any sort (e.g. night store heater, immersion heater) the flex must be of a special 'high temperature' type suitable for the elevated temperatures encountered. Use of ordinary flex will result in the insulation breaking down causing the flex to become dangerous.

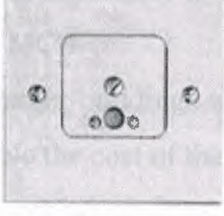


Fig.5.5 Button

A clock outlet is a similar type of unit, but with a small fuse fitted in a special plug connected to the flex. The plug may be retained in the socket by a screw or knurled thumbscrew. Though called a clock outlet, they are also suitable for other small low current appliances such as extractor fan units, door bells.

5.2.2 Radial Circuit

A radial circuit is a mains power circuit found in some homes to feed sockets and lighting points. It is simply a length of appropriately rated cable feeding one power point then going on to the next. The circuit terminates with the last point on it. It does not return to the consumer unit or fuse box as does the more popular circuit.

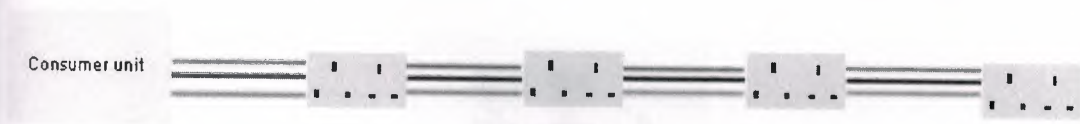


Fig 5.6 Basic radial circuit design

The ring main there is no limit to the number of sockets used on a radial circuit and, just like a ring main, spurs, or extra sockets, can be added. The number of spurs must not exceed the number of existing sockets.

Two types of radial circuit are permitted for socket outlets.

20 Amp fuse or miniature circuit breaker protections with 2.5 mm^2 cable can feed a floor area of not more than 50 m^2. The maximum length of cable is 33m

30 Amp cartridge fuse to B888 or miniature circuit breaker of 32 amp with a 4 mm^2 cable can supply a floor area no greater than $75m^2$.

The maximum length of cable to be used is cable is 38m when used with a cartridge fuse and only 15m when used with an MCB

Radial circuits are generally used in larger buildings where, to return the cable back to the consumer unit can effectively double the cost of the installation.

As with a ring main, units and appliances which draw large amounts of current such as showers and electric cookers nut be installed on their own circuit.

Additional wiring can be added to a radial circuit to turn it into a ring main.

5.2.2.1 High Power circuits

Within domestic premises, there may be a number of high wattage appliances, the most common being an electric cooker and electric shower. Each of these appliances should be connected to the consumer unit using a dedicated fuse/trip and cable run. The installation instructions for the appliance should detail the wattage of the appliance (which will also normally be shown somewhere on the appliance), the amperage of the fuse/trip and the size of cablrequired. Any switches on these circuits must also be of a suitable current rating.

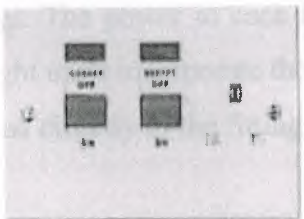


Fig. 5.7 Typical cooker socket

5.3 Lighting

5.3.1 Domestic Electric Lighting Circuits

In modern domestic properties in the UK, the main electric lighting circuits are separate from the power ring main circuit. Each house should ideally have at least two lighting circuits; each protected by a 5 amp fuse or 6 amp trip in the consumer unit. A single 5/6 amp circuit can cope with up to twelve 100 watt lamps, it is usual in a multi-storey house, to have at least one lighting circuit for each floor even if the number of lamps are less than 12 on each level.

Shaver units may also be connected to the lighting circuit (treat it as equivalent to one 100 watt lamp) - where installed in a bathroom or a room containing a shower, the shaver unit must incorporate an isolating transformer.

5.3.1.1 Lighting cable

Unlike the ring power circuit, the lighting circuit does not form a loop returning to the consumer unit. The consumer unit is normally connected to the first lamp, which in turn is connected to the second lamp and so on.

The cable used is a 1 mm^2 PVC twin core and earth rated for up to 12 amps. It consists of a red insulated core for live, black insulated core for neutral with a bare earth conductor between them. The three conductors are laid side by side within a PVC sheath. When connecting the cable, the exposed earth connector must be covered with a sleeve coloured yellow and green (to denote that it's an earth).

The lighting cable is routed from the consumer unit to a series of lighting points for ceiling roses or wall light fittings. The power to each lamp is connected via a wall or ceiling mounted switch. Some light units incorporate their own switch, for these fittings, the power circuit is then connected directly to the fitting.

5.3.1.2 Light Switches

Most room lights are controlled by wall mounted toggle switches (although alternatively touch sensitive or rotary light dimmers can be fitted); the cable normally runs down the wall within conduit within the plaster. A flush fitting wall box is sunk into the wall to take the switch, or alternatively a surface mounted box is fitted. Multi-switch units enable more than one light to be controlled from one position.

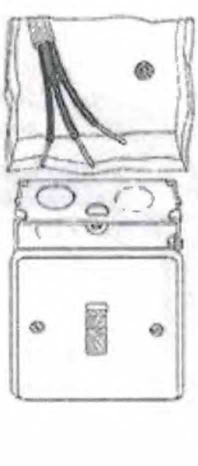


Fig. 5.8 Lamp switch connection

These switches can also be used when new lights are being installed they can easily be screwed under a ceiling joist with minimal disturbance to the decorations. There is a tendency to feel that pull switches are only suitable for bathrooms etc., however this limits the opportunities and should be avoided. When a new light is to be positioned over a work surface or even an external light fitted, there is no reason why a pull switch should not be mounted in any convenient position. In bathrooms and shower rooms, the switch must be a 'pull string' type.

Fig. 5.9 Lamp connection

5.3.2. Wiring Methods of Lighting

There are two basic methods of wiring lights - by ceiling rose and by junction box.

5.3.2.1 By Ceiling Rose

Systems using the ceiling roses make all the connections at the ceiling rose. While this removes the need for one junction box per lamp, it is often more awkward for the average diy'er.

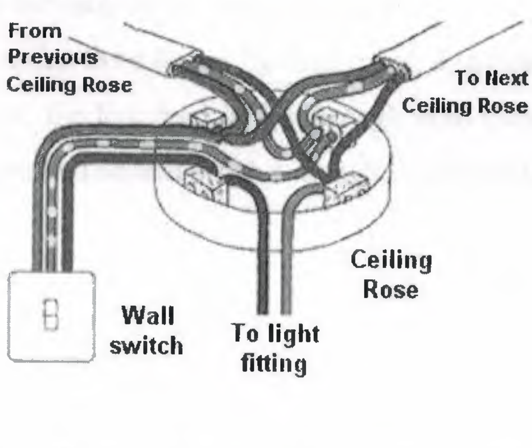


Fig.5.10 Lamp connection type (ceiling rose)

5.3.2.2 By Junction Box

With the junction box system (an old standard but still found in older installations), a cable is taken to a series of junction boxes, one for each light fitting/switch. The junction boxes are generally located between the ceiling joists or under floorboards close to the switch. Junction box type connections are required for fluorescent lights and other fittings that do not use a ceiling rose.

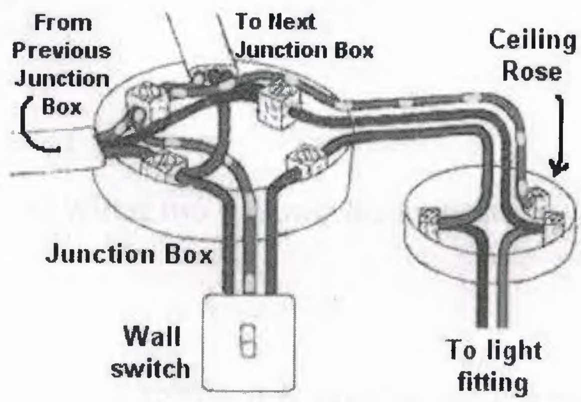


Fig. 5.11 lamp connection type (junction box)

5.3.3 Wiring two way switches for lighting

Sometimes, a light circuit needs to be controlled from two positions - across a room, at each end of a corridor or at the top and bottom of a stairway. Such lighting circuits are commonly known as 'two way' light circuits and are quite easy to install.

The two switches need to be of a 'change-over' type. These have three terminals, a common terminal and one for each of the switch positions.

The cable to the switches needs to be 4 core lighting cable, 3 insulated cores and earth.

The circuit is shown below, the live feed is fed through both switches to the light and the switches are cross connected so that when a switch is operated, the state of the light is changed.

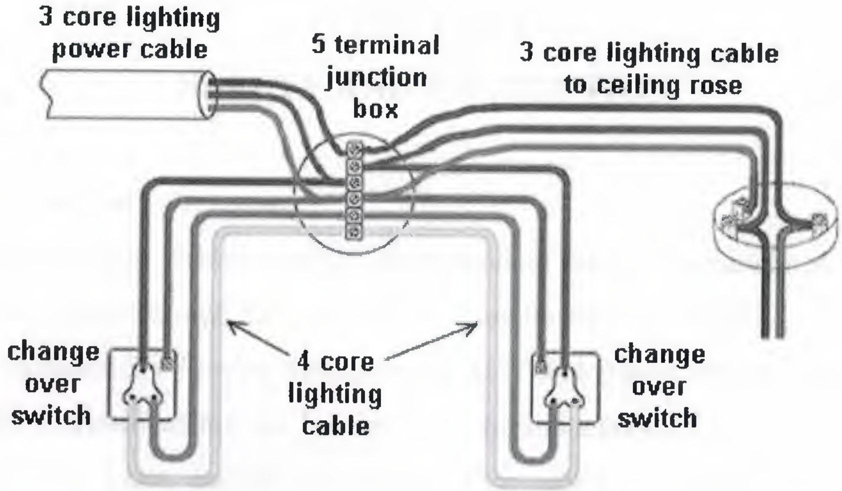


Fig. 5.12 Wiring two way switches for lighting

Because of the number of wires involved, it is easier to use a separate junction box (minimum of 5 terminals) rather than trying to make the connections in the ceiling rose.

5.3.3.1 An alternative method (by Mike Pheysey)

Where space in the conduit to the switch allows, a simpler circuit can be used, this removes the need for the 5 terminal junction box but requires both a three core and a four cable to be connected to one of the switches. The circuit is shown below (thanks for your contribution mike):

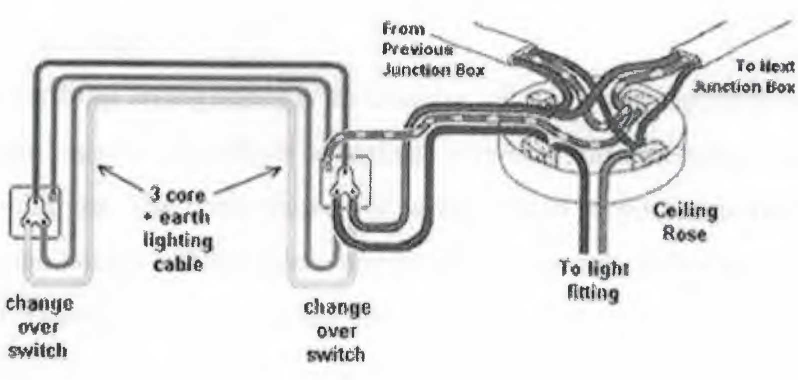


Fig. 5.13 Alternative wiring style

CHAPTER 6
SAFETY AND PROTECTION

6.1 Electric Current

Injuries received from electric current are dependent on the magnitude of current, the pathway that it takes through the body and the time for which it flows.

The nature of electricity flowing through a circuit is analogous to blood flowing through the circulatory system within the human body. In this analogy the source of energy is represented by the heart, and the blood flowing through arteries and veins is analogous to current flowing through the conductors and other components of the electric circuit.

The application of an electric potential to an electric circuit generates a flow of current through conductive pathways. This is analogous to the changes in blood pressure caused by contraction of cardiac muscle that causes blood to flow into the circulatory system. For electric current to flow there must be a continuous pathway from the source of potential through electrical components and back to the source.

6.2 Leakage Current

Electrical components and systems are encased in no conducting insulation, to ensure that the electric current is contained and follows the intended pathways. If the insulation cracks or deteriorates current will leak through the insulation barrier and either flow to earth through the protective earth conductor or through the operator.

Medical equipment and clinical areas are fitted with a number of protective devices to protect the patient and operator from harmful leakage currents.

6.3 Electrical Earting

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

“Earthing” may be described as a system of electrical connections to the general mass of earth. The characteristic primarily determining the effectiveness of an earth electrode is the resistance, which it provides between the earthing system and the general mass of earth.

The earthing of an electrical installation has two purposes:

. To provide protection for persons or animals against the danger of electric shock.

. To maintain the proper function of the electrical system.

6.3.1 Low Soil Resistivity

Soil Resistivity (specific resistance of the soil) is usually measured in Ohm meters, one Ohm meter being the resistivity the soil has when it has a resistance of one Ohm between the opposite faces of a cube of soil having one meter sides. The other unit commonly used is the Ohm centimeter; to convert Ohm meters to Ohm centimeters, multiply by 100.

Soil resistivity varies greatly from one location to another. For example, soil around the banks of a river has a resistivity in the order o f1.5 Ohm meters. In the other extreme, dry sand in elevated areas can have values as high as 10,000 Ohm meters.

6.3.2 The Earth Path

The resistance of the earth path is determined,

(1) By the resistivity of the soil surrounding the earth rod,

(2) By its contact resistance between the earth rod and the surrounding soil and,

(3) By the resistance of the earth rod and connecting conductors.

When an electrical current passes into the soil from a buried earth rod, it passes from a low resistance metal into an immediate area of high resistance soil. Reference to Figures 1 & 2 depicts what happens when a current flows from an earth rod into the surrounding earth. The areas of resistance can be described as being that of a number of sheaths of ever increasing diameters. The current path passes into the first sheath immediately adjacent to the earth rod and then into the second sheath which is of a larger cross-section with a greater area for current flow and, therefore, of lower resistance than the first sheath, and so on into a succession of sheaths or shells of ever increasing area and, because of this, of ever decreasing resistance.

Eventually at a distance of three of four meters, the area of current dissipation becomes so large, and the current density so small, the resistance at this point is negligible. Measurements show that 90% of the total resistance around an earth rod is within a radius of three meters.

However, it is this resistance at the interface where the current leaves the earth rod and flows into the main body of the earth that is important and explains why soil resistivity tests are very necessary in order to secure lowest overall resistance.

Fig. 6.1 distribution of electrons

Fig. 6.2 Earthing Rot

6.3.3 Principal Factors Affecting Soil Resistivity

The factors chiefly affecting soil resistivity are:

6.3.3.1. Type of Soil

The soil composition can be: clay, gravel, loam, rock, sand, shale, silt, stones, etc. In many locations, soil can be quite homogenous, while other locations may be mixtures of this soil
types in varying proportions. Very often, the soil composition is in layers or strata, and it is
the resistance of the varying strata, especially at sub-soil level and lower where the moisture
content is not subject to drying out that is important in securing a good electrical earth.

6.3.3.2. Climate

Obviously, arid and good rainfall climates are at opposite extremes for conditions of soil resistivity.

6.3.3.3. Seasonal Conditions

The effects of heat, moisture, drought and frost can introduce wide variations in "normal" soil resistivity. Soil resistivity usually decreases with depth, and an increase of only a few percent of moisture content in a normally dry soil will markedly decrease soil resistivity. Conversely, soil temperatures below freezing greatly increase soil resistivity, requiring earth rods to be driven to even greater depths. See Table 2 for variations of soil resistivity with moisture content, and Table 3 for variations of soil resistivity with temperature.

6.3.3.4. Other Factors

Other soil properties conducive to low resistivity are chemical composition, soil ionization, homogeneous grain size and even grain distribution - all of which have much to do with retention of soil moisture, as well as providing good conditions for a closely packed soil in good contact with the earth rod. In view of all the above factors, there is a large variation of soil resistivity between different soil types and moisture contents. Every earth is an individual and the only way to know that an earthing installation meets code requirements is to carry out proper resistance measurements on site. There are a variety of test instruments available; however, they can be generally categorized as three terminals of four-terminal test instruments.

Table 6.1 Variations of soil resistivity

Type of Soil or Water	Typical Resistivity (Wm)	Usual Limit (Wm)
Sea Water	2	0.1 to 10
Clay	40	8 to 70
Ground well and spring water	50	10 to 150
"Clay and sand mixtures	100	4 to 300
Shale, slates, sandstone, etc.	120	10 to 1000
Peat, loam and mud	150	5 to 250
Lake and brook water	250	100 to 400
Sand	2000	200 to 3000
Morane gravel	3000	40 to 10000
Ridge gravel	15000	3000 to 30000
Solid granite	25000	10000 to 50000
Ice	100000	10000 to 100000

6.4 Type of Earth Electrode

6.4.1 Cast-iron or cooper plate

This type of earth electrode is used where space is restricted. It has the advantage of being capable of carrying large currents. The conductivity of the surround earth is often increased by using salt or coke round the electrode. It should be noted that salt may have a corrosive effect on the electrode. The salt must be renewed periodically. Plate electrodes are often drilled to maximize contact surface. Cooper conductors should be tinned before being connected to an iron plate to prevent chemical action corroding the connection.

6.4.2 Cooper Earth Rods

Cooper rods of 20mm or 25mm diameter are used where there are high-resistance earth conditions. It is possible to obtain cooper rods with end-on connections where a length (usually about 1,5m) may be driven in, the removable hard-steel tip unscrewed, and a further length of rod screwed.

6.4.3 Cooper Tapes

This is buried in a trench or stream where rock soil predominates. Low earth resistance can be obtained by using this method, but it is costly and requires a long trench. The length required depends upon the soil conditions.

6.4.4 Supply Authority's Earth

This is the connection taken from the led sheath of the incoming supply cable of the fifth wire of an overhead system. It can only be used as an earth terminal with the permission of the supply Authority.

Also the termination to the earth electrode should be available for inspection and testing. The resistance areas of separate electrodes should not overlap as these decreases the effectiveness of the system by increasing the overall resistance of the earth path.

6.4.5 Proctive Multiple Earthing (p.m.e)

This is a system of earthing used in conditions where soil resistivity is high. In this system the neutral line is earthed at a series of points along the distribution system to ensure that earth leakage currents flow back t the source of supply. Permission to use this system can only be granted by Area Electricity Board.

6.4.6 Power for out of doors

When power is required for the shed, patio, garden pond or other out of doors purpose, a separate circuit from the consumer unit should be used. Where a Residual Current Device (RCD) is not already fitted before the consumer unit, one should be installed. The Residual Current Device will switch off the electricity almost instantaneously if a fault develops in the circuit.

Waterproof sockets must be used where an outside socket is required, an internal control switch is also recommended so that the outside socket can be isolated if necessary.

There are a number of alternatives to using mains electricity in the garden, low voltage garden lights and appliances are available to reduce the risk of using electricity out of doors.

6.5 Wiring for bathroom

Using electrical equipment in bath or shower rooms has always needed care to ensure safety. Now the IEE Wiring Regulations have identified particular zones within the bathroom to indicate what type of electrical equipment that can be installed.

6.5.1 The zones

The zones are identified from 0 to 3, with 0 being the wettest.

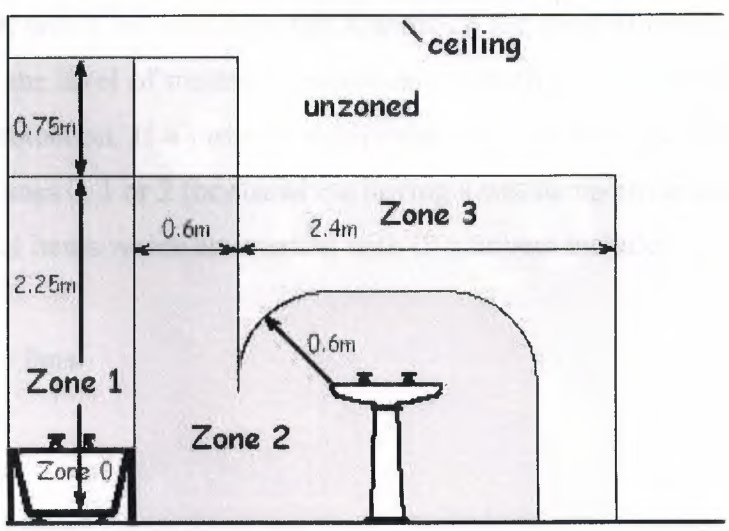


Fig. 6.3 Zones for bathroom

Zone 0: The interior of the bath or shower which can hold water.

Zone 1: The area directly above zone 0 limited vertically to 2.25m above the bottom of the bath or shower.

Zone 2: The area beyond zones 0 and 1, 0.6m horizontally and up to 2.25m vertically. Zone 2 also included any window with a sill next to the bath.

Zone 3: The area beyond zones 2, 2.4m horizontally and up to 2.25m vertically.

Note:
Where ceiling heights exceed 2.25m, the zones are effectively up to 3m - beyond 3m, the walls are 'out of scope'.
Basins are not covered, however they are usually considered to be Zone 2.
Providing that the space under the bath cannot be accessed without using tools (i.e. screwdriver etc), that space is considered to be 'out of scope'.

6.5.2 Equipment for bathrooms & IP Regulation

Electrical equipment may be identified as having a certain level of mechanical and moisture protection, these are quoted as 'Ingress Protection' (or IP) numbers - such as 'IPXY', where X and Y are numbers, the X showing the level of mechanical protection and Y showing the level of moisture protection - in both cases, the higher the number, the better the protection. If a piece of equipment does not have an IP number, it must not be used in zones 0, 1 or 2 (or elsewhere having a wet/damp environment).
Typical electrical items which are marked with IP numbers include:

- Extractor fans
- Lighting
- Heaters
- Shower pumps

Shaver power points are not IP rated, however, if they comply with BS EN 60742
As well as IP numbers, items may be classed as PELV or SELV.

- Protective Extra-Low Voltage (PELV) - As the name suggests, the item uses low voltage but it is connected to earth.
- Safety Extra-Low Voltage (SELV) - Again a low voltage system but the output is isolated from the input.

Standard electrical wall fittings (such as wall sockets, flexible cord outlets and fused switches etc) are not IP rated so cannot be installed within zones 0, 1 or 2. No standard socket outlets are allowed anywhere in the bathroom.

6.5.3 Use of Equipment for bathroom

Any electrical item approved for use in a zone may be used in another zone with a higher number, but not in a lower number zone.

Zone 0

Requires electrical products to low voltage (max. 12 volts) and be IPX7 (the mechanical protection is unimportant).

Zone 1

Requires electrical products to be IPX4 or better, or SELV with the transformer located in zone 3 or beyond. If the fitting is 240v, a 30mA RCD must be used to protect the circuit.

Zone 2

Requires electrical products to be IPX4 or better, or SELV with the transformer located in zone 3 or beyond.

Zone 3

The regulations do not specify any IP number for zone 3; however reference should be made to the manufacturer's data in case it indicates any exclusion. Portable electrical equipment is not permitted other than that using a SELV or shaver unit.

Beyond zone 3

When the size of bathroom extends beyond zone 3, portable equipment is allowed, however they should be positioned such that that their flex length does not enable them to be used in zone 3.

6.6 Insulation for human

Protection from electric shock is provided by isolation and/or insulation. Live parts must be separated from users and those likely to come into contact with the appliance and covered with non-conducting material to reduce the risk of electric shock.

Table 6.2 Type of insulation and their description

Type of insulation	Description
Basic	insulation applied to live parts to provide basic protection against electric shock.
Supplementary	independent insulation applied in addition to basic insulation to ensure protection against electric shock in the event of a failure of the basic insulation.
Double	comprises both basic and supplementary insulation.
Reinforced	a single insulation system applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation.

6.6.1 Appliance classification

Appliances are classified according to their protection against electric shock and against moisture:

Table 6.3 Classification according to appliance

Classification	Description
Class 0	appliances are those in which protection against electric shock relies upon basic insulation without provision for accessible conductive parts, if any, to the protective conductor in the fixed wiring of the installation, reliance in the event of a failure of the basic insulation being placed on the environment. Such appliances have either an enclosure of insulating material or a metal enclosure which is separated from live parts by insulation. This construction is not permitted in the UK.
Class 01	appliances have at least basic insulation and an earthing terminal. Their power supply cords do not have an earthing conductor and are connected to a plug without earthing contact which cannot be inserted into a socket-outlet with earthing contact.
Class l	appliances have protection against electric shock which does not rely on basic insulation only but includes an additional safety precaution in that accessible conductive parts are connected to the protective Earthing conductor in the fixed wiring of the installation in such a way that accessible conductive parts cannot become live in the event of a failure of the basic insulation.
Class ll	appliances do not rely on basic insulation only but have double or reinforced insulation without provision being made for protective earthing or reliance upon installation conditions.
Class lll	appliances rely on supply at safety extra-low voltage [SELV] for protection against electric shock i.e. 24 V maximum.

Appliances are further classified with regard to their protection against moisture:

- ordinary
- drip -proof,
- splash -proof, and
- watertight.

6.7 Earth faults

Fuses and miniature circuit breakers cannot provide protection against earth faults to protect against the risk of electric shock except by indirect contact when combined with earthing and bonding. This can be achieved only by the use of earth fault circuit breakers known as Residual Current Devices (RCDs).

Earth fault is the condition of electric current flowing to earth under fault conditions:

a. direct contact i.e. contact of persons or animals with live parts e.g. conductors and terminals, which may result in electric shock, or

b. indirect contact i.e. contact of persons or animals with exposed conductive parts, such as the metal casing of a washing machine, made live by a fault, e.g. in the wiring of the plug, which may result in electric shock.

Protection against direct contact is normally achieved by the insulation of live parts and protection by suitable enclosures. For indirect contact protection this can be met using fuses or circuit breakers where the earth-loop impedance is low but otherwise a much more sensitive RCD will have to be used.

6.7.1 Residual Current Devices (RCDs)

This term covers a number of protective devices:

a. Residual Current Circuit Breaker (RCCB)

These are to be found in consumer units protecting all or a number of circuits.

b. Residual Current Breaker with over current protection (RCBO)

A combined RCD and MCB (miniature circuit breaker) providing overload short-circuit and earth fault protection in one unit.

Socket-outlets with combined RCD (SRCD) - provides RCD protection at one socket outlet only.

c. Portable RCD (PRCD)

An integral part of a plug providing protection to the appliance being used only.

It is not recommended to use RCD protection in circuits supplying security and emergency systems e.g. burglar alarms, fire alarms, security lighting. RCDs have developed a reputation for "nuisance" tripping. Causes have been put down to radio frequency suppression devices, electronic timers and leakage to earth due to dampness when cooker hot plates warm up. This problem has been considerably reduced by improvements in design.

RCDs are provided with various levels of sensitiveness:

Table 6.4 Protection area according to range

10mA	for specialist uses e.g. laboratories or where children may need to be protected.
30mA	ideal for domestic situations and is the most commonly used. It is a requirement of the Wiring Regulations that all socket outlets 'which might reasonably be expected' to supply equipment to be used outside the dwelling (the equipotential zone).
100mA	for protection against indirect contact situations. Less likelihood of nuisance tripping and therefore could be used to protect a freezer circuit.
300mA	for fire risk protection.

protection.

Inadvertently cutting through electric mower cables has resulted in many avoidable deaths. Every precaution however should be taken to ensure the safe use of equipment rather than relying on the RCD for protection against shock. RCDs themselves are not 100% reliable and, in rare instances, may malfunction and fail to cut off the current in a critical situation.
It is proposed in the review mentioned above that RCDs be installed on a number of circuits such as the downstairs ring, circuits to sheds and garages, pond pump and other outdoor circuits where the risk of electrocution is greatest. RoSPA welcomes this proposal.

6.7.2 Static Electricity

A static charge is an imbalance of electrons on objects (matter) that can build up on all matter and transfer from one object to another by conduction or induction. The discharge of static electricity can cause shock or a fire or explosion. Although this type of shock is painful, it is not normally physically hazardous and therefore is not considered reportable as an electric shock. It should be noted, however, that injuries may result from reaction to the shock (i.e., by a person rapidly pulling his/her hand away from a metal object and hitting an elbow against a wall or cabinet).

6.8 What is Lightning?

Lightning is the visible discharge of static electricity within a cloud, between clouds, or between the earth and a cloud. Scientists still do not fully understand what causes lightning, but most experts believe that different kinds of ice interact in a cloud. Updrafts in the clouds separate charges, so that positive charges flow towards the top of the cloud and the negative charges flow to the bottom of the cloud. When the negative charge moves downwards, a"stepped leader" is created. The leader rushes towards the earth in 150-foot discrete steps, producing an ionized path in the air. The major part of the lightning discharge current is carried in the return stroke, which flows along the ionized path.

6.8.1 Lightning Protection Systems (LPS)

A Lighting Protection System (LPS) provides a means by which a lightning discharge may enter or leave earth without passing through and damaging personnel, electrical equipment, and non-conducting structures such as buildings. A Lightning Protection System does not
prevent lightning from striking; it provides a means for controlling it and prevents damage by providing a low resistance path for the discharge of the lightning energy.
Three types of Lightning Protection architecture are follows:

□ IF type system, where the Indoor/Outdoor units are connected via coaxial cables that carry the IF signals and DC supply voltages
□ Subscriber Indoor Units connected to outdoor antennas
□ Base band type system, where Indoor/Outdoor connections are via shielded CAT5 cables that carry the base band signals and a DC supply voltage.

The Lightning Protection System comprises grounding methods and
Transient suppression techniques (TVS).
A grounding system constitutes a part of the safety network adapted to
the electricity laws of the country, the terrain conditions, and the
accepted and relevant standards for the country.

6.8.2 Lightning effects on power systems

Lightning surges entering a power system through direct strokes are the primary concern in planning surge protection. These strokes may hit phase conductors directly, or they may strike the overhead ground wires or masts that shield the conductors. In either case, it is necessary to understand the associated surge currents and voltages produced before a protection system can be designed.

a. Flashover

A lightning stroke terminating directly on phase conductors or equipment terminals develops a very high voltage, which, with no surge protection, will flash over the insulation in the majority of cases. If the flashover occurs through air or across porcelain insulation, it rarely causes permanent damage. If, on the other hand, the flashover occurs through solid insulation such as in a transformer or cable, permanent damage results.

b. Shielding.

The magnitude of surge voltages applied to equipment and line insulation systems can be limited by providing grounding masts or ground wires to intercept direct strokes. Even with a shielding network, though, there is some chance of flashover, depending on stroke current magnitude, impedance of the shielding system, and the amount of insulation between the network and the energized circuits.

c. Induced surges.

A lightning stroke terminating near a transmission line can induce a voltage in the circuit that seldom exceeds 500 kV. Lines, shielded with overhead ground wires and operating at 69 Kv and above, generally have sufficient insulation to prevent flashover by voltages in this range. The same applies to some well insulated 34.5 kV lines. Lower voltage lines, however, with insulation levels appreciably below 500 kV, may be fla shed over by induced surges. In most cases, these circuits do not have ground wires, and are, therefore, subject to flashover each time they are contacted by a direct stroke. In general, flashovers by induced surges do not create a significant problem since the number of flashovers from direct strokes far exceeds those from induced strokes.

d. Traveling waves.

A lightning stroke terminating on a power system initiates traveling waves that propagate within the system. To determine the resulting surge voltages and currents in various parts of the system, a traveling wave analysis is required. Simple networks with linear impedances can be analyzed manually; more complicated networks, characteristic of practical power systems, require analog or digital computer analysis.

e. Surge voltages.

In protecting power systems against lightning, surge voltages and currents must be considered. In general, lightning protection is primarily concerned with surge voltages; surge currents cause less concern. A lightning stroke to a power system develops very high surge voltages across equipment and line insulation systems. If these voltages exceed the insulation strength, a flashover occurs. Once lightning enters a power system, the surge current is unlikely to cause any damage. Although the current may be extremely high, it is very short lived and can easily be handled by a small conductor. The largest recorded conductor to be fused or vaporized by a direct stroke was an American Wire Gage (AWG) No. 10. The size of conductors, installed expressly for conducting lightning currents, is usually determined by mechanical strength considerations, rather than by current-carrying capacity. On some rare occasions, overhead ground wires have been severed by lightning at the point of contact.

This is probably due to the stroke channel heating the conductor at the point of impingement, rather than from simply conducting the lightning current.

6.8.3 Principles of protection

Main lightning protection requirements are dependent upon the structure, component, or system to be protected. According to National Fire Protection Association (NFPA) 780, Standard for Installation of Lightning Protection Systems 91997), there are two classifications for a building. Class I is a building with less than 75 feet height. The Class II building is higher than 75 feet or has a steel frame with any height.

a. Shielding

Shielding masts are commonly used in substations, and overhead ground wires are used in both substations and on transmission lines. Both use the lightning rod principle. The voltage at the top of the mast is significantly less than the 2,000 kV that would be developed for the same stroke on a conductor. Grounded masts and grounded wires, then, offer an important reduction in the magnitude of surge voltages.

b. Arresters

Even with an effective shielding system, the surge voltages must be limited to magnitudes consistent with practical and economical equipment insulation levels to allow for voltages developed by strokes to the shielding network. On rare occasions, strokes may also bypass the shielding system and terminate directly on the energized circuits. For these situations, an arrester is used to control and limit surge voltages to a safe level. The arrester, applied on or near the terminals of the protected equipment, is connected from phase to ground. Under normal operating conditions, the arrester has no effect on the power system. Under surge conditions, the arrester will spark over and conduct the surge current to ground, limiting the voltage applied to the equipment insulation to a safe level. After conducting the surge current to ground, the arrester will interrupt the power-follow current and restore itself to its normal operating conditions. There are two general types of arrester designs: valve type and expulsion type. The valve type has one or more sets of spark gaps (series connected) which establish spark-over voltage, interrupt the flow of current, and prevent high current flow. The expulsion type has an arc extinguishing chamber in series with the gaps to interrupt the power frequency current that flows after the gaps have been sparked over. Design refinements include using oxide film coated components and sealing the inner components in a chamber filled with an inert gas. Aluminum cells are used in some units.

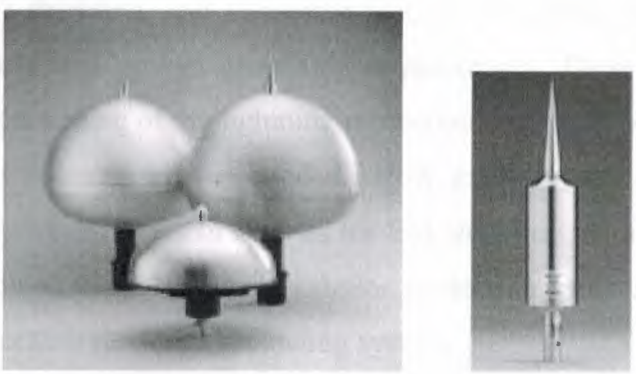


Fig. 6.4 Type of Arrester

c. Air terminals

Air terminals are used to intercept lightning discharges above facilities. Air terminals will be in accordance with Underwriters Laboratories, Inc. (UL) 96, UL Standard for Safety Lightning Protection Components, Fourth Edition (2000), and 96A, UL Standard for Safety Installation Requirements for Lightning Protection Systems, Tenth Edition

(1998), NFPA 780, or MIL–HDBK-419A, Grounding, Bonding, and Shielding. Where building roof is not metal and building construction includes steel framing, air terminal connection assemblies are required.

Fig. 6.5 Air Terminal

d. Grounding

Grounding generally will conform to NFPA 780, unless otherwise specified. Guidance or grounding for purposes such as electromagnetic pulse (EMP), electromagnetic interference (EMI) shielding, and electronic facility grounding, are subjects of other engineering manuals that govern grounding requirements. Those grounding systems will also serve as grounding of the lightning protection system. Where separate systems are installed, such systems will be bonded below grade to any other independently installed exterior grounding system such as for EM shielding not suitable for complete lightning protection system. However, exterior protection grounding system will be bonded to static electricity exterior grounding system.

e. Ground rods

Ground rods are generally not less than 10 feet in length, nor less than ¾-inch diameter pipe or equivalent solid rod. Rods are driven so that tops are at least six inches below finished grade, and three to eight feet beyond perimeter of building foundation. Where ground rods are used with a counterpoise, tops are driven to same elevation as counterpoise below finished grade. Contact with chemically injurious wastewater or other corrosive soils is avoided. Where avoidance of chemically injurious or corrosive soils is impracticable, stainless steel rod and magnesium anode protection is used.

Where buried metal pipes enter a building, the nearest ground rod will be connected thereto.

f. Counterpoise

Each earth electrode subsystem or counterpoise consists of one or more closed oops or a grid arrangement of No. 1/0 AWG bare copper conductors installed around facility rimeter to less than 2 feet below earth surface. Larger conductors should be used when installed in highly corrosive soils. A second loop, if used, should not be less than 10 feet beyond the first and inner loop. At east two ground rods are provided at each corner of each counterpoise loop where earth-seeking current end to concentrate. Counterpoise will extend not less than 3 feet or more than 8 feet beyond the perimeter of building walls or footings.

g. Radial systems

A radial system of grounding consists of one or more No. 1/0 AWG copper conductors not less than 12 feet long, extending away from each ground rod or grounding connection. The use of multiple radials is an effective form of grounding, offering substantially lower reactance to the high frequency of lightning current wave fronts than do single straight conductors. Installation of grounding radials takes advantage of crags and cracks in surface rock formations in obtaining maximum available earth cover.

h. Structural components

Lightning protection is provided on the outside of exterior surfaces without reliance upon components of the building for conductors. Reinforcement steel may be used for down conductors in conformance with NFPA 780 and if approved by the using agency. Joints are made in no less than every fifth reinforcement rod and at corners of buildings. Joints are made electrically conductive and are connected top and bottom for connections to roof conductors and to grounding electrodes, respectively. Grounding pigtails from bottoms of reinforcement fabric are connected to exterior grounding system at same or lower elevation as that where pigtails leave walls and footings.

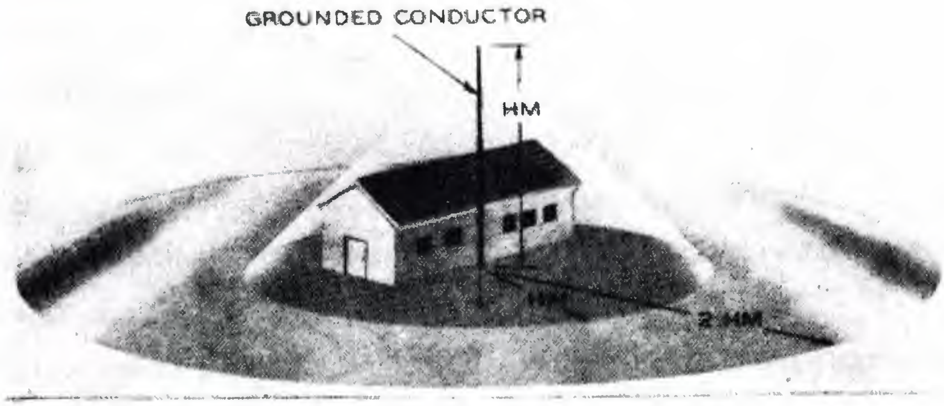


Fig 6.6 Protection by a Vertical Grounded Conductor

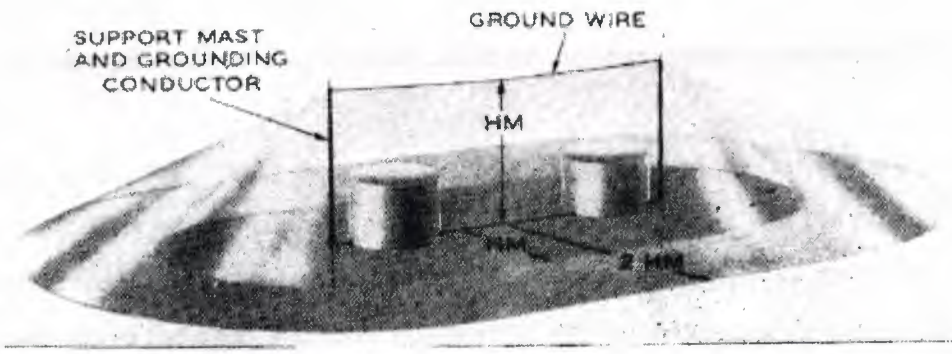


Fig.6.7 Protection of Horizontal Aerial Ground Wire

6.8.4 Protect Yourself

When to act

If you hear thunder and see lightning, act right away – especially if you count 30 seconds or less between the thunder and lightning. If the thunder gets louder or you see the lightning more often, the storm is getting closer. (Sometimes lightning will strike out of a sunny sky 10 miles or more from a storm.)

Lightning hits tall things, metal, and water – or a person standing on open ground or a roof.

Your worksite should have a plan for what to do in a lightning storm.

If a storm is near

6.8.4.1 Do NOT:

- Be the tallest object in an area.
- Stand out in the open.
- Stand under a tree. (If the tree is hit, you can be too.)
- Stand in a gazebo or open shelter, like a baseball dugout or bus shelter.
- Stand next to metal objects – pipes or light poles or door frames or metal fences or communication towers – indoors or out.
- Stay next to water – ponds or running water – indoors or out. (Do not take a shower.)
- Use plug-in power tools or machines – indoors or out.
- Use a plug-in telephone (or a computer with a modem) – indoors or out.

6.8.4.2 Do:

- Get into an enclosed building – like a house or shopping center or school or office building.
- Get into a car, van, truck, or bus with the windows closed all the way. Do not touch the doors or other metal inside. (Open cabs on heavy equipment will not protect you. A convertible with the top up will not protect you. Rubber tires will not protect you.)

If you are out in the open and have nowhere to go, squat down with your feet together and only let your feet touch the ground. Put your hands over your ears (to protect against noise). That way, you are so low the lightning may hit something else. And by not touching much of the ground, you have less chance that the lightning will move across the ground to you. Do not lie flat on the ground.

Do not go back to work outdoors until a half-hour after the lightning and thunder stop.

6.9 Biological Effects of Electrical Hazards

6.9.1 Influential Variables. The effects of electric current on the human body can vary depending on the following:

- Source characteristics (current, frequency, and voltage of all electric energy sources).
- Body impedance and the current's pathway through the body.
- How environmental conditions affect the body's contact resistance.
- Duration of the contact.

6.10 Source Characteristics.

An alternating current (ac) with a voltage potential greater than 550 V can puncture the skin and result in immediate contact with the inner body resistance. A 110-V shock may or may not result in a dangerous current, depending on the circuit path which may include the skin resistance. A shock greater than 600 V will always result in very dangerous current levels. The most severe result of an electrical shock is death.

Conditions for a serious (potentially lethal) shock across a critical path, such as the heart, are

1. More than 30-V root mean square (rms), 42.4-V peak, or 60 V dc at a total impedance of less than 5000 ohms.
2. 10 to 75 mA.
3. More than 10 J.

Conditions for a potentially lethal shock across the heart are

1. More than 375 V at a total body impedance of less than 5000 ohms.
2. More than 75 mA.
3. More than 50 J.

The worst possible frequency for humans is 60 Hz, which is commonly used in utility power systems. Humans are about five times more sensitive to 60-Hz alternating current than to direct current. At 60 Hz, humans are more than six times as sensitive to alternating current than at 5000 Hz--and the sensitivity appears to decrease still further as the frequency increases. Above 100-200 kHz, sensations change from tingling to warmth, although serious burns can occur from higher radio-frequency energy.

At much higher frequencies (e.g., above 1 MHz), the body again becomes sensitive to the effects of an alternating electric current, and contact with a conductor is no longer necessary; energy is transferred to the body by means of electromagnetic radiation (EMR).

6.11 Body Impedance.

Three components constitute body impedance: internal body resistance and the two skin resistances at the contact points with two surfaces of different voltage potential. One-hand (or single-point) body contact with electrical circuits or equipment will prevent a person from completing a circuit between two surfaces of different voltage potential. Table provides a listing of skin-contact resistances encountered under various conditions. It also shows the work area surfaces and wearing apparel effects on the total resistance from the electrical power source to ground. This table can be used to determine how electrical hazards could affect a worker in varying situations.

Table 6.5 Human Body Resistance

Human resistance (Ω) for various skin-contact conditions		
Body contact condition	**Dry (ohms)**	**Wet (ohms)**
Finger touch	40,000-1,000,000	4,000-15,000
Hand holding wire	15,000-50,000	3000-5000
Finger-thumb grasp	10,000-30,000	2000-5000
Hand holding a pliers	5000-10,000	1000-3000
Palm touch	3000-8000	1000-2000
Hand around 1.5-in. pipe or drill handle	1000-3000	500-1500
Two hands around 1.5-in. pipe	500-1500	250-750
Hand immersed	--	200-500
Foot immersed	--	100-300

6.11.1 Life-Threatening Effects

Charles F. Dalziel, Ralph H. Lee, and others has established the following criteria for the lethal effects of electric shock:

- Currents in excess of a human's "let-go" current ($\geq$16 mA at 60 Hz) passing through the chest can produce collapse; unconsciousness, asphyxia, and even death.
- Currents ($\geq$30 mA at 60 Hz) flowing through the nerve centers that control breathing can produce respiratory inhibition, which could last long after interruption of the current.
- Cardiac arrest can be caused by a current greater than or equal to 1 A at 60 Hz flowing in the region of the heart.

- Relatively high currents (0.25-1 A) can produce fatal damage to the central nervous system.
- Currents greater than 5 A can produce deep body and organ burns, substantially raise body temperature, and cause immediate death.
- Delayed reactions and even death can be caused by serious burns or other complications.

The most dangerous current flow via the chest cavity is through the heart when the shock occurs in the time relative to the normal heart rhythm. This current may cause ventricular fibrillation, which is defined as repeated, rapid, uncoordinated contractions of the heart ventricles. Ventricular fibrillation that alters the heart's normal rhythmic pumping action can be initiated by a current flow of 75 mA or greater for 5 seconds (5-s) or more through the chest cavity.

Probability of Ventricular Fibrillation. To determine the 5-s current flow (in mA) necessary to cause a 0.5% probability of ventricular-fibrillation, multiply a person's weight (in lb) by 0.49. To determine the 5-s current flow (in mA) necessary to cause a 99.5% probability of ventricular fibrillation, multiply a person's weight (in lb) by 1.47.

B.3 Determining How Much Current Is Passing through a Body

Use the information in Table to project how electrical hazards could affect a worker in varying situations when protective equipment and apparel are in series with current flowing through a body. To determine how much current, I, is passing along a body path, use the formula $I = E/R$. The voltage, E, can be obtained using an appropriate voltmeter.

Table 6.6 How electrical hazards could affect

Resistance values for equal areas (130 cm^2) of various work-area materials	
Material	**Resistance (Q)**
Rubber gloves or soles	2.0×10^7
Dry concrete above grade	1.0×10^6 to 5.0×10^6
Dry concrete on grade	2.0×10^5 to 1.0×10^6
Leather sole, dry, including foot	1.0×10^5 to 5.0×10^5
Leather sole, damp, including foot	5.0×10^3 to 2.0×10^4
Wet concrete on grade	1.0×10^3 to 5.0×10^3

CHAPTER 7

DRAWING PROJECT

1 The Calculation Of Internal Illumination

ıe formulates symbols:

= Number of light

T=Necessary total of light flow

L=Light flow of a light

= Index of room

= Lenght

= Wide

= The high of light resource to working table

I= The high of light resource from ground

1= The high of working table from ground

= the flow coming to working table

= m^2 of working table

)= Dirty factory

ή = the light flow coming by reflexion

The calculation of illumination by the light flow method. The calculation of internal lumination by efficiency method. This method is mostly used in internal illumination ıstallations. As it is known the ΦT light that cames to plane has the components ΦL and ɔend (E shows the flow coming to working table, ή shows the light flow coming by eflexion)

can be calculated easily from formula.

$$h=H-h1$$

o that efficiency method is used in internal illumination installations. Then we can calculate alue of k from

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

Now in order to understand this method let's think about an ideal room that it's walls nd ceiling reflects the light totally, (δ=%100) and absorbs the light completely.(α = %100) nd no object absorbing the light in it. The E comes out of the light sources falls on the plane and it is absorbed their whatever the dimensions of the room, number of the lambs, tlement of the lambs, illumination system. The average illumination degree of the plane for ideal room is

shows the avarage level of light of working table, Φo represents the total light flow from nbs in lumen and S represents the area of the plane in m². In reality some of the light flow absorbed by walls, ceiling, and illumination devices. So that the average illumination gree of the plane is:

$$E_o = \frac{\Phi L X \eta X n}{S}$$

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

$$= \frac{\Phi T}{\Phi_L}$$

Φ_a represents flow of light to plane and

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

Efficiency of device is related with the illumination device. Efficiency of the room is lated with geometric dimensions of room, reflection factors and colours of walls and ceiling, ght distribution curves of illumination devices, height of them to plane and their places. able 10.1 shows belowed in same situations that are used mostly;

Table 7.1 Area efficiency of illumination

Reflection Rate												
	Cillent	**0,80**				**0,50**				**0,30**			
	Wall	**0,50**		**0,30**		**0,50**		**0,30**		**0,50**		**0,30**	
	Ground	**0,3**	**0,1**	**0,3**	**0,1**	**0,3**	**0,1**	**0,3**	**0,1**	**0,3**		**0,1**	
Room index K= **axb** / **h(a+b)**	**room efficiency**												
0,60		**0,24**	**0,23**	**0,18**	**0,18**	**0,20**	**0,19**	**0,15**	**0,15**	**0,12**		**0,15**	
0,80		**0,31**	**0,29**	**0,24**	**0,23**	**0,25**	**0,24**	**0,20**	**0,19**	**0,16**		**0,17**	
1,00		**0,36**	**0,33**	**0,29**	**0,28**	**0,29**	**0,28**	**0,24**	**0,23**	**0,20**		**0,20**	
1,25		**0,41**	**0,38**	**0,34**	**0,32**	**0,33**	**0,31**	**0,28**	**0,27**	**0,24**		**0,24**	
1,50		**0,45**	**0,41**	**0,38**	**0,36**	**0,36**	**0,34**	**0,32**	**0,30**	**0,27**		**0,26**	
2,00		**0,51**	**0,46**	**0,45**	**0,41**	**0,41**	**0,38**	**0,37**	**0,35**	**0,31**		**0,30**	
2,50		**0,56**	**0,49**	**0,50**	**0,45**	**0,45**	**0,41**	**0,41**	**0,38**	**0,35**		**0,34**	
3,00		**0,59**	**0,52**	**0,54**	**0,48**	**0,47**	**0,43**	**0,43**	**0,40**	**0,38**		**0,36**	
4,00		**0,63**	**0,55**	**0,58**	**0,51**	**0,50**	**0,46**	**0,47**	**0,44**	**0,41**		**0,36**	
5,00		**0,66**	**0,57**	**0,62**	**0,54**	**0,53**	**0,48**	**0,50**	**0,46**	**0,44**		**0,40**	

a; lenght of one side of a square room

h; height of light sources to the plane in direct and semi-direct illumination system. Height of ceiling to the plane in direct; mixed and semi-direct illumination system.

Situation where is ceiling is white (ρ_T= **%80**) and walls are quite white **(ρ_D = %50)**

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

ile preparing the table, only two efficiency about illumination devices

yg = %70 and **η ayg** = **%80**) is taken.

nother illumination device that has the efficiency **η' ayg** is used(η' is an aygıt different n %70, %80 efficensy level) , the efficiency that is found from table is multiplied with a or of **η' ayg / η ayg**

After finding the efficiency **η** , light flow that goes to plane (**Φ_o**) is found with the o of flow of light by illumination sources (**Φ_s**). Then the average illumination level is:

$$E_O = \frac{\Phi_s}{S} = \eta \frac{\Phi_o}{S}$$

ne average illumination level of plane is given and total light flow that light sources give) is looked for ;

$$\Phi_o = \frac{E_o S}{\eta}$$

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

Table 7.2 Illumination Units

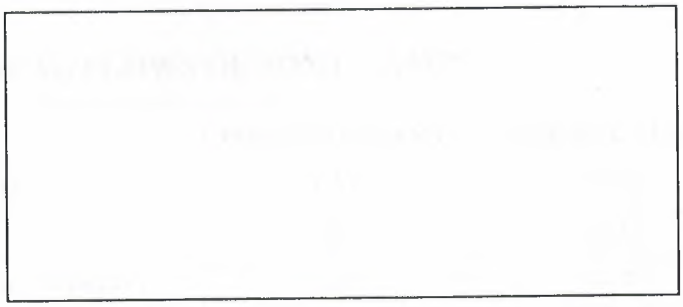
NAME	SYMBOL	UNIT	EXPLANATION
Light flow		Lumen (lm)	It is the amount of the total light source gives in all directions. In other words it is the port of the electrical energy converted into the light energy. That is given to light source.
Light intensity	I	candela (cd)	It is the amount of light flow in any direction. (the light flow may be constant but the light indensity may be different in various directions)
Illumination intensity	E	lux (lux)	It is the total light flow that comes to 1 m^2 area
flashing	L	cd/cm2	It is the light indensity that comes from light sources or unit surfaces that the light sources lighten.

Table 7.3 Illumination Equation

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

a

kitchen



= 4m

= 5m b

I=2.9m

= 0,85m

=50 lüx From table

= H-h1 = 2,9-0,8 =2,1 M

= (axb)/h(a+b) = (4x5)/2,1(4+5) = 0.8

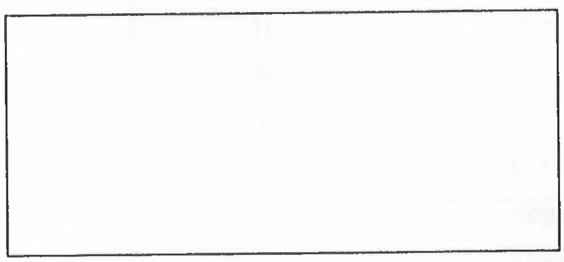
or k = 1,2 η=0,41

=1,25

ÞT= ExAxd / η = 50x20x1,25 / 0,41 = 3048 Lum <2x2850 lum

'he armature tipe = fluorescant lamb tipe = 36/40 W have been choosen.

bedhroom a



= 4m

= 4m b

I=2.9m

= 0,85m

E=50 lüx From table

= H-h1 = 2,9-0,8 =2,1 M

= (axb)/h(a+b) = (4x4)/2,1(4+4) = 0,95

'or k = 0,95 η=0,36 is chosed from table

d=1,25

ΦT= ExAxd / η = 50x16x1,25 / 0,36 = 2777 Lum <1x2850 lum

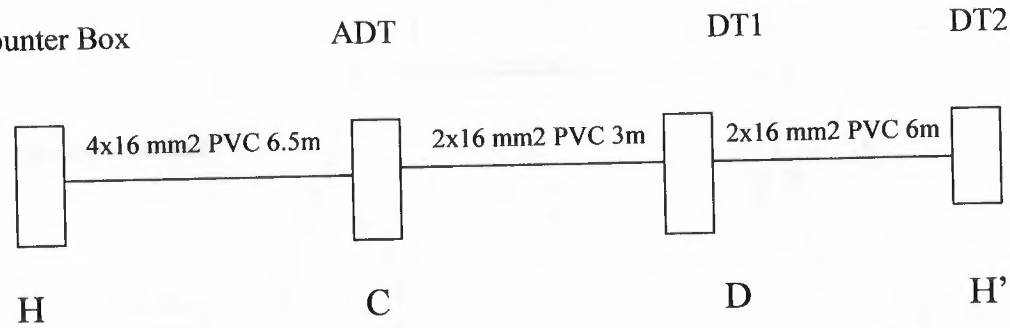
The armature tipe = fluorescant lamb tipe = 36/40 W have been choosen.

Table 7.4 Some typicallapm's flux

TYPICAL FLOWS OF SOME LAMPS

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

Count of Reduce Voltage



veen counter DT2

HC = g1xL1xI1 = 2.2x6,5x100= 1,43 V

CD = g2xL2xI2 = 2,6x3x63= 4,9 V

DH' = g3L3xI3 = 2,6x6x68= 9.8 V

HH' = ▲UHC + ▲UCD + ▲UDH' = 1,43 + 4,9 + 9,8 = 16.1 < %2.5VCables are satisfy

Special Wiring

inas

ina heaters are a kind of heater that brings in mousture by evaporating the liquid that is ired down on the heater.They work with electricity generally.This kind of heater makes the isture increase,this equipments that used are should be suitable for moisture and heat.

7.3.1 Suitable sauna room

ina room is showed like in the figure and its shaped is measurable. The height can be asured to 190 cm, 210 cm and 230 cm as to basicly the minimum distance that is pointed on the sauna heater. The weight is 250 cm and it can be measured by moving the walls. If cannot be had the minimum capacity of the sauna room, a dividing wall that its heigh is 0 cm is put together. The walls, ceiling and ground of the sauna room is about 20 mm thick ntraplak. Sauna room is aired with an air that is a stable wall and pass through in an rance hole that is in 20°C ± 5°C. The space is in the level of ground and its heights is 150 n x 150 mm. It is opened an air exit that its space almost the same to the opposite wall, 30 n from ceiling and minimum 100 cm at below from the wall that is fixed. The air have to be anged six times in an hour

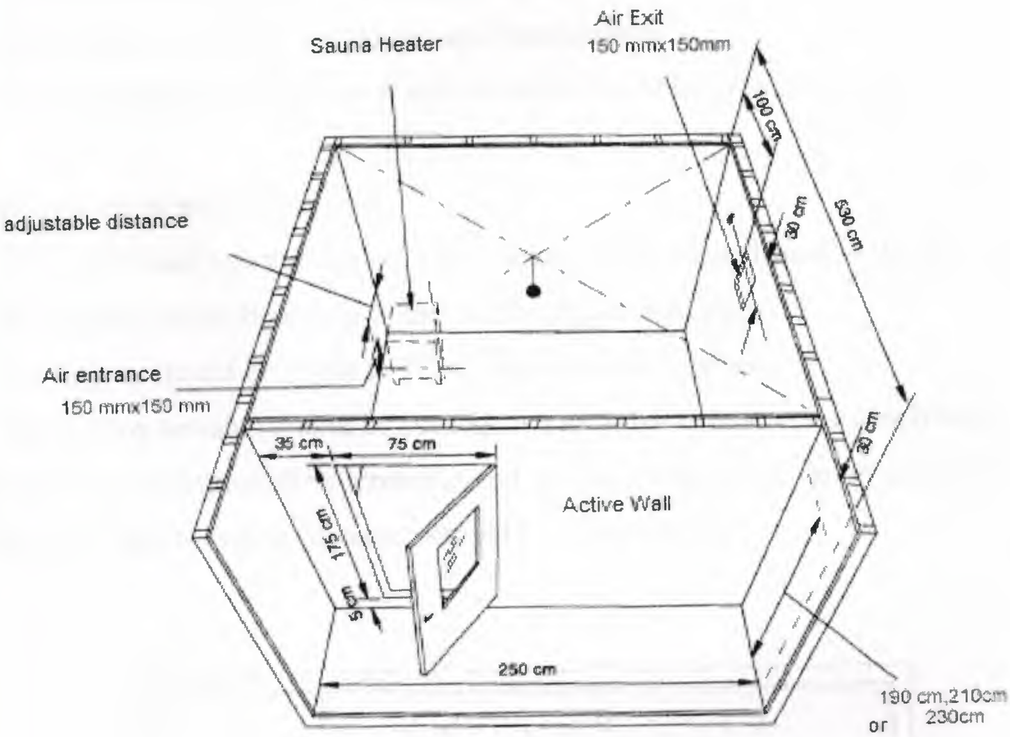


Fig.7.1 Suitable Sauna Room

Table 7.5 Choosing Sauna Heater

Power of The Sauna Heater (kW)	Area of The Sauna Room (m^3)
3,5	5
5	6
8	10
10	12
13	16
16	20
20	25

7.3.2 Security precautions for sauna room

is not available switch in sauna room

1. sauna heater should be protected to direct contact

. the plug cannot be used for the sauna heater

. sauna heater's switch should be out of sauna room

. the aleminum cable is not used and the cable should be protected except metal

a room is examined in four parts

. It is established just the rigging that is belong to the sauna heater in the first area

. the rigging has to be strong of the heat in the second area

. the rigging should be stable to 125 C degree in the third area

. the lighting armatur should be put together as stable to heat in the fourth area

ıeat have to be controlled by termostat and this termostat should be set up to 125 C

degree protection rigging for sauna should be minimum IP24

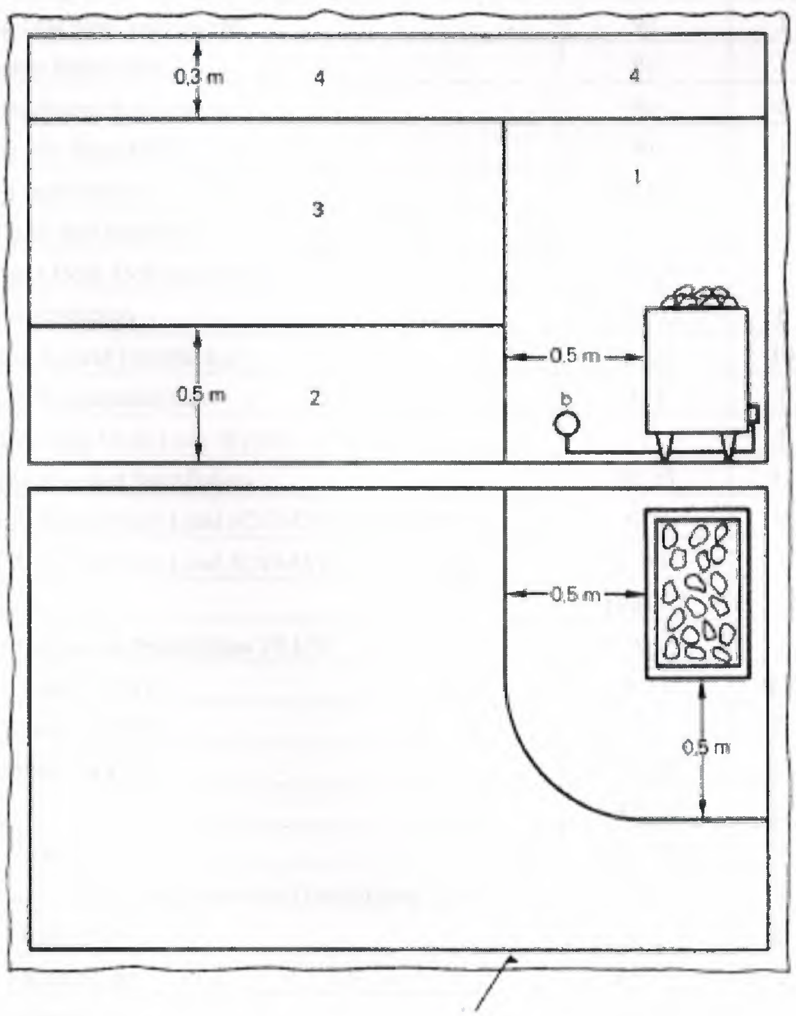


Fig.7.2 Heating Area

7.4 COST CALCULATION

	Definition of Works	Unit Cost (YTL)	Unit	Cost (YTL)
1	Ceiling G lobe Installation	50,6	8	404,8
2	Wall Lighting	98,5	17	1674,5
3	Spot Lamp Installation (240)	85,2	14	1192,8
4	Chandelier Installation	85,2	5	426
5	1x20W Floresent Installation	78	1	78
6	2x65/80 W Floresent Installation	126,7	4	506,8
7	Honney comb Diffuser 4x40W Floresent Installation	656	1	656
8	1x13 Amp. Socket Installation	56	27	1512
9	2x13 Amp. Socket Installation	67	12	804
10	1x13 Amp.W/Proof Socket Installation	145	3	435
11	Shaving Socket Installation	148,15	2	296,3
12	Water Pump Installation	168	1	168
13	Water Heater 3kW Installation	137	1	137
14	Cooker Control Installation	122	1	122
15	Washing Machine Installation	91	1	91
16	Dishwasher Installation	91	1	91
17	Bathroom Heater Installation	91	4	364
18	Sauna Heater Installation	91	1	91
19	Air King Installation	122,5	1	122,5
20	240 V Door Bell Installation	85	1	85
21	Tansformer Door Bell Installation	116,5	1	116,5
22	Fotocell Installation	329,75	8	2638
23	Telephone Socket Installation	61,25	10	612,5
24	Telephone Connection box	212	1	212
25	In The Building Main Line Wiring	7	1	7
26	Tv Antenna Socket Installation	75,25	11	827,75
27	Current Automat Over Load (C/O-O/L) 3x60 Amp.	670	2	1340
28	Current Automat Over Load (C/O-O/L) 3x100 Amp.	1.390	1	1390
29	Soft Starter	1981,25	1	1981,25
30	3 Phase Equipment Installation 20 kW	159,25	1	159,25
31	(2x2.5+1)mm Cu PVC	3,25	300	975
32	(2x6+2.5)mm Cu PVC	4	6	24
33	(2x16+6)mm Cu PVC	14,25	21	299,25
34	Earthing	42,25	22	929,5
35	Central Earthing	2250	1	2250
36	(3x4) Ways -3x100 Amp Bus-Bur Distribution Table	612,5	1	612,5
37	MCB 1 Phase 45 A	34	21	714
38	MCB 1 Phase 63 A	49,25	2	98,5
39	MCB 3 Phase 63 A	208,75	1	208,75
40	(1x4) Way Distribution Table	262	1	262
41	(1x8) Way Distribution Table	463	1	463

TOTAL COST **25378,45 YTL**

CONCLUSION

examined the electricity installation in this project. The first thing when you hear about lectricity is certainly safety. The fires that are caused by electricity is over the world specially in our country, always remind us to think largely in this subject the installations hat are mistaken in situation effecting human's life.

took information from Turkish Standard and ICE (International Electrotechnical Commission) Regulation.

hope this project I have prepared will be a useful source for the students.

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