CHAPTER 6: PERFORMING ELECTRICAL INSTALLATION

Unit of learning code ENG/CU/EI/CR/02/5
Related Unit of Competency in Occupational Standard: Perform Electrical Installation

6.1 Introduction to Electrical installation

This unit specifies the competencies required for performing electrical installation. Competencies required includes; applying health, safety and environmental standards, preparation of working drawings, assembling of tools, equipment, materials and drawing instruments, performing electrical installation, facilitating other service providers and maintain housekeeping.

6.2 Summary of Learning Outcomes

1. Apply health, safety and environmental standards.
2. Prepare working drawings.
3. Assemble tools, equipment, materials and drawing instruments.
4. Perform electrical Installation
5. Facilitate other service providers
6. Maintain housekeeping.

6.2.1 Learning Outcome 1: Apply Health, Safety and Environmental standards

6.2.1.1 Introduction to the learning outcome

To apply EHS standards, the learner needs to understand relevant clauses in appropriate acts (OSHA, WIBA and EMCA), relevant regulations on IEE, KPLC by-laws, county by-laws, meaning, purpose, types and correct handling of PPEs, the causes of accidents and their sources, classes of fire and firefighting equipment and first aid procedures

6.2.1.2 Performance Standard

6.2.1.2.1 Apply appropriate safety regulations.

6.2.1.2.2 Apply Occupational health and safety standards.

6.2.1.2.3 Apply Good housekeeping practices.

6.2.1.2.4 Record and report accident, incidents and near misses to the management.

6.2.1.2.5 Apply First aid and seek specialised treatment when necessary.

6.2.1.3 Information Sheet

An accident

It is a sudden happening that causes harm to the body suddenly and unexpectedly.

First Aid

This is the first help given to a person who is injured before taking them to a health center or hospital or it is the first treatment given to an accident victim before regular medical treatment is obtained.

Personal Protective Equipment (PPE)

the term 'personal protective equipment' (PPE) refers to a vast group of products (e.g. safety helmets, safety footwear and harnesses, eye protection, gloves, high-visibility clothing, etc.) designed with the aim to protect users against low-, medium- and high-level hazards. This group of products is regulated by the **European Directive (EU) 2016/425**

Safety

This is the behaviour undertaken to prevent injury to people and damage to machines and equipment.

Electric shock

This is the passage of electricity in the human body

The Occupational Health and Safety Act (OSHA)

The act provides for the health, safety and welfare of persons employed, and all persons lawfully present at workplaces and related matters. It is obligatory for an occupier to provide and maintain plant and systems and procedures of work that are safe and without risk to workers' health. Employer must ensure safety and absence of risks to health in connection with the use, handling, storage and transport of articles and substances. Provision of such information, instruction, training and supervision of workers as is necessary is very crucial maintain safe and healthy workplace.

Workplace and work environment that is safe, without health risks and adequate as regards facilities and arrangements for the worker's welfare at work should be maintained. Workers should be well informed of any risks and imminent danger related to new technologies and they should participate in the application and review of safety and health measures.

Occupier must also ensure proper cleanliness, ventilation, lighting, drainage of floor, sanitary convenience, avoid overcrowding and control air pollution, noise and vibration at the workplace. Every occupier is required to establish a safety and health committee at the workplace in accordance with regulations prescribed under the law.

Preventive and protective measures should be taken after proper risk assessment (at least once a year) to ensure that all chemicals, machinery, equipment, tools and process are safe and without risk to health and comply with the requirements of safety and health provisions in this Act. An occupier who fails to comply with a duty imposed on him commits an offence and he/she is liable to a fine not exceeding 500,000 shillings or to imprisonment up to six months or to both.

All the above provisions are applicable also to the mine workers, as enunciated under the Mines Act 2016.

Free Protection

In accordance with the Occupational Safety and Health Act 2007, it is the responsibility of employer to provide free protective equipment including clothing and appliances, and where necessary, suitable gloves, footwear, goggles and head coverings to the workers involved in hazardous work. The type of PPE needed varies depending on the nature of work being performed. The right use of PPE reduces risk of accident and illness and helps in creation of safer working environment.

Safety consultant, registered by the Director, assesses the suitability and effectiveness of protective clothes and appliances.

Training

In accordance with the Occupational Safety and Health Act 2007, it is the responsibility of an employer to provide instruction, training and supervision as is necessary to ensure health and safety at work of his workers.

Employment of worker at any machine or in any process that may cause ill health or bodily injury is prohibited unless worker has been fully instructed about the hazards involved and precautions that must be observed. Worker should be properly trained or required to work under supervision of experienced persons.

The training is carried out on recruitment; transfer or change of job; introduction of new work equipment or materials or change in equipment or materials; and introduction of new technology. The training must be arranged regularly at workplace during working hours and adapted accordingly with the new and changed risks.

Employer must ensure that all the persons involved in work must receive appropriate instructions regarding safety and health risks including emergency procedures during their activities at the workplace and actions to be taken in case of an emergency.

If a person fails to comply with these provisions, he/she commits an offence and is liable to a fine up to 200,000 shillings or to imprisonment up to six months or to both.

Labour inspection system

Labour inspection system is present in Kenya. Occupational Safety and Health Act provides for a vibrant Labour inspection system (part IV).

The Occupational Safety, Health and Injury Benefits Authority (OSHIBA) is responsible for the implementation of occupational health and safety, for improving and ensuring health, safety, security and good working conditions at the enterprises, inspecting enterprises and ensuring the law enforcement.

The national legislation provides inspectors the power to enter, inspect and examine the work premises at any time during day or night with or without prior notice; take measurements, photographs, samples and make recordings for the purpose of examination and investigation; ask for registers, documents, certificates and notices to inspect, examine and copy them; interview any one; if the inspector is a

medical practitioner he/she may carry out medical examinations; and may take police officer along with him/her if necessary.

If an occupier or his representatives do not facilitate the inspector and obstruct the execution of his duties, he/she commits an offence and is liable to a fine up to 100,000 shillings or to imprisonment up to six months or to both.

Labour inspectors are authorized to conduct proceedings arising under this Act; to obtain samples of any substance used or intended to be used at workplace; to deal with the cause of imminent danger by seizing it or causing it to be rendered harmless; and issue notices (improvement or prohibition). Inspector must not disclose any information obtained during the course of his/her duty, otherwise he/she is liable (Work Injury Benefits Act, 2007)le to a fine up to 100,000 shillings.

Work injury benefits act (WIBA)

Work Injury Benefits Act, 2007 (WIBA, 2007) is subordinate to The Constitution of Kenya, 2010. Enacted in 2007, WIBA, 2007 is still effective by virtue of section 7 of the 6th Schedule of the Constitution.

Article 41 of the Constitution gives right to every individual to entitlement of reasonable working conditions.

One of the work conditions is compensation of injuries sustained at work by workers.

WIBA, 2007 provides for compensation of injuries sustained at work.

A number of sections in WIBA, 2007 were however nullified by high court in petition No. 185 of 2008 by LSK and to this date the sections remain unconstitutional. The sections include: -

- 4, 7(1) and (4), 10(4), 16, 23(1), 25(1) and (3), 52(1) and (2), 58(2)

Work injury benefits act, 2007

This Act is applicable to all employees except the armed forces (the army, air force and navy).

For the purpose of the Act, the following persons are not regarded as employees: -

- Casual employee not employed for the employer's trade or business.
- An employee deployed outside Kenya for a continuous period of 12 or more months.
- A dependent – Any person who at the time of the accident is dependent upon the employee for necessaries of life.

Employer's obligations

- Register with the Directorate of Occupational Safety and Health Services
- Repair, maintain and replace when necessary appliances for use of victim due to the condition inflicted by the accident
- Furnish the Director with particulars of the business.
- Keep a register for at least 6 years of earning and other employee records and produce it to the Director when required.

- Send notice of occurrence of an accident to the Director
- Convey the accident victim to and from hospital
- Provide first aid to the injured person
- Defray any expenses reasonably incurred by an employee as the result of an accident arising out of and in the course of employment
- Pay compensation to an employee injured while at work.
- Pay reasonable funeral expenses of a deceased employee.

Right of compensation

- An employee who is involved in an accident resulting in disablement or death is subject and entitled to compensation.
- An employee on his/her way to/from place of work by means of transport provided by the employer is entitled to compensation if injured in the process.
- An employee temporarily deployed outside Kenya for a period of 12 or less months and injured during that deployment has right of compensation.
- An employee injured while undertaking training for performance of emergency services

Not eligible for compensation

- Misconduct and if the accident is not serious.

NB. An accident is deemed serious if the degree of disablement is 40% or more.

- An employee who willingly presents false information about the injury is not entitled to compensation
- An employee whose disablement or death was caused or prolonged by deliberate refusal or willful neglect of employee to submit to medical aid.
- If an accident is not reported within 12 months, then the benefits are lost**.**

Reporting of Accidents

- To the employer by the employee or on behalf of the employee immediately upon occurrence of the accident.
- To the Director by the employer
    i. Within 24 hours if fatal
    ii. Within 7 days if non-fatal
- The employee may also report the accident to the Director directly.

The director

- May make inquiry into the occurrence of the accident
- May cause medical examination to be carried out on the claimant
- May require production of medical report by the employer for the purpose of the claim

- May lodge a claim of compensation within 12 months after the date of the accident on behalf of the injured or 12 months after the death of an accident victim if the accident was not reported to the Director.
- May convey the compensation funds to the claimant within 30 days from the date of remittance by employer/insurer.

The injured person just like any other person has a right to fair administrative action pursuant to article 47 of the Constitution.

The Director of Occupational Safety and Health services has a duty of administering WIBA, 2007.

Being a public servant, he is bound by article 232 of the Constitution to uphold values and principles of public service bearing in mind provisions of article 47 in the discharge of duties outlined in WIBA, 2007.

It follows for other public servants e.g. the Director of WIBA, 2007 and implied officers working under the 2 Directors in the Act's spirit.

Compensation

An accident disabling a worker for 3 or more days should be compensated with periodical payment equivalent to employees' earnings but not for a period of exceeding 12 months.

Compensation expires upon termination of disablement or if the employee resumes work of greater earnings

Permanent disablement = Monthly salary x percentage of incapacity x 96 months

Percentage of incapacity may be determined by the doctor attending to the injured.

Earning in respect of temporary incapacity will be equivalent to the periodical earnings while away if the accident victim was not paid while away.

Occupational Diseases

- These are diseases arising from the work conditions where the employee was engaged. On the event of occurrence of an occupational disease, an employee is entitled to compensation whereby the percentage of incapacity is determined by the doctor.

Appeals

- Any person aggrieved by the decision of the Director is to lodge an objection to the Director within 60 days of such decision.
- The Director is to reply within 14 days. If not satisfied by the reply, the objector to appeal to the industrial court.

Functions of the Director of WIBA

- Register employers
- Supervise implementation of WIBA
- Ensure all employers insure their employees
- Receive reports of accidents and carry out investigations
- Ensure compensation of the injured

General Penalty

200,000/= fine or a jail term not exceeding 12 months or both

It is not explicit as to whom delegated prosecutorial powers are vested in WIBA, 2007.

Contravention of provisions of WIBA, 2007 is criminal and their provisions of Criminal Procedure Code Cap. 75 and the Evidence Act Cap.80 come into play during prosecution.

Article 157 of the Constitution establishes the office Director of Public Prosecutions (DPP) in whom powers of prosecution of all criminal cases are vested.

Courts before whom WIBA, 2007 cases are brought have judicial authority as provided for in article 159

The state has a duty to ensure access to justice by any person aggrieved in matters relating to compensation in line the requirement of article 48.

Persons coming within purview of action under the provisions of the WIBA, 2007 have rights as enshrined in articles 49, 50 and 51 of the constitution.

In conclusion

WIBA, 2007 is compliant to the Constitution of Kenya, 2010 by being explicitly in line with the following articles and section of Schedules: - articles 41, 47, 48, 49, 50, 51, 157, 159, 232 and section 7 of the 6th Schedule.

The IEE wiring regulations BS 7671

Protection of persons and livestock from shock and burns, etc. and the prevention of damage to property are priorities. In consequence, therefore, thorough inspection and testing of an installation and subsequent remedial work where necessary will significantly reduce the risks. Electric shock is the passage of current through the body of such magnitude as to have significant harmful effects. Figure 1 illustrates the generally accepted effects of current passing through the human body. There are two ways in which we can be at risk:

1. Touching live parts of equipment or systems that are intended to be live.
2. Touching conductive parts which are not meant to be live, but have become live due to a fault.

The conductive parts associated with the second of these can either be metalwork of electrical equipment and accessories (Class I) and that of electrical wiring systems such as metallic conduit and trunking, etc. called exposed conductive parts, or other metalwork such as pipes, radiators, girders, etc. called extraneous conductive parts.

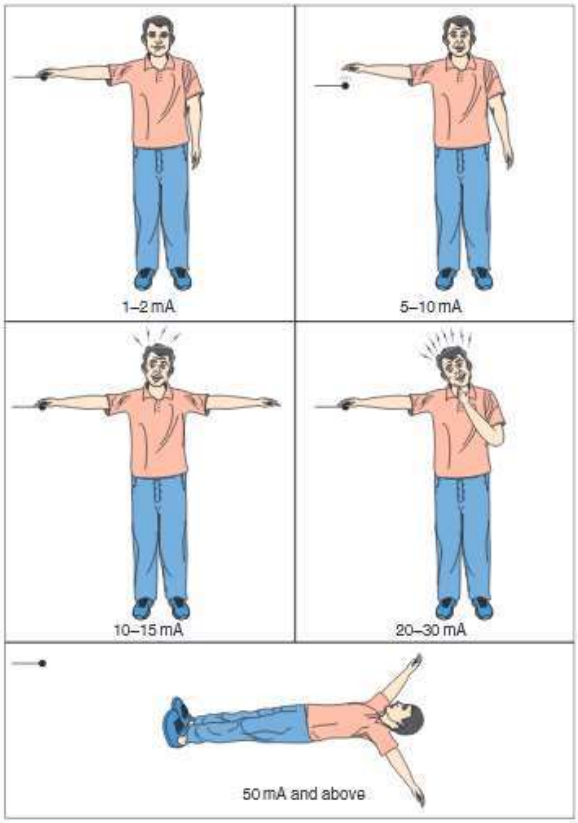

Figure 227 Shock levels

Shock levels.

1 mA – 2 mA	Barely perceptible, no harmful effects
5 mA – 10 mA	Throw off, painful sensation
10 mA – 15 mA	Muscular contraction, can't let go
20 mA – 30 mA	Impaired breathing
50 mA and above	Ventricular fibrillation and death

Protection against shock from both types of contact

One method of achieving this is by ensuring that the system voltage does not exceed extra low (50 V ac, 120 V ripple-free dc), and that all associated wiring, etc. is separated from all other circuits of a higher voltage and Earth. Such a system is known as a separated extra low voltage (SELV). If an SELV system exceeds 25 V ac, 60 V ripple-free dc, then extra protection must be provided by barriers, enclosures and insulation.

Basic protection

Apart from SELV, we can minimize the risk of such contact, and this may be achieved in one or more of the following ways:

1. Insulate any live parts.
2. Ensure that any uninsulated live parts are housed in suitable enclosures and/or are behind barriers.
3. Place obstacles in the way. (This method would only be used in areas where skilled and/or authorized persons were involved.)

4. Placing live parts out of reach. (Once again, only used in special circumstances, e.g. live rail.

A residual current device (RCD) may be used as additional protection to any of the other measures taken, provided that it is rated at 30 mA or less and has an operating time of not more than 40 ms at a test current of five times its operating current. It should be noted that RCDs are not the panacea for all electrical ills, they can malfunction, but they are a valid and effective back-up to the other methods. They must not be used as the sole means of protection.

Fault protection

Protection against shock from contact with unintentionally live, exposed or extraneous conductive parts whilst touching earth, or from contact between unintentionally live exposed and/or extraneous conductive parts can be achieved by using protective earthing, protective equipotential bonding and automatic disconnection in case of a fault. All extraneous conductive parts are connected with a main protective bonding conductor and connected to the main earthing terminal, and all exposed conductive parts are connected to the main earthing terminal by the circuit protective conductors (CPC). Add to this over-current protection that will operate fast enough when a fault occurs and the risk of severe electric shock is significantly reduced. Other means of fault protection may be used, but are less common and some require very strict supervision

Use of class ii equipment

Often referred to as double-insulated equipment, this is typical of modern appliances where there is no provision for the connection of a CPC. This does not mean that there should be no exposed conductive parts and that the casing of equipment should be of an insulating material; it simply indicates that live parts are so well insulated that faults from live to conductive parts cannot occur.

Non-conducting location

This is basically an area in which the floor, walls and ceiling are all insulated. Within such an area there must be no protective conductors, and socket outlets will have no earthing connections. It must not be possible simultaneously to touch two exposed conductive parts, or an exposed conductive part and an extraneous conductive part. This requirement clearly prevents shock current passing through a person in the event of an earth fault, and the insulated construction prevents shock current passing to earth.

Earth-free local equipotential bonding

This is in essence a Faraday cage, where all metal is bonded together but not to earth. Obviously, great care must be taken when entering such a zone in order to avoid differences in potential between inside and outside. The areas mentioned in this and the previous method are very uncommon. Where they do exist, they should be under constant supervision to ensure that no additions or alterations can lessen the protection intended

Electrical separation

This method relies on a supply from a safety source such as an isolating transformer to BS EN 61558-2-6 which has no earth connection on the secondary side. In the event of a circuit that is supplied from a source

developing a live fault to an exposed conductive part, there would be no path for shock current to flow (see Figure 2). Once again, great care must be taken to maintain the integrity of this type of system, as an inadvertent connection to earth, or interconnection with other circuits, would render the protection useless. Additional protection by RCDs is a useful back-up to other methods of shock protection. The use of enclosures is not limited to protection against shock from contact with live parts, they clearly provide protection against the ingress of foreign bodies and moisture. In order to establish to what degree an enclosure can resist such ingress, reference to the Index of Protection (IP) code (BS EN 60529) should be made. Table 0.1 illustrates part of the IP code. The most commonly quoted IP codes in the 17th edition are IPXXB or IP2X, and IPXXD or IP4X. The X denotes that protection is not specified, not that there is no protection. For example, an enclosure that was to be immersed in water would be classified IPX8, there would be no point using the code IP68.

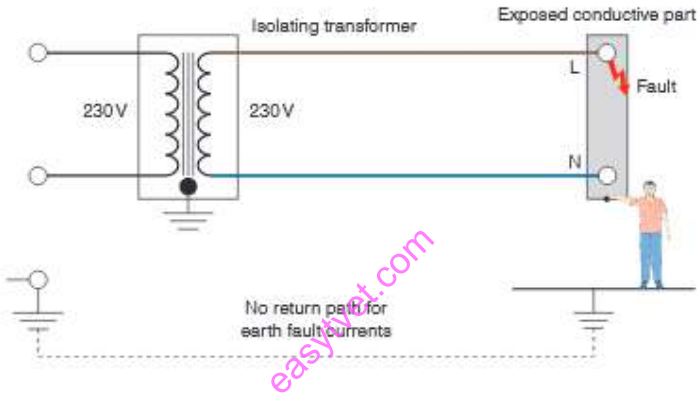

Figure 228 Current flow when not earth

Environmental management and coordination (amendment) act, 2015

The Environmental Management and Coordination Act, 1999, was amended to comply with the Constitution and integrate emerging environmental issues. The Environmental Management and Coordination (Amendment) Act (EMCA) provides the framework law for environmental conservation, management and coordination. Through EMCA, the government has attempted to harmonize policy regulations for the management of natural resources in Kenya. The EMCA provides for the protection of forests and Environmental Impact Assessment (EIA) of forestry related developments. The institutions formed under EMCA are:

- National Environment Management Authority,
- National Environmental Complaints Committee,
- National Environment Tribunal,
- National Environment Action Plan Committees and;

- County Environment Committees.

The National Environment Management Authority (NEMA) was established as the lead agency of government charged with the implementation of all policies relating to the environment, and to exercise general supervision and coordination over all matters relating to the environment. In consultation with lead agencies, like KFS, NEMA is empowered to develop regulations, prescribe measures and standards and, issue guidelines for the management and conservation of natural resources and the environment.

Provisions of the Act relevant to forestry a) Environmental Protection

The right to a clean and healthy environment was first acknowledged in the EMCA, 1999. This right has now been elevated to constitutional status. The EMCA provides for environmental protection through; Environmental Impact Assessments, Strategic Environmental Assessments, Environmental Audits and monitoring as well as environmental restoration orders, conservation orders, and easements. The Act is based on principles such as: the precautionary principle, the polluter-pays principle, environmental restoration and compensation to victims of pollution. These principles also apply in the Forest Conservation and Management Act (FCMA, 2016). Section 44 provides that the KFS must consider the aforementioned before granting concessions and mining permits within a forest reserve. Section 28 of EMCA also provides that persons engaged in activities that are most likely to have adverse environmental effects must pay deposit bonds equivalent to the cost of environmental restoration. This is the Environmental Protection Bond in the FCMA, 2016. The Amendment Act is also based on principles of sustainable development such as public participation, cultural and social principles, the principle of international co-operation in the case of shared environmental resources and the principle of intra-generational and intergenerational equity.

Protection of the rights of forest adjacent communities

Traditional interests of forest adjacent communities are also protected in the EMCA (Section 43). The Act also promotes community conservation of forests.

The roles of County governments in environmental management

The EMCA has included the role of County governments in forest management through formation of a County Environment Committee (CEC) in Section 29. The committee will be in charge of proper management of the environment within the county for which it is appointed, including forestry functions such as provision of extension services to individuals and communities within their jurisdiction.

Functions of NEMA related to forestry

The NEMA, which is the lead implementing agency of EMCA, is mandated to promote the integration of environmental considerations into national development goals, conduct the valuation of natural resources in the country, review land use guidelines in consultation with other lead agencies and make recommendations to the relevant authorities. It is also mandated to promote environmental education, public awareness and public participation in environmental management, encourage incentives for

voluntary environmental conservation practices and work with other lead agencies to issue guidelines and prescribe measures for the attainment of at least 10% tree cover of the land area of Kenya.

Registration of forests

Section 48 of EMCA outlines the procedure regarding registration of forests. NEMA and the Chief Conservator of Forests, following consultations, may enter into contractual arrangements with private owners for the registration of land as forest land.

Climate change mitigation and adaptation

The EMCA expressly provides for climate change mitigation and adaptation. Section 56 states that the Cabinet Secretary, in consultation with relevant lead agencies will issue guidelines and prescribe measures on climate change. The Act also has provisions for the protection of wetlands in Section 42. The Act restricts introduction of alien species to the environment, which coincides with the provisions of the FCMA, 2016.

Dispute resolution mechanisms under the Act

The EMCA gives power to citizens to apply for redress on environmental issues, whether affected directly or indirectly. Specifically, the establishment of the National Environmental Complaints Committee in Section 31 and the National Environment Tribunal in Article 125 to address environmental grievances. The Land and Environment Court formed under the Environment and Land Act, 2011 will also be charged with handling appeals of environmental grievances as well as forest-based conflicts. These institutions were established to provide the link between environmental management and the judiciary.

Forest conservation and management

Section 124A of the Act provides for the development of legislation by NEMA and lead institutions. In collaboration with KFS, NEMA will develop, issue and implement regulations, procedures, guidelines and measures for the sustainable use of forests, to control harvesting, protect water catchment areas, prevent soil erosion and regulate human settlement. Article 46 of the Act requires that every County Environment Committee (CEC) should identify areas for afforestation and reforestation as well as encourage community members to plant trees. Article 49 (d) of EMCA also provides for the promotion of renewable energy through planting of trees and woodlots by individual, communities and institutions.

Conservation of biodiversity

Sections 50 and 51 of the Act provides for the conservation of biological diversity. The Act requires NEMA to prepare an inventory on biological diversity and specific conservation measures, including *in situ* and *ex situ* conservation, identifying endangered, rare or threatened species, identifying potential threats to biodiversity, prohibiting and controlling the introduction of alien species into natural habitats and protection of indigenous knowledge among others. Section 8 of the FCMA, 2016 has a similar provision. The EMCA also provides for the protection of genetic resources and environmentally significant areas (Section 53 and 54).

The IEE Wiring Regulations 17th edition requirements for electrical installations

The Institution of Electrical Engineers Requirements for Electrical Installations (the IEE Regulations) are non-statutory regulations. They relate principally to the design, selection, erection, inspection and testing of electrical installations, whether permanent or temporary, in and about buildings generally and to agricultural and horticultural premises, construction sites and caravans and their sites. Paragraph 7 of the introduction to the EWR says: 'the IEE Wiring Regulations is a code of practice which is widely recognized and accepted in Kenya and compliance with them is likely to achieve compliance with all relevant aspects of the Electricity at Work Regulations'. The IEE Wiring Regulations are the National Standard in Kenya and apply to installations. However, they do not apply to electrical installations in mines and quarries, where special regulations apply because of the adverse conditions experienced there.

The current edition of the IEE Wiring Regulations is the 17th edition 2008. The main reason for incorporating the IEE Wiring Regulations into British Standard BS 7671: 2008 was to create harmonization with world Standards.

The IEE Regulations take account of the technical intent of the CENELEC world, which in turn are based on the IEC International Standards.

The purpose in harmonizing Standards is to help develop a single market economy so that there are no trade barriers to electrical goods and services across the world Economic Area.

To assist electricians in their understanding of the Regulations a number of guidance notes have been published. The guidance notes which I will frequently make reference to in this book are those contained in the *On*-Site *Guide.* Eight other guidance notes booklets are also currently available. These are:

- *Selection and Erection*
- *Isolation and Switching*
- *Inspection and Testing*
- *Protection against Fire*
- *Protection against Electric Shock*
- *Protection against Overcurrent*
- *Special Locations*
- *Earthing and Bonding*

These guidance notes are intended to be read in conjunction with the Regulations.

The IEE Wiring Regulations are the electrician's bible and provide the authoritative framework of information for anyone working in the electrotechnical industry.

Common causes of workplace accidents

1. **Lifting**

It is so easy to injure yourself while lifting heavy objects. Eliminate back injuries and muscle strains by ensuring that everyone practices safe lifting procedures. It's always best to recruit a helping hand or to use machinery to move large objects.

2. **Lighting**

Poor lighting can be a major cause of trips, falls, and other workplace injuries. If you can't see the hazards, they're much more likely to become serious problems. Every area in the workplace should be well lit, including offices, warehouses, parking areas, and outside entryways.

3. **Violence**

Hundreds of people die each year from workplace violence. Employees in conflict with one another tend to be especially unsafe when working together. OSHA has guidelines for violence prevention if you need help resolving these issues in your workplace.

4. **Trips/Falls**

Consistently one of the leading causes of workplace injuries, trips and falls continue to be a major problem. Slippery floors, improper footwear, rushing employees, and weather conditions all contribute to trip and fall hazards. Make sure all employees are well trained on the relevant safety information and verify that the physical conditions in the workplace are up to standards to lower the number of injuries in this category.

5. **Stress**

Physical and mental stress are less commonly recognized workplace hazards, but they can cause serious or even fatal accidents. Employees must be in the right mindset and physically sound for the job. Communicate the importance of mental and physical health to all employees. It's important to take breaks and seek help with managing stressful situations.

6. **Fatigue**

As mentioned before, it is imperative that employees show up to work physically prepared. A lack of adequate sleep can cause exhaustion, inattention, and accidents. Even a well-rested employee can grow fatigued while on the job, so it's necessary to take breaks at regular intervals or when needed.

7. **Shortcuts**

Employees should never take shortcuts on the jobs, especially when dealing with dangerous machinery or circumventing safety procedures. The regulations are in place to protect employees and to make sure everything is done correctly.

8. **Overconfidence**

Employees should be confident about what they're doing, but overconfidence may diminish carefulness or attention. Overconfident employees are likely to ignore safety precautions and forego double checking their work. It's important for them to understand that accidents can occur any time to anyone, no matter how skilled or experienced.

9. Poor Housekeeping

A messy workplace is a dangerous workplace. Objects and debris on the floors pose tripping hazards, wet or dirty floors can cause slips, cluttered surfaces can conceal sharp objects, poorly contained chemicals are an obvious hazard… you get the picture. Besides the dangers, good housekeeping sets a good example for other safety precautions as well.

10. Lack of Preparation

No one should ever be on the job without the proper knowledge, training, certifications, tools, or PPE. Preparedness on the job is one of the absolute best ways for employees to stay safe.

11. Mental Distractions

It's easier said than done, but employees must try to leave personal matters at the door. Being distracted on the job is similar to being fatigued, stressed, or overconfident. Workers simply cannot perform their jobs to their full potential if their mind is elsewhere.

Have you noticed any of these behaviors in your workplace? It may be time to set up some refresher training to reduce the risk of injuries and improve overall performance in your organization. Better safe than sorry, as they say.

Personal Protective equipment (PPE)

PPE, falling under the scope of the above-mentioned Directive, is intended for use in work and home activities, as well as in leisure and sport events. Such activities can bring harm to the user's body in various ways. To be ensured user's health and safety in any risky situation, a proper type of PPE must be held or worn. In this regard, there are eight types of personal protective equipment critical for the defense of users against hazards.

Many people are injured or killed in electrical accidents due to ignorance or carelessness.

There are various safety/protective wear that needs to be used in a work environment.

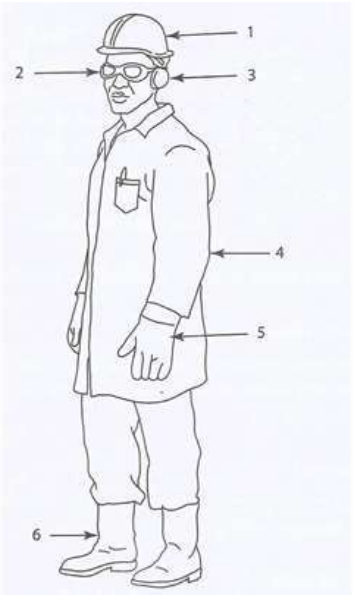

Figure 229 various safety/ protective wears

- Safety helmet-Protects head from falling objects
- Goggles-Protects eyes from flying objects and excessive light
- Ear muffles-Protects ears from excessive sound.
- Dust coat/Overall- Protects personal clothing from dirt
- Hand gloves- Protects hands from injury.
- Safety boots- Protects feet from falling objects.

Types of Personal Protective Equipment (PPE)

a. Head protection

Wearing PPE for head protection will help you avoid any harm that may come to you from falling materials or swinging objects. Moreover, the head protectors are designed to protect you from knocking against stationary objects. Some kinds of head protection equipment (e.g. caps and hair nets) can even protect against entanglement or scalping on machinery.

Examples of head protection equipment:

- Helmets;
- Hard hats;
- Bump Caps;
- Guards;
- Accessories.

Examples of activities where you may need head protection:

- Workplace related: construction or building repair (e.g. renovation, restoration, etc.) and work in tunnels or excavations;
- Leisure/Sport related: driving motorcycles.

b. Hand protection

Arms, hands and fingers are often injured and, therefore, it is vital to wear hand protection equipment when it is required. The hand protection equipment can ensure protection against heat, cold, vibrations, burns, and cuts by sharp objects, bacteriological risks and chemical contamination. Examples of hand protection equipment:

- Work gloves and gauntlets;
- Wrist cuff arm nets.

Activities requiring hand protection equipment:

- construction and outdoor work;
- working with vibrating apparatus;
- working in hot or cold environments;
- working with chemicals and hazardous elements;
- Manual handling of abrasive or sharp objects.

c. Eye and face protection

Numbers are scary! Every day, 600+ workers worldwide suffer from eye injuries. Such injuries can be avoided simply by wearing the proper eye and face protection equipment. As examples of such PPE can be mentioned the following ones:

- Safety glasses and goggles;
- Eye and face shields;
- Eyewear accessories;
- Over specs;
- Visors.

You are encouraged and advised to wear eye and face protection equipment when:

- working with lasers or power-driven tools;
- using gas or vapour under pressure;
- performing welding operations;
- Handling hazardous substances.

d. Respiratory protection

The respiratory protection covers a broad group of PPEs: breathing apparatus, full face or half mask respirators, powered respirators, protective hoods, disposal face masks, detectors, monitors, etc. Adequate training on how users should use the equipment is always required.

This type of PPE must be present when being in contact with large amounts of gases, powders, dust and vapours.

e. Hearing protection

The hearing protection equipment is vital when working in an environment with high-sound levels. The type of hearing protection should not only be suitable for the working environment but also provide a level of hygiene and comfort to the users. A good practice is to provide employees with a range of protectors and then allow them to select the ones which suit them the best.

Examples of hearing protection equipment:

- Earplugs and defenders;
- Noise meters;
- Communications sets;
- Acoustic foam.

f. Foot protection

The foot protection equipment is designed to protect the feet and legs against various hazards, such as extreme temperatures, crushing, piercing, slipping, cutting, chemicals and electricity. It is typically required when users are involved in construction activities, working in very cold or hot environments, working with chemicals and forestry, or when manually handling heavy objects.

As examples of foot protection equipment can be pointed out the following ones:

- Safety boots and shoes;
- Anti-static and conductive footwear.

g. Body protection

Usually, body protection equipment is required in the following cases:

- For protection against weather conditions when working outdoors;
- Ensuring the high-visibility of users when they work in areas where there is a mixed vehicle (e.g. bikes, motors, cars and busses) and pedestrian traffic;
- For users' protection against extreme temperatures;
- Ensuring protection against entanglement, drowning, chemical contamination, etc.

Examples of body protection equipment:

- Life jackets;
- Clothing for specific weather conditions;
- High-visibility clothing;
- Harnesses, and others.

h. Height and access protection

This type is highly specialized, and it usually requires users to undergo thorough training before they are allowed to use it. The height and access protection equipment must be inspected periodically by a competent person to ensure it is still fit for use and the health and safety of users is not threatened in any way.

As examples of height and access protection equipment can be mentioned the following ones:

- Fall-arrest systems;
- Body harnesses;
- Lowering harnesses;
- Rescue lifting;
- Energy absorbers, and others

Types of Fires

I. Class A

Class A fires are fires in ordinary combustibles such as wood, paper, cloth, rubber, and many plastics

II. Class B

Class B fires are fires in flammable liquids such as gasoline, petroleum greases, tars, oils, oil-based paints, solvents, alcohols. Class B fires also include flammable gases such as propane and butane. Class B fires do not include fires involving cooking oils and grease

III. Class C

Class C fires are fires involving energized electrical equipment such as computers, servers, motors, transformers, and appliances. Remove the power and the Class C fire becomes one of the other classes of fire.

IV. Class D

Class D fires are fires in combustible metals such as magnesium, titanium, zirconium, sodium, lithium, and potassium.

V. Class K

Class K fires are fires in cooking oils and greases such as animal and vegetable fats.

Types of Fire Extinguishers

I. Water and Foam

Water and Foam fire extinguishers extinguish the fire by taking away the heat element of the fire triangle. Foam agents also separate the oxygen element from the other elements. Water extinguishers are for Class A fires only - they should not be used on Class B or C fires. The discharge stream could spread the flammable liquid in a Class B fire or could create a shock hazard on a Class C fire.

II. Carbon Dioxide

Carbon Dioxide fire extinguishers extinguish fire by taking away the oxygen element of the fire triangle and also be removing the heat with a very cold discharge. Carbon dioxide can be used on Class B & C fires. They are usually ineffective on Class A fires.

III. Dry Chemical

Dry Chemical fire extinguishers extinguish the fire primarily by interrupting the chemical reaction of the fire triangle.

Today's most widely used type of fire extinguisher is the multipurpose dry chemical that is effective on Class A, B, and C fires. This agent also works by creating a barrier between the oxygen element and the fuel element on Class A fires. Ordinary dry chemical is for Class B & C fires only. It is important to use the correct extinguisher for the type of fuel! Using the incorrect agent can allow the fire to re-ignite after apparently being extinguished successfully.

IV. Wet Chemical

Wet Chemical is a new agent that extinguishes the fire by removing the heat of the fire triangle and prevents re-ignition by creating a barrier between the oxygen and fuel elements. Wet chemical of Class K extinguishers was developed for modern, high efficiency deep fat fryers in commercial cooking operations. Some may also be used on Class A fires in commercial kitchens.

V. Clean Agent

Halogenated or Clean Agent extinguishers include the halon agents as well as the newer and less ozone depleting halocarbon agents. They extinguish the fire by interrupting the chemical reaction and/or removing heat from the fire triangle.

Clean agent extinguishers are effective on Class A, B and C fires. Smaller sized handheld extinguishers are not large enough to obtain a 1A rating and may carry only a Class B and C rating.

VI. Dry Powder

Dry Powder extinguishers are similar to dry chemical except that they extinguish the fire by separating the **fuel** from the **oxygen** element or by removing the **heat** element of the fire triangle. However, dry powder extinguishers are for Class D or combustible metal fires, only. They are ineffective on all other classes of fires.

VII. Cartridge Operated Dry Chemical

Cartridge Operated Dry Chemical fire extinguishers extinguish the fire primarily by interrupting the **chemical reaction** of the fire triangle. Like the stored pressure dry chemical extinguishers, the multipurpose dry chemical is effective on Class A, B, and C fires. This agent also works by creating a barrier between the oxygen element and the fuel element on Class A fires.

Ordinary dry chemical is for Class B & C fires only. It is important to use the correct extinguisher for the type of fuel! Using the incorrect agent can allow the fire to re-ignite after apparently being extinguished successfully.

Type of fire extinguisher / Type of fire	(i) Water Signal red flash on red	(ii) Foam Pale cream flash on red	(iii) Carbon dioxide gas Black flash on red	(iv) Dry powder French blue flash on red	(v) Vapourizing foam Emerald green flash on red
Class A. Paper, wood and fabric	✓ Yes	✓ Yes	✗ No	✓ Yes	✓ Yes
Class B. Flammable liquids	✗ No	✓ Yes	✓ Yes	✓ Yes	✓ Yes
Class C. Flammable gases	✗ No	✗ No	✓ Yes	✓ Yes	✓ Yes
Electrical fires	✗ No	✗ No	✓ Yes	✓ Yes	✓ Yes
Motor vehicle protection	✗ No	✓ Yes	✗ No	✓ Yes	✓ Yes

Figure 230 Fire extinguishers and their applications (colour codes to BSEN3:1996)

Rescuing electric shock victim

When a person gets into contact with a live wire and gets an electric shock, the following steps should be followed to save the victim:

1. Switch off the current if possible if not do not waste
2. Secure release from contact. Safeguard yourself when removing the casualty from the contact. Use a dry insulator to remove the victim from electrical contact e.g. rubber, mat gloves, a length of dry rope or a length of dry wood to pull or push the casualty away from the contact
3. Start respiratory resuscitation once the casualty is not breathing. Use the method known best. Continue until casualty is breathing satisfactorily.
4. Send for a doctor and ambulance immediately.

Methods of resuscitation

I. **Kiss of life**

The procedure for this method of artificial respiration is as follows.

- Place a support below the neck and loosen the clothing.
- Clear all air passages.
- Pinch the nose and breathe into victim's mouth until the chest rises.
- Release the nose and let the air rush out.
- Continue with this process until the victim breathes normally.
- Take the victim to hospital for further medical check-up.

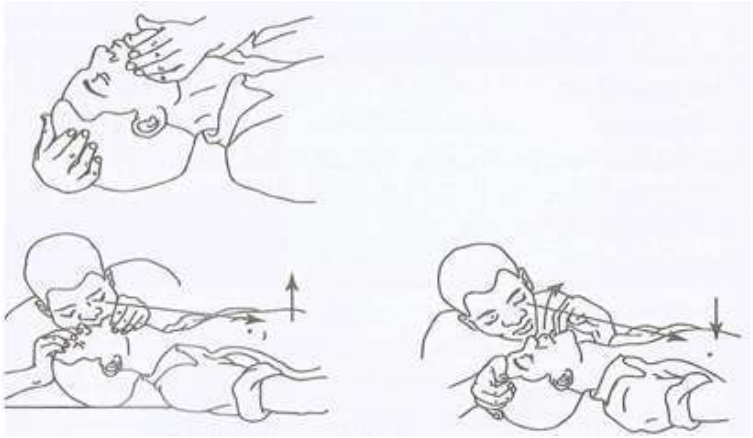

Figure 231 Kiss of life method

II. Holger-Nielsen method of artificial respiration

- Lay the casualty in a prone position on a flat surface.
- Place the casualty's hands one over the other under his forehead
- The hand must be turned slightly on one side.
- Nose and mouth must be unobstructed.

- Place one knee with its inner side in line with the casualty's cheek, a few inches from the top of his head.
- Place the other foot with the heel in line with the casualty's elbow.
- Place your hands on the casualty's back on the lower part of the shoulders back, fingers pointing at casualty's feet.
- Keeping the arms straight, rock forward gently until arms are vertical. The movement takes seconds counting ONE,TWO.This pressure causes **expiration**
- Then rock back counting, THREE for one second, and slide your hand past the casualty's shoulder until you can grab his upper arms near the elbows.
- Rise and pull the arms until tension is felt for two seconds counting FOUR, FIVE.
  Do not raise chest from ground. This movement causes **inspiration**.
- Your hands should remain straight, count SIX for one second.

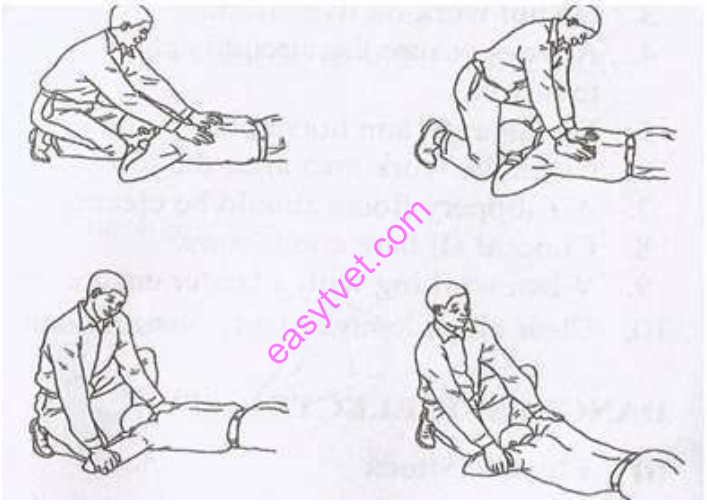

Figure 232 Holger- Nielsen method

III. Revised Silvester Method

Place the victim on his back. First loosen his clothes around the chest and stomach. Remove false teeth, if any and put a pillow under the shoulders, so that his chest will be rise up and head will titled backward. The tongue should be drawn forward. The rescuer must stand beside the victim in the position shown in fig 7 Grasp the victim just below the elbows. Draw his arm over his head until horizontal, retaining them for two seconds. Next, bring the victim's arms down on each side of his chest and pressing inwards upon it. Leaning upon his arm so as to compress his chest. Remain in his position for two seconds and then again keep repeating the two motions at the same rate. If one more person is present, he should be asked to draw out victims tongue at each action of the victim's lungs inflating and deflating. Be careful in this method to avoid any injury to internal organs resulting from excessive and sudden pressures. Do not give anything to drink to a victim until he is conscious.

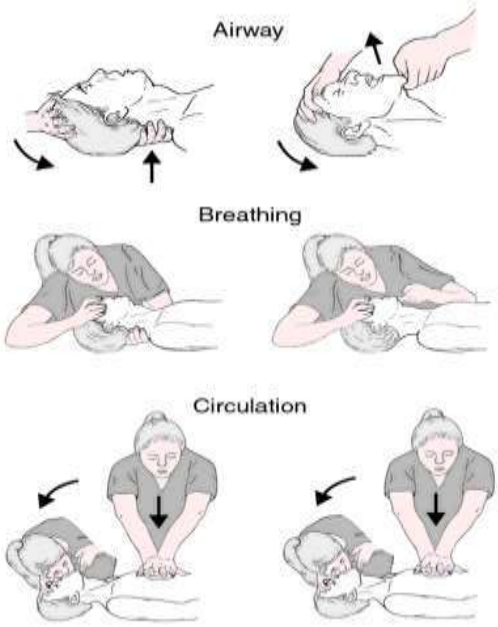

Figure 233 Revised Sylvester method

IV. Schafer's Method

The subject is laid in prone position and a small pillow is placed underneath the chest and epigastrium. The head is turned to one side. The operator kneels down by the side of the subject facing towards his head. Two hands are placed on the two sides of the lower part of the chest and then the operator slowly puts his body weight leaning forwards and pressing upon the loins of the subject. Intra-abdominal pressure rises, the diaphragm is pushed up and air is forced out of the lungs.

After this the operator releases the pressure and comes back to his original erect position. The abdominal pressure falls, diaphragm descends and air is drawn in. These movements are repeated about twelve times a minute (roughly the normal rate of respiration).

By this means it is possible to have a total pulmonary ventilation of 6,500 ml per minute, and this amount is sufficient for complete aeration of blood. The advantage of this method is that the patient being in the prone position, mucus or saliva comes out of the mouth and cannot obstruct his airways.

Figure 234 Schafer's method of artificial respiration

6.2.1.4 Learning Activities
Project/workshop

Practical activity	Knowledge	Special instruction
1. Demonstrate the knowledge on safety regulations in the workshop	• Relevant safety regulations	
2. Demonstrate knowledge of OSHA standards in the workshop	• OSHA, WIBA, EMCA	
3. Demonstrate good housekeeping practices in the workshop.	• Housekeeping elements	
4. Demonstrate how to write reports on accidents, incidents and near misses	• Causes of accidents	
5. Demonstrate the first aid procedures and methods in the field, identify the various PPEs, identify various firefighting equipment	• Firefighting equipment • Methods of resuscitation • PPEs types and applications	

6.2.1.5 Self-Assessment
1. What is the meaning of the term PPE
2. What are some of the five pieces of PPE which a trainee could be expected to wear at work and the protection given by each piece?
3. What are some causes of accidents
4. What types of fire extinguishers do you know? And how or when are they applied?
5. Which two methods of artificial resuscitation do you know?

6.2.1.6 Tools, Equipment, Supplies and Materials
Recommended Resources

Tools and equipment	**Materials and supplies**
➢ Cable Strippers ➢ Pliers ➢ Screw drivers ➢ Hammers ➢ Chisels ➢ Allen keys ➢ Electrician knives ➢ Crimping tools ➢ Bending springs ➢ Bending machine ➢ Steel tapes ➢ Draw wires ➢ Hack saws ➢ Drilling tools ➢ Stock and die ➢ Bench vice ➢ Machine vice ➢ PPE – hand gloves, dust coats, dust masks, helmets, ear muffs, industrial boots	• Stationery • Cables • Light fittings • Accessories • Conduits and fittings • Cable trays • Cable ducts • Trunkings • Computers • Drawing instruments • Screws
Reference materials • IEE regulations • Occupational safety and health act (OSHA) • Work injury benefits act (WIBA) • Manufacturers' catalogues • British standards • KEBS standards	

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6.2.1.8 Model Answers to self-assessment

1. What is the meaning of the term PPE

the term 'personal protective equipment' (PPE) refers to a vast group of products (e.g. safety helmets, safety footwear and harnesses, eye protection, gloves, high-visibility clothing, etc.) designed with the aim to protect users against low-, medium- and high-level hazards. This group of products is regulated by the European Directive (EU) 2016/425

2. What are some of the five pieces of PPE which a trainee could be expected to wear at work and the protection given by each piece?
   - **Safety helmet-Protects head from falling objects**
   - **Goggles-Protects eyes from flying objects and excessive light**
   - **Ear muffles-Protects ears from excessive sound.**
   - **Dust coat/Overall- Protects personal clothing from dirt**
   - **Hand gloves- Protects hands from injury.**
   - **Safety boots- Protects feet from falling objects.**

3. Causes of accidents

- **Trips/fall**

- **Fatigue**
- **Stress**

4. Types of fire extinguishers
    - **Carbon dioxide**
    - **Dry chemical**
    - **Water and foam**

5. Methods of artificial resuscitation
    - **Kiss of life**
    - **Holger-Nielsen**
    - **Silvester method**
    - **Schafer's method**

6.2.2. Learning Outcome 2: Prepare working drawings

6.2.2.1 Introduction to the learning outcome

To prepare working drawings appropriately, the learner need to interpret installation drawings, apply symbols and nomenclature in accordance with British standards (BS 3939), apply appropriate drawing tools, identify components and their ratings, clearly show cable sizes and lengths, show power supply and distribution circuits using single line diagrams, carry out phase balancing of the loads as per the usage, clearly indicate cable routes and prepare working drawings and share any deviation with the relevant bodies

6.2.2.2 Performance Standard

6.2.2.2.1 Interpret installation drawing

6.2.2.2.2 Apply symbols and nomenclatures in accordance with British standards[BS 3939]

6.2.2.2.3 Apply appropriate drawing tools

6.2.2.2.4 Identify components and their ratings.

6.2.2.2.5 Clearly show cable sizes and lengths

6.2.2.2.6 Show power supply and distribution circuits using single line diagrams

6.2.2.2.7 Carry out phase balancing of loads as per usage.

6.2.2.2.8 Clearly indicate cable routes.

6.2.2.2.9 Prepare working drawings and share any deviations with relevant bodies.

6.2.2.3 Information Sheet

Working drawings

It is scale drawing of an object to be made or structure to be built intended for direct use by the workman

Types of electrical drawings

1. Site plans or layout drawings

These are scale drawings based upon the architect's site plan of the building and show the position of the electrical equipment which is to be installed. The electrical equipment is identified by a graphical symbol. The standard symbols used by the electrical contracting industry are those recommended by the British Standard EN 60617, *Graphical Symbols for Electrical Power, Telecommunications and Electronic Diagrams.* Some of the more common electrical installation symbols are given in Fig. 9. The site plan or layout drawing will be drawn to a scale, smaller than the actual size of the building, so to find the actual measurement, you must measure the distance on the drawing and multiply by the scale. For example, if the site plan is drawn to a scale of 1:100, then 10 mm on the site plan represents 1 m measured in the building. The layout drawing or site plan of a small domestic extension is shown in Fig. 10.

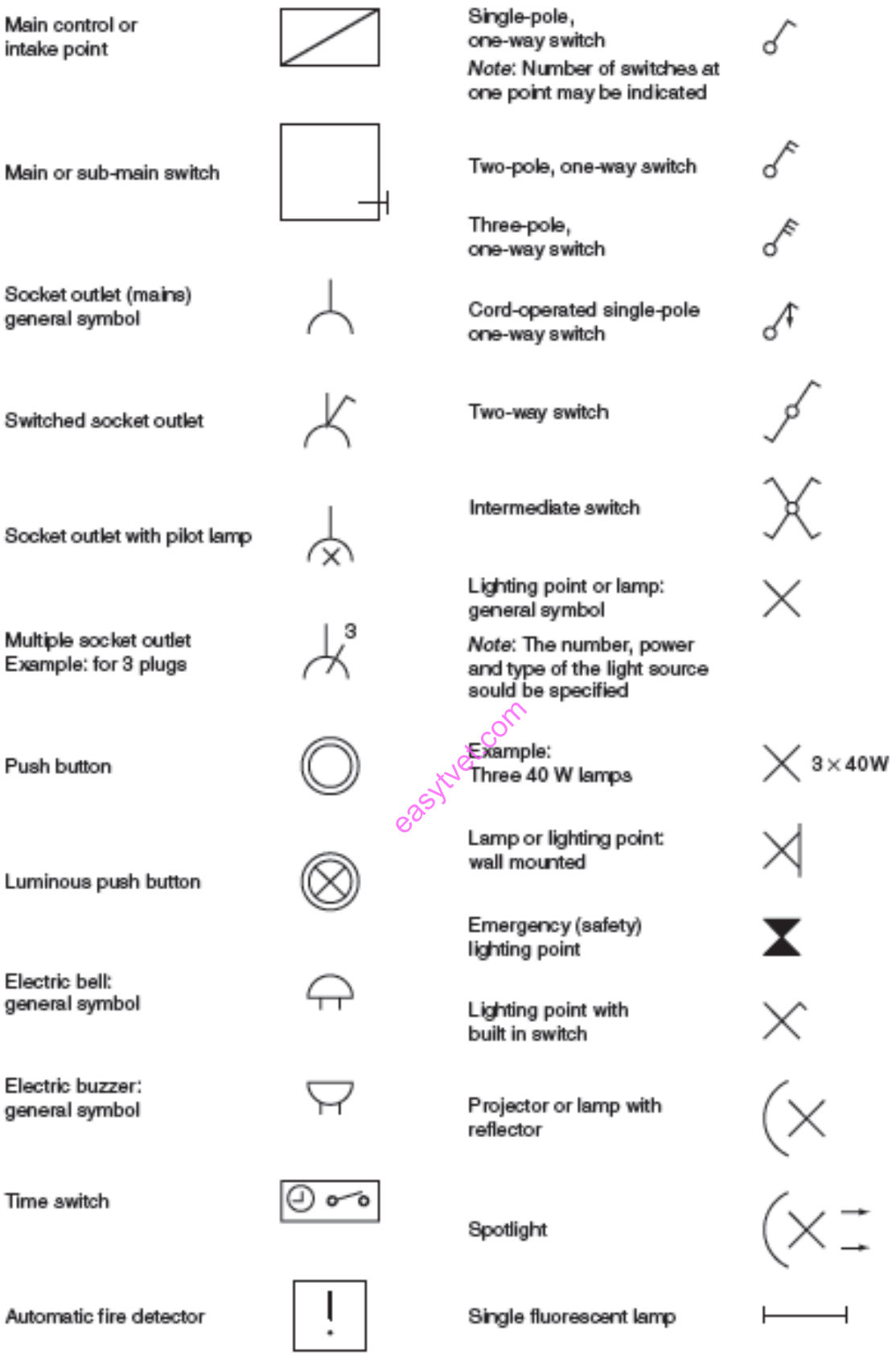


Figure 235 Some BS EN 60617 electrical installation symbols

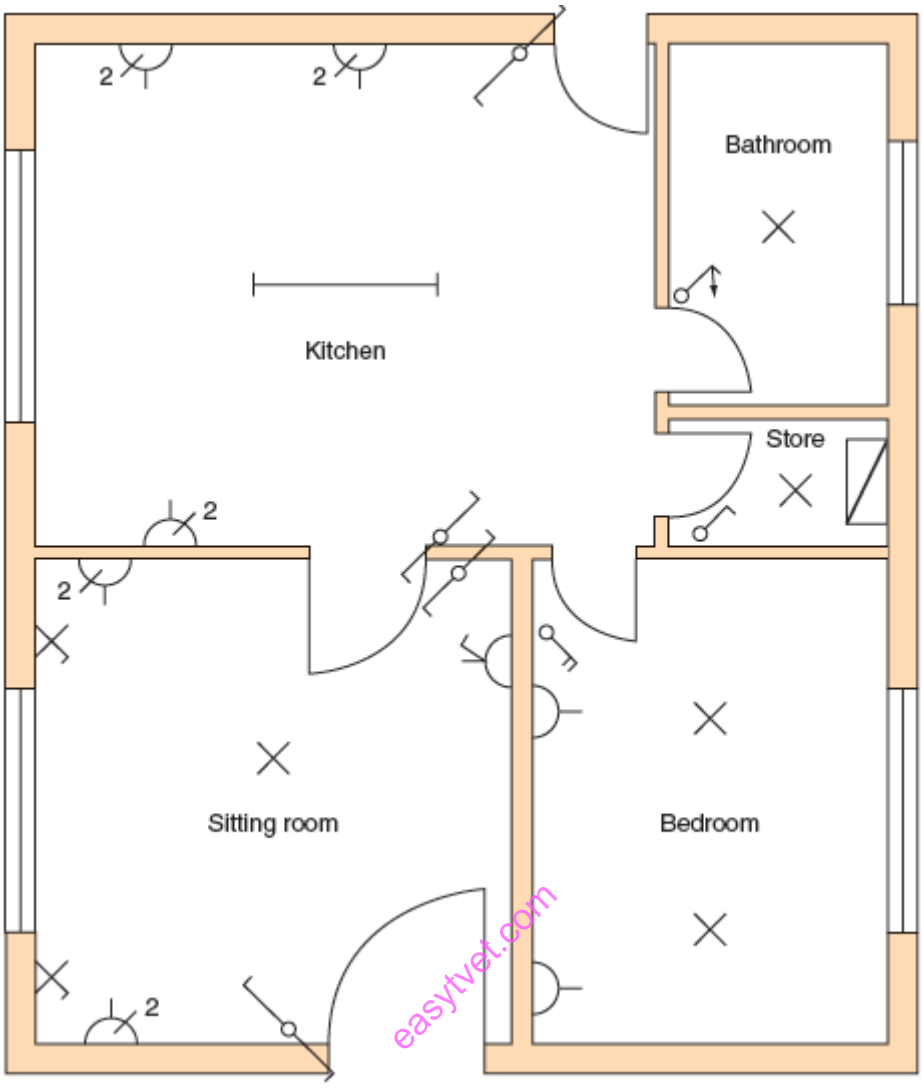


Figure 236 Layout drawing or site plan of a small electrical installation

2. As-fitted drawings

When the installation is completed a set of drawings should be produced which indicate the final positions of all the electrical equipment. As the building and electrical installation progresses, it is sometimes necessary to modify the positions of equipment indicated on the layout drawing because, for example, the position of a doorway has been changed. The layout drawings or site plans indicate the original intentions for the position of equipment, while the 'as-fitted' drawing indicates the actual positions of equipment upon completion of the contract.

3. Detail drawings and assembly drawings

These are additional drawings produced by the architect to clarify some point of detail. For example, a drawing might be produced to give a fuller description of a suspended ceiling arrangement or the assembly arrangements of the metalwork for the suspended ceiling.

4. Location drawings

Location drawings identify the place where something is located. It might be the position of the manhole covers giving access to the drains. It might be the position of all water stop taps or the position of the

emergency lighting fittings. This type of information may be placed on a blank copy of the architect's site plan or on a supplementary drawing.

5. **Distribution cable route plans**

On large installations there may be more than one position for the electrical supplies. Distribution cables may radiate from the site of the electrical mains intake position to other sub-mains positions. The site of the sub-mains and the route taken by the distribution cables may be shown on a blank copy of the architect's site plan or on the electricians 'as-fitted' drawings.

6. **Block diagrams**

A block diagram is a very simple diagram in which the various items or pieces of equipment are represented by a square or rectangular box. The purpose of the block diagram is to show how the components of the circuit relate to each other and, therefore, the individual circuit connections are not shown. Figure 11 shows the block diagram of a space heating control system.

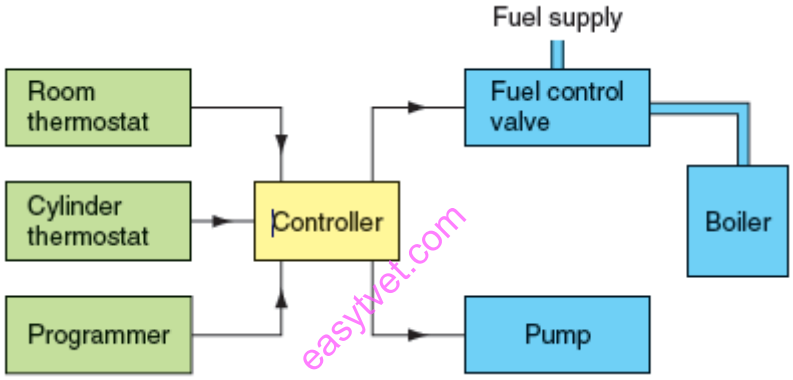


Figure 237 Block diagram of pace heating control system

7. **Wiring diagrams**

A wiring diagram or connection diagram shows the detailed connections between components or items of equipment. They do not indicate how a piece of equipment or circuit works. The purpose of a wiring diagram is to help someone with the actual wiring of the circuit. Figure 12 shows the wiring diagram for a space heating control system.

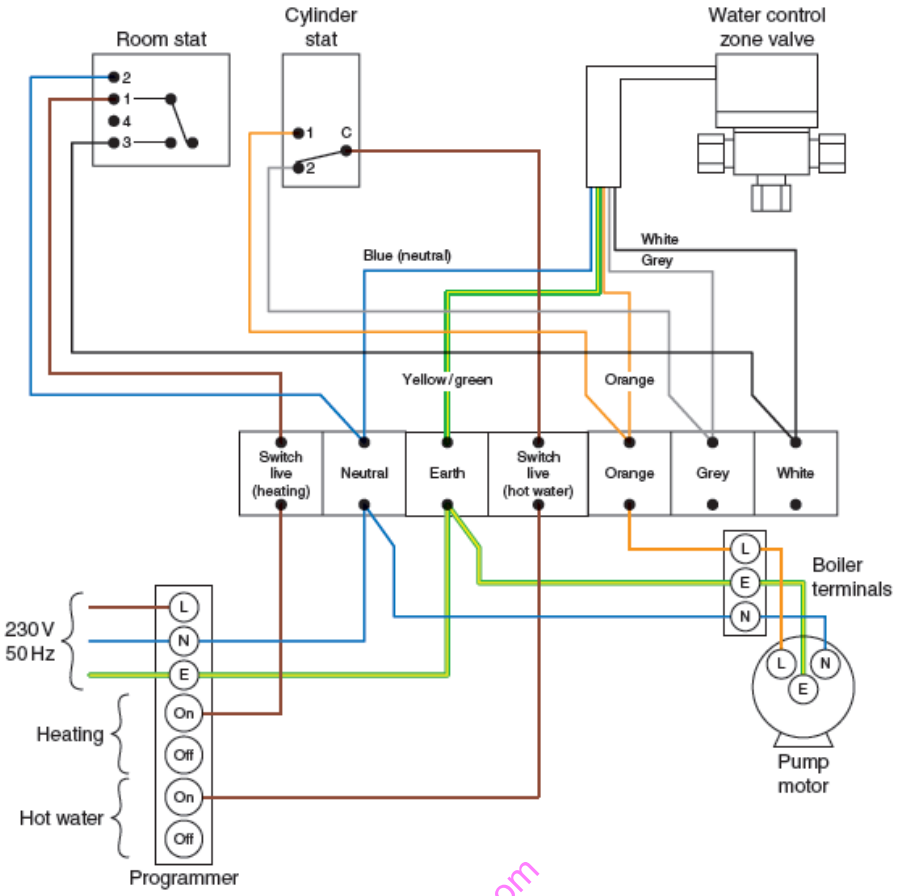


Figure 238 Wiring diagram-space heating control system (Honeywell Y Plan)

8. Circuit diagrams

A circuit diagram shows most clearly how a circuit works. All the essential parts and connections are represented by their graphical symbols. The purpose of a circuit diagram is to help our understanding of the circuit. It will be laid out as clearly as possible, without regard to the physical layout of the actual components and, therefore, it may not indicate the most convenient way to wire the circuit. Figure 13 shows the circuit diagram of our same space heating.

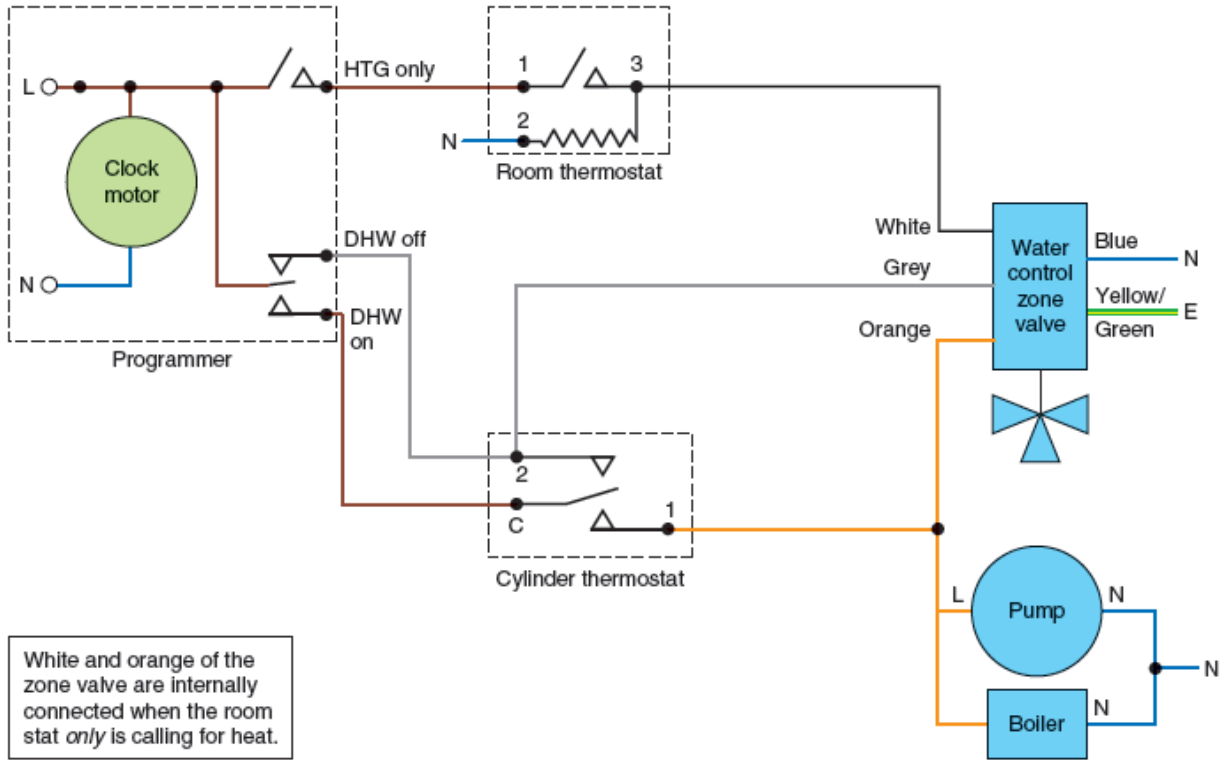


Figure 239 Circuit diagram- space heating control system (Honeywell Y Plan)

9. Schematic diagrams

A schematic diagram is a diagram in outline of, for example, a motor starter circuit. It uses graphical symbols to indicate the interrelationship of the electrical elements in a circuit. These help us to understand the working operation of the circuit but are not helpful in showing us how to wire the components. An electrical schematic diagram looks very like a circuit diagram. Figure 14 shows a schematic diagram.

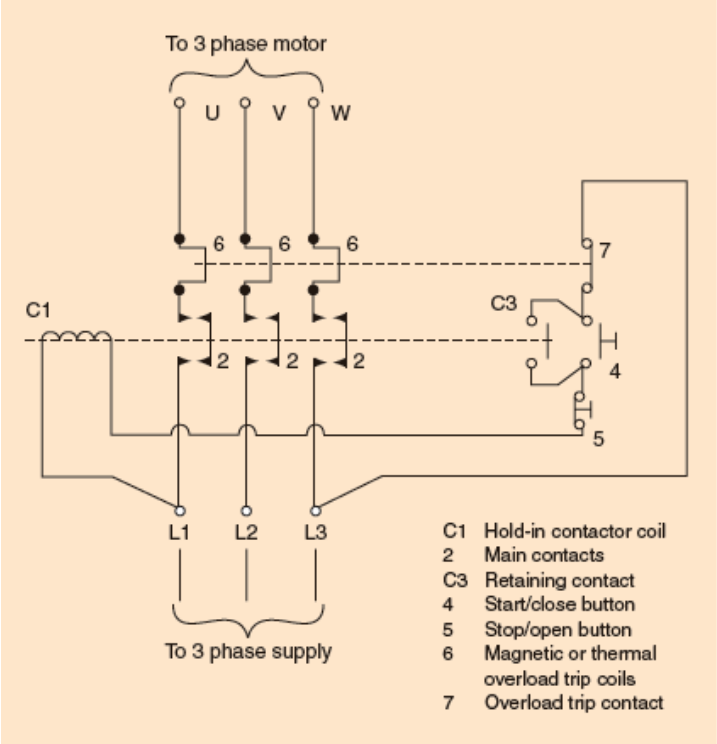


Figure 240 Schematic diagram of a motor starter

10. Freehand working diagrams

Freehand working drawings or sketches are another important way in which we communicate our ideas. The drawings are done from freehand sketches. A freehand sketch may be done as an initial draft of an idea before a full working drawing is made. It is often much easier to produce a sketch of your ideas or intentions than to describe them or produce a list of instructions.

To convey the message or information clearly it is better to make your sketch large rather than too small. It should also contain all the dimensions necessary to indicate clearly the size of the finished object depicted by the sketch.

11. Line diagram

This is a one-line diagram or single-line diagram is a simplified notation for representing an electrical system. The one-line diagram is similar to a block diagram except that electrical elements such as switches, circuit breakers, transformers, and capacitors are shown by standardized schematic symbols.

12. Pictorial diagram

This is a diagram that represents the elements of a system using abstract, graphic drawings or realistic pictures.

13. Building plans

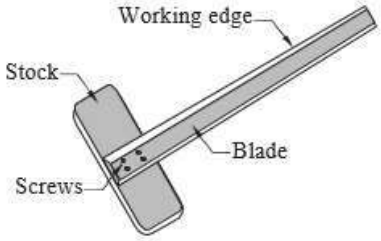
These are architectural drawings which the technician uses to design electrical wiring systems.

The drawing shows the various elevations of the building.

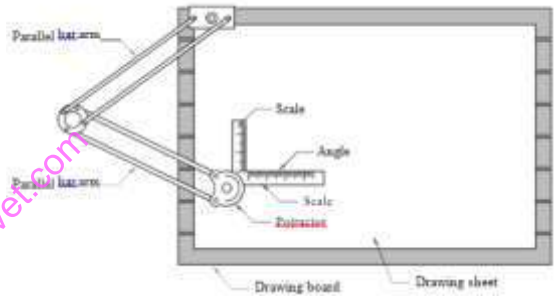
Drawing instruments

Drawing instruments are used to prepare neat and accurate drawings. Accuracy of drawings depend on the quality of instruments used to prepare them. The following is the list of drawing instruments and other materials required.

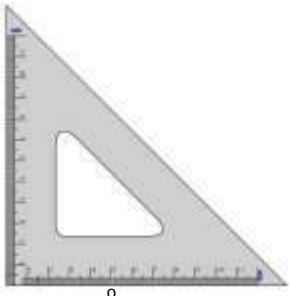
- Drawing board
- T-square or drafter (drafting machine)
- Set squares
- Protractor
- Drawing instrument box
- Drawing sheet
- Drawing pencils
- Drawing pins/clips



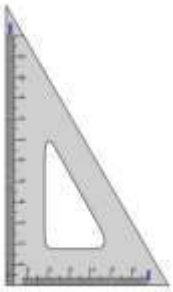
T-square



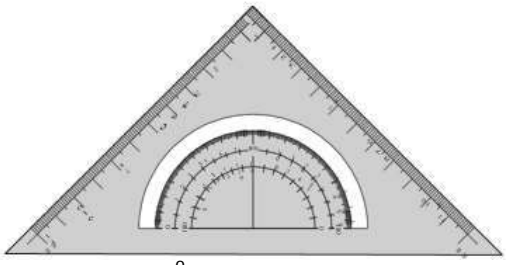
Drafting machine/drafter



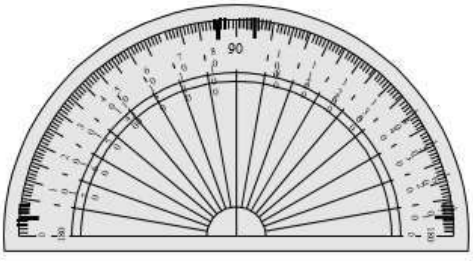
45^{0} set square



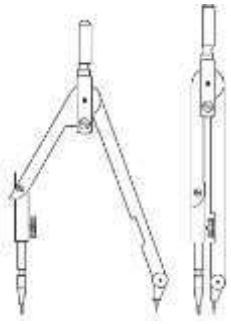
30^{0}-60^{0} set square



45^{0} setsquare with protractor



Protractor



Compass

Figure 241 Drawing instruments

Drawing Pencils:

The accuracy and appearance of a drawing depends on the quality of Pencil used to make drawing. The grade of a Pencil lead is marked on the Pencil. HB denotes medium grade. Increase in hardness is shown by value put in front of H such as 2H, 3H etc., Softer pencils are marked as 2B, 3B, and 4B etc. A pencil marked 3B is softer than 2B and Pencil marked 4B is softer than 3B and so on. Beginning of a drawing may be made with H or 2H. For lettering and dimensioning, H and HB Pencils are used.

Drawing Pins and clips:

These are used to fix the Drawing sheet on the Drawing board.

Drawing paper sizes

ISO standard determines the paper dimensions for the A paper series. The most common paper sizes are A0, A1, A2, A3, A4, and A5. The table below shows the dimension of the most common A series paper sizes.

Table 15 Dimensions for A paper series

Paper size	Dimensions (cm)	Paper Area
A5	14.8 x 21 cm	0.03108 m2
A4	21 x 29.7 cm	0.0612 m^2
A3	29.7 x 42 cm	0.125 m^2
A2	42 x 59.4 cm	0.25 m^2
A1	59.4 x 84.1 cm	0.50 m^2
A0	84.1 x 118.9 cm	1 m^2

Notice that if we split an A1 paper into two equal parts we get two A2 papers. If we split an A2 paper into two equal part we get two A3 papers. If we split an A3 paper into two equal part we get two A4 papers and so on. This is shown visual in the Figure 16.

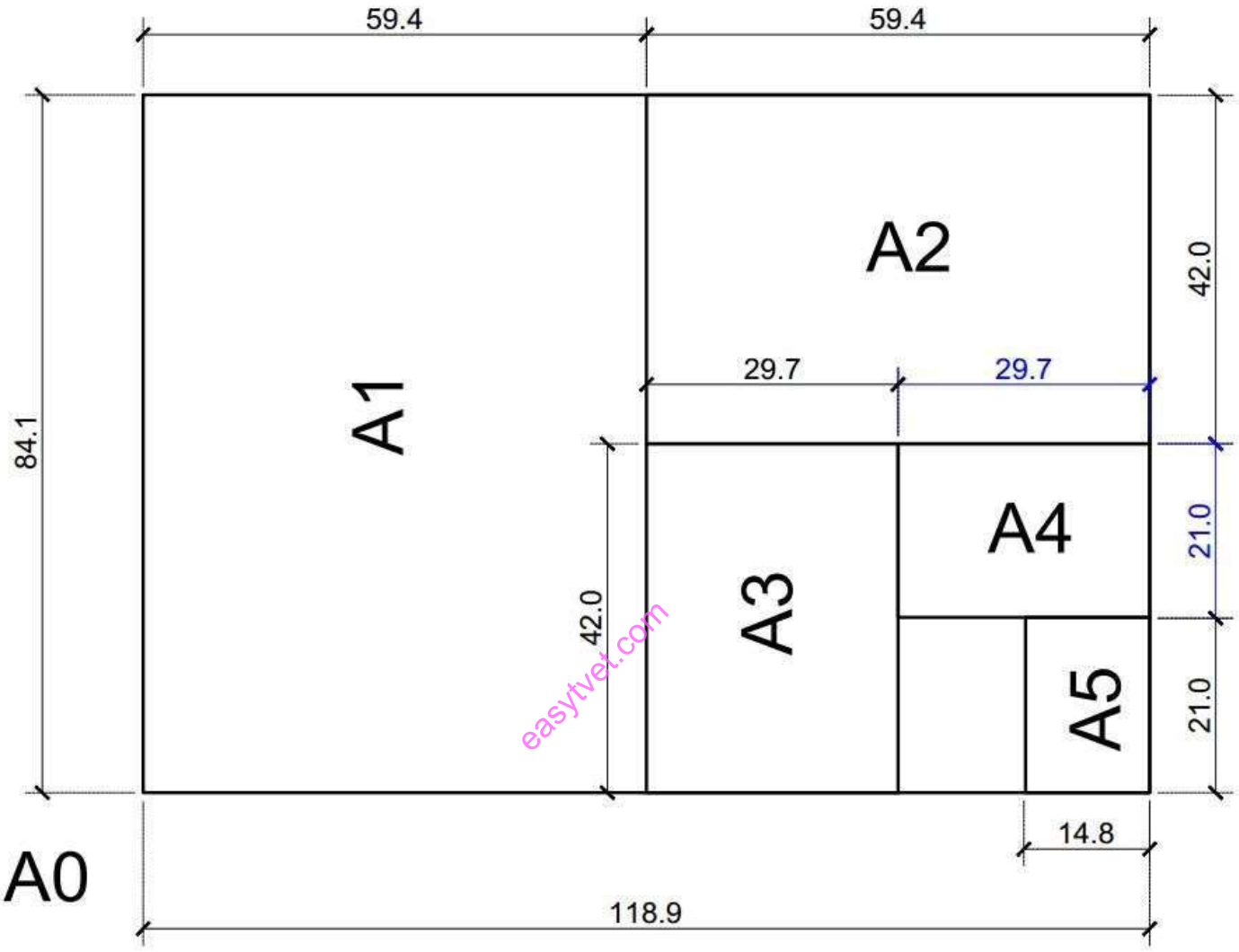


Figure 242 Technical drawing paper sizes

Lines

Lines are the continuous association of points. Lines are classified as follows:-

a) According to Thickness.
b) According to Shape.
c) According to Darkness.

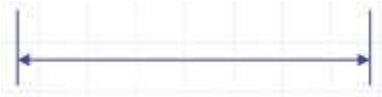
Lines used in Engineering drawings:-

a) Outlines- Lines drawn to represent visible edges and surface boundaries. These are also called principal lines.

b) Dashed lines- Interior or hidden edges and surfaces are shown by dashed lines. Also called dotted lines. They are of medium thickness. They are short dashed lines of about 3-4mmwith 1mm distance between them.

c) Centre lines- These lines indicate axes of cylindrical, conical or spherical objects and the centers of circles. These are medium thick lines consisting of long and short dashes, long dashes of 6-8mm and 1mmdistance between them.

d) Dimension lines- These are continuous thin lines terminated at the outer ends by pointed arrow-heads.

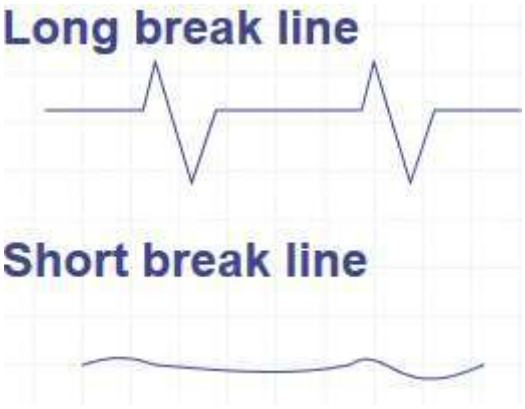


e) Construction lines- These are thin lines drawn during the drawing to help in drawing complex geometrical structures.

f) Hatching lines- These are thin lines drawn parallel to each other at about 3mm. These lines show the presence of material while object is cut through.

g) Cutting plane lines- These lines show the location of the cutting plane. It is thin & long chain line with two small dashes of about 3-4mm and a long dash of about 6-8mm width

h) Break lines- These lines show imaginary boundaries of the object or to skip up very long part of the object of similar width



How to draw a title block

The title block of a drawing, usually located on the bottom or lower right hand corner, contains all the information necessary to identify the drawing and to verify its validity. The drawing title and the drawing number are used for identification and filing purposes.

The title block of a drawing is usually located on the bottom or lower right hand corner, contains all the information necessary to identify the drawing and to verify its validity. All engineering drawings should feature a title block. The Figure 17 shows an example of a title block. The title block should include:

- Title: -title of the drawing
- Name: -name of the person who produced the drawing
- Checked: -before manufacture, drawings are usually checked
- Version: -many drawings are amended, each revision must be noted
- Date: -the date the drawing was produced or last amended
- Notes: -any note relevant to the drawing
- Scale: -the scale of the drawing
- Company name: -name of the company
- Projection: -the projection system used to create the drawing.

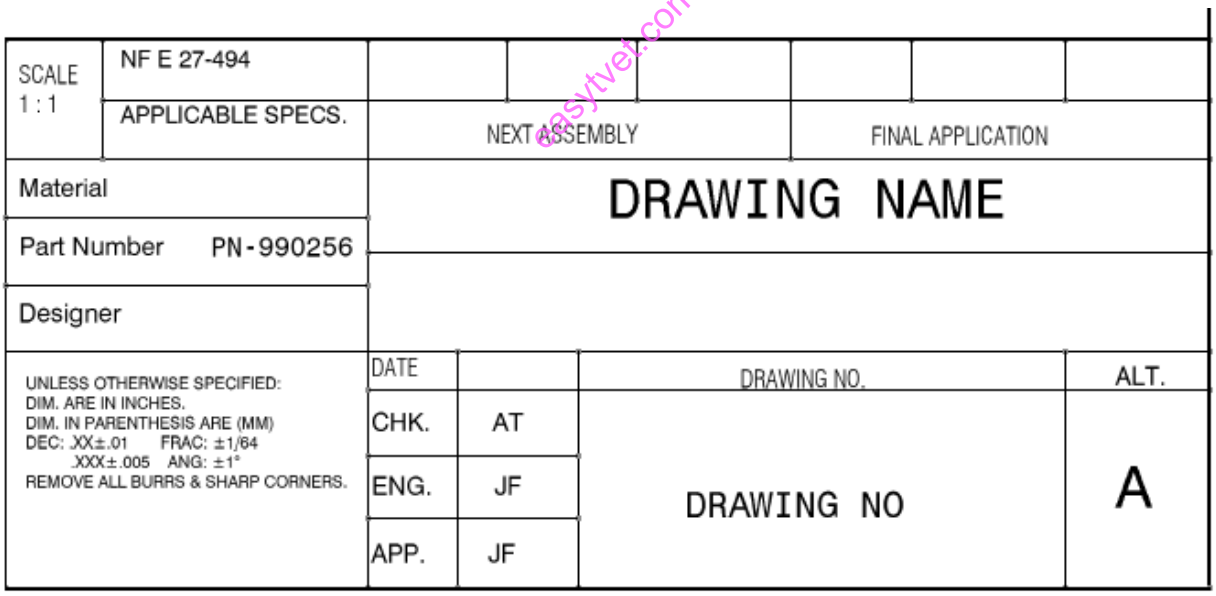
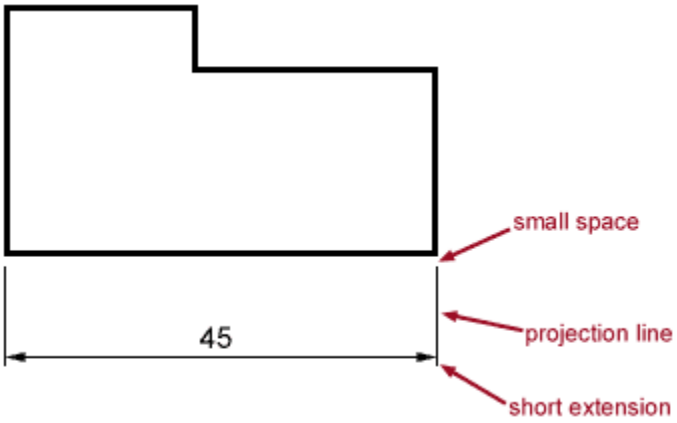


Figure 243 Title block

Dimensioning of drawings

A dimensioned drawing should provide all the information necessary for a finished product or part to be manufactured. An example dimension is shown below.



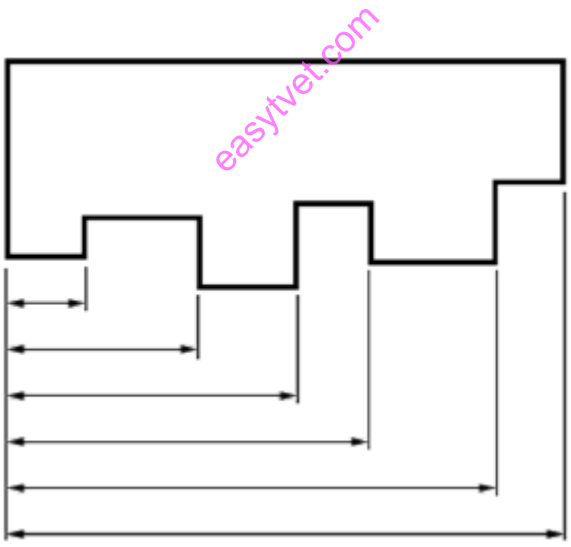
Dimensions are always drawn using continuous thin lines. Two projection lines indicate where the dimension starts and finishes. Projection lines do not touch the object and are drawn perpendicular to the element you are dimensioning.

All dimensions less than 1 should have a leading zero. i.e. .35 should be written as 0.35

Types of Dimensioning

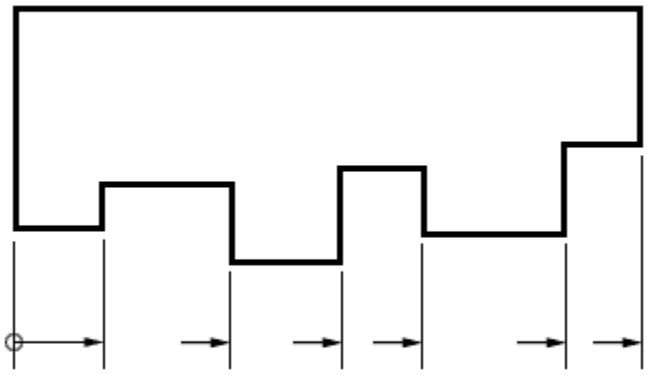
I. **Parallel Dimensioning**

Parallel dimensioning consists of several dimensions originating from one projection line.

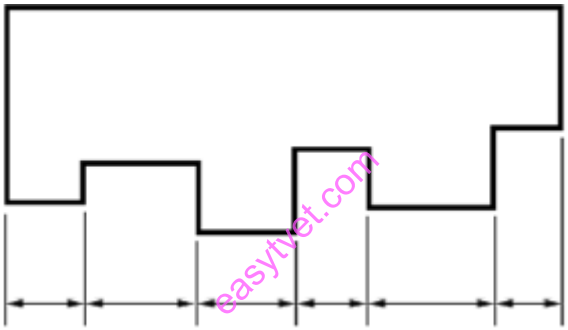


II. **Superimposed Running Dimensions**

Superimposed running dimensioning simplifies parallel dimensions in order to reduce the space used on a drawing. The common origin for the dimension lines is indicated by a small circle at the intersection of the first dimension and the projection line.

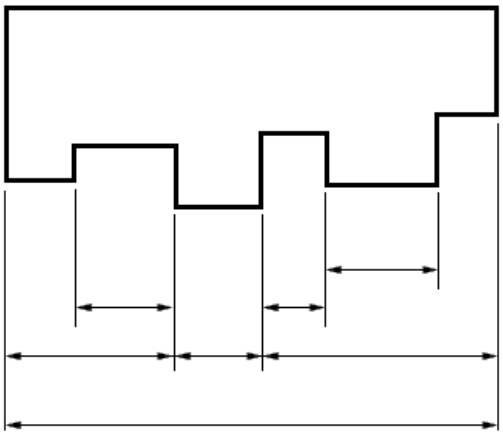


III. **Chain Dimensioning**

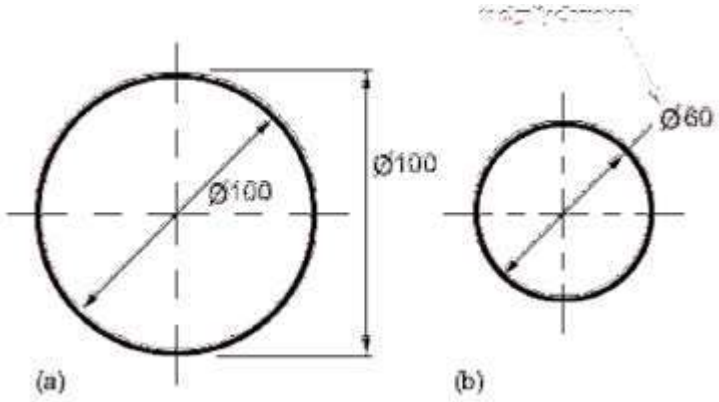


IV. **Combined Dimensions**

A combined dimension uses both chain and parallel dimensioning.



V. Dimensioning of circles

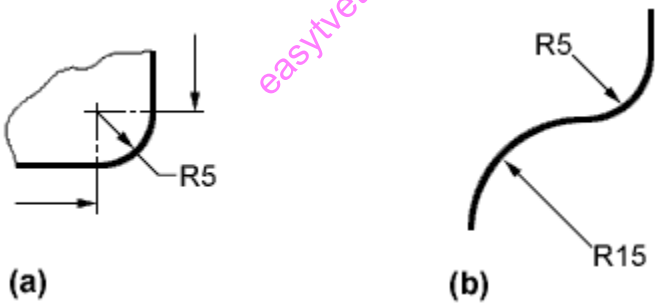


(a) Shows two common methods of dimensioning a circle. One method dimensions the circle between two lines projected from two diametrically opposite points. The second method dimensions the circle internally.

(b) Is used when the circle is too small for the dimension to be easily read if it was placed inside the circle.

VI. Dimensioning Radii

All radial dimensions are proceeded by the capital **R**.

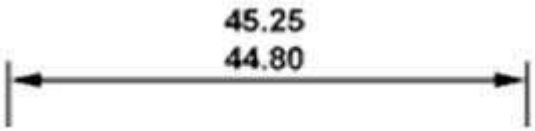


(a) Shows a radius dimensioned with the center of the radius located on the drawing.

(b) Shows how to dimension radii which do not need their centers locating.

VII. Tolerancing

It is not possible in practice to manufacture products to the exact figures displayed on an engineering drawing. The accuracy depends largely on the manufacturing process. A tolerance value shows the manufacturing department the maximum permissible variation from the dimension. Each dimension on a drawing must include a tolerance value. This can appear either as: a general tolerance value applicable to several dimensions i.e. note specifying that the General Tolerance +/-0.5 mm. or a tolerance specific to that dimension



Orthographic Projections

Orthographic Projections are a collection of 2-D drawings that work together to give an accurate overall representation of an object.

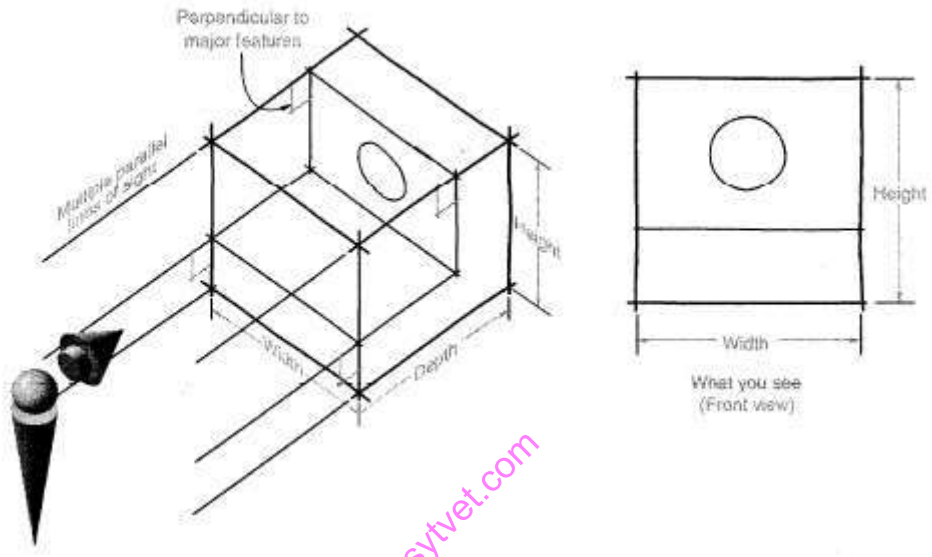


Figure 244 Orthographic projections

Defining the Six Principal Views or Orthographic Views

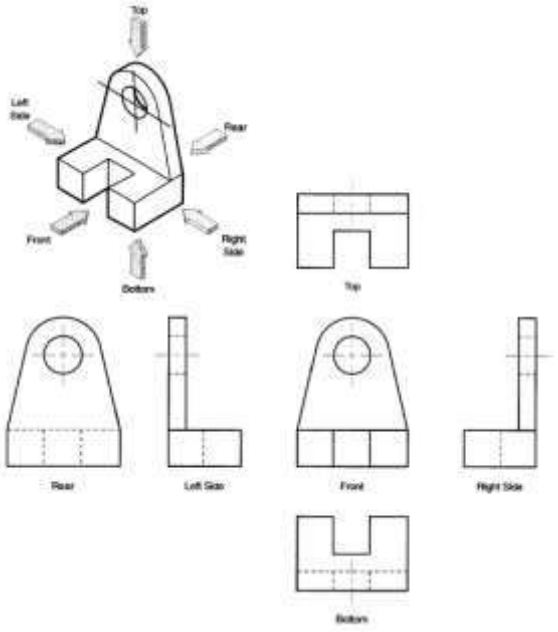


Figure 245 orthographic views

General Guidelines on which views to present

Pick a Front View that is most descriptive of object. Normally the longest dimension is chosen as the width (or depth). Most common combination of views is to use: Front, Top, and Side View. The figure 20 shows the views to be present.

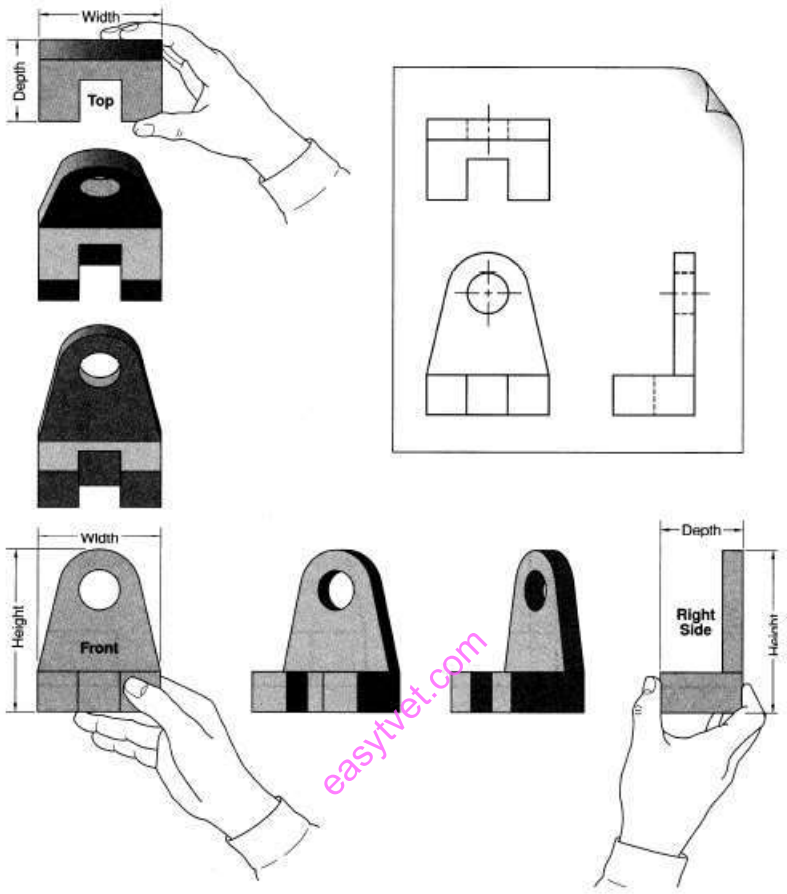
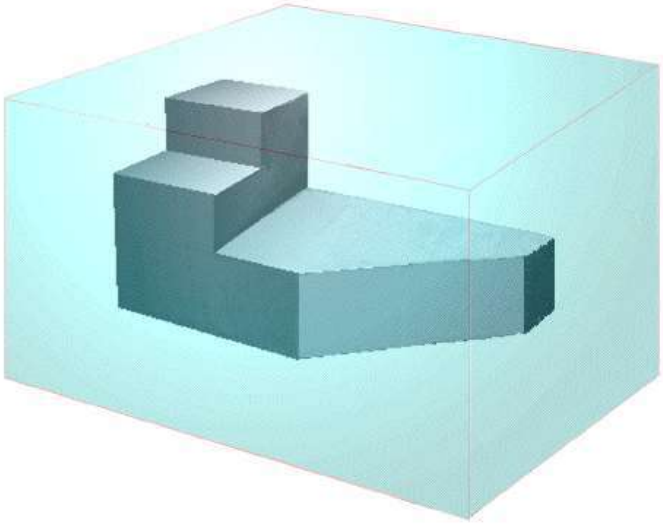


Figure 246 Views to present

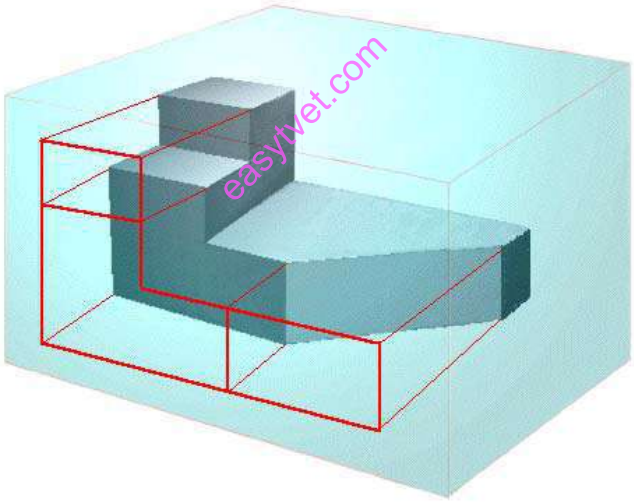
Glass Box Approach

Place the object in a glass box. Freeze the view from each direction (each of the six sides of the box) and unfold the box

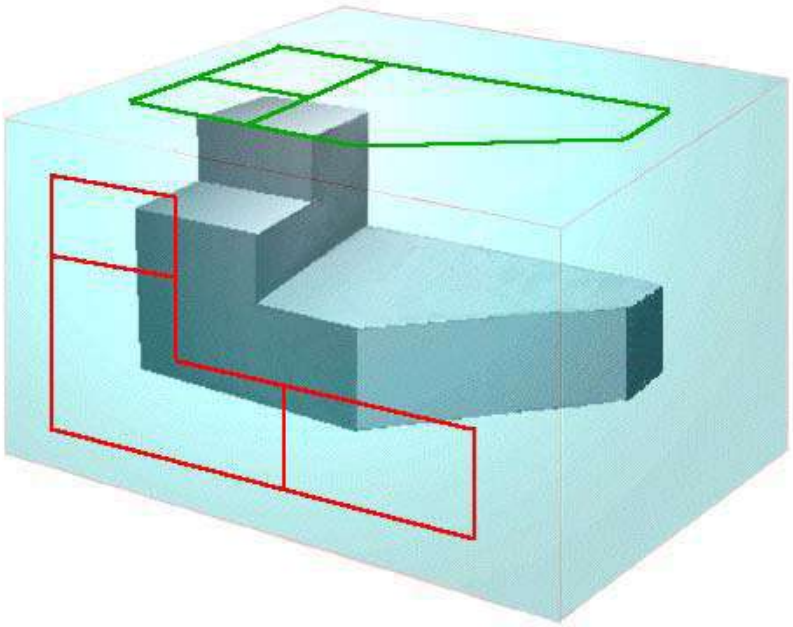
Projection of points to the three views



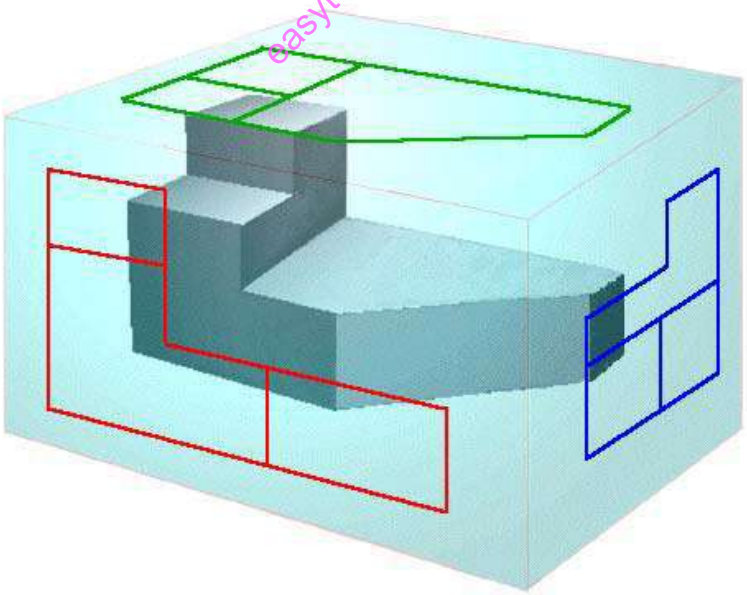
Projection of points to FRONT VIEW

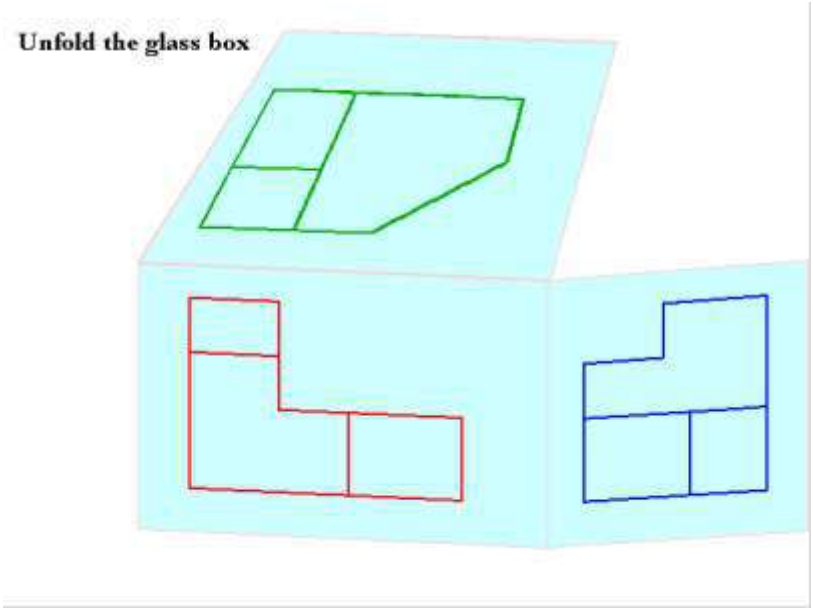


Projection of points to TOP VIEW

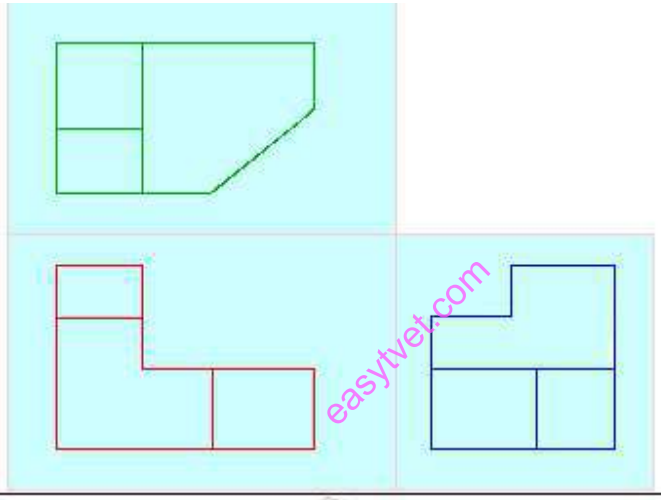


Projection of points to RIGHT SIDE VIEW

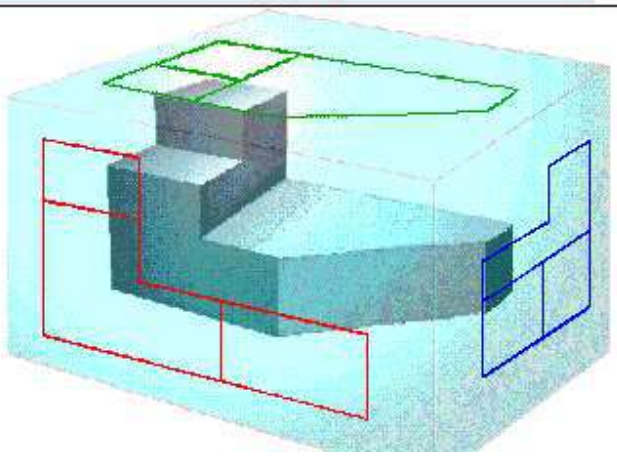




Unfolded glass-box



Object in the glass-box



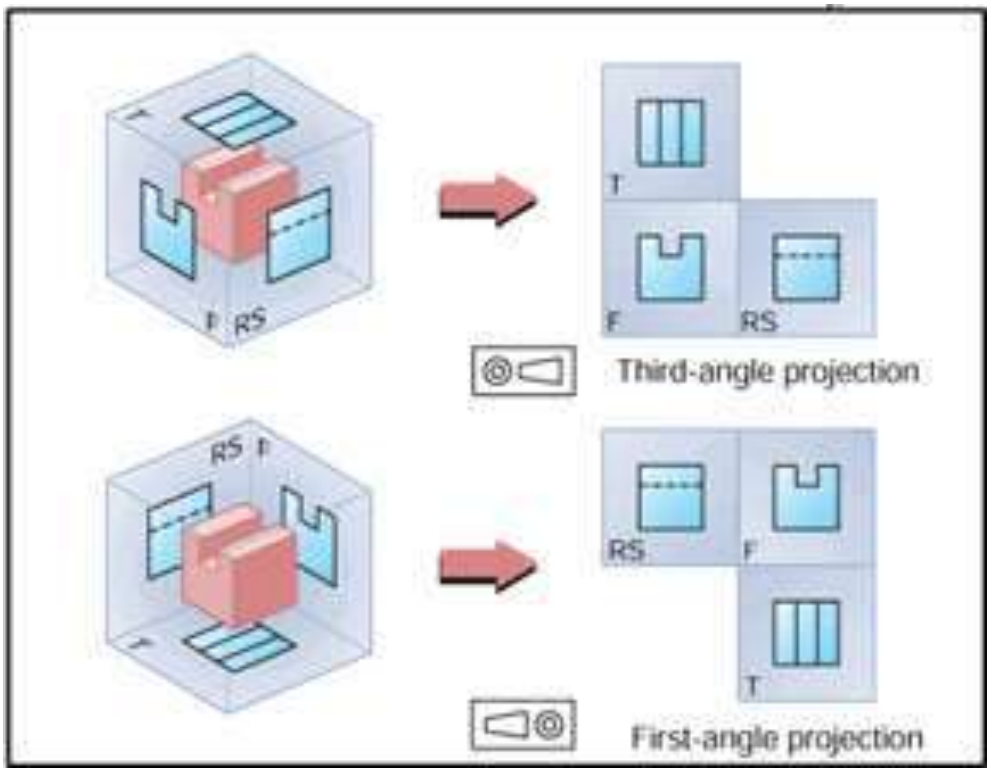


Figure 247 first and third angle projections

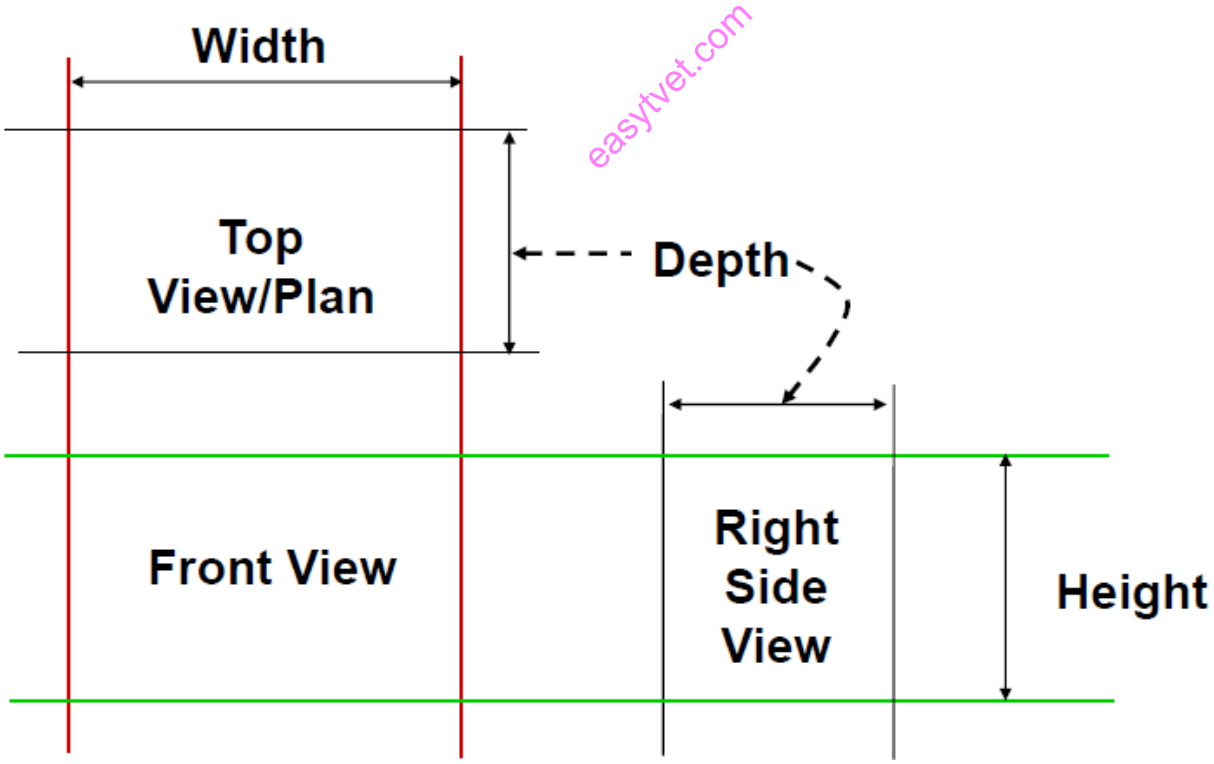


Figure 248 Conventional orthogonal views

How to read and interpret architectural drawings

The first time you opened a set of architectural plans, you were probably instantly lost and confused. If you are managing your company's real estate project, but don't have any real training in architecture,

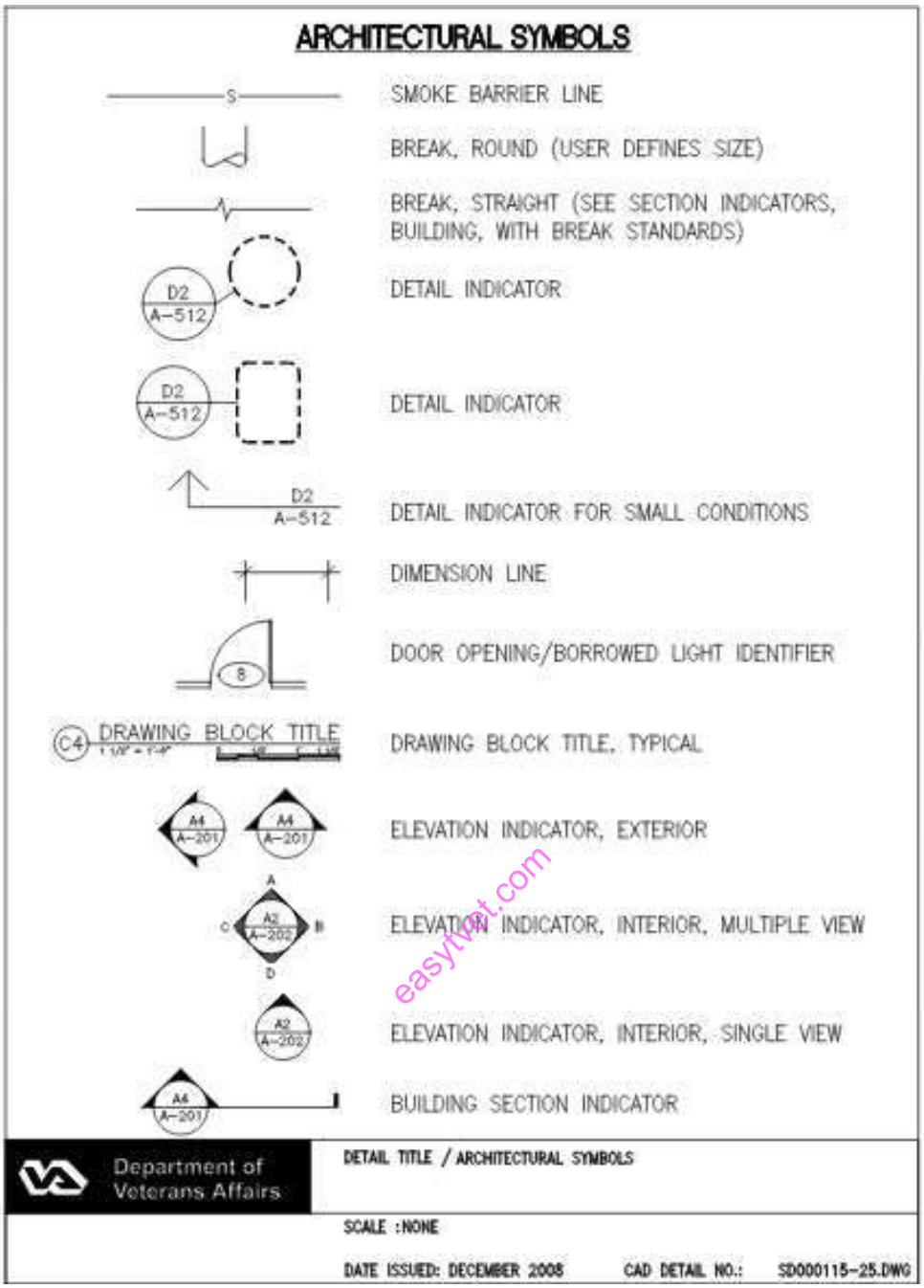
reading these plans can extremely difficult. To save you some time and trouble, we've put together a guide as to how to read architectural plans.
Here are a few additional general guidelines to keep in mind:

- Be organized and diligent when reading plans. Start in upper left corner and work way across page so as not to miss any details.
- Read the plan cover sheet. This contains important project information like the project name, architect, contact information, project information and the date. It might also include a drawing of the finished product.
- There are often reference points that are used between professionals and sets of drawings. These can come in many forms: room numbers, a grid system, structural references, etc.
- Review the plan index which provides a list of all plan sheets.

Start with the Site or Plot plan. This provides an overhead view of the property and details about the boundaries and orientation of the building. There will also be a symbol legend will depict the symbols used to indicate windows, doors, elevation, etc. Many symbols contain numbers within them which refer to the section and the page number of the plans. Reviewing the symbol legend will help when looking at the actual plans so that you recognize what the symbols are referring to. You may also want to review the list of abbreviations, many of which are standard in the industry, but some may be specific to the architect. This will also help later when you are reading design notes.

Once you move into reading the actual architectural sheets, it's important to know that architectural plans are labeled with an A (A 001 or A1-X, A2-X, etc.). The architectural plans are where you will see where your office is, where the bathrooms are in relation to workstations, etc. They will also provide measurements, elevations, locations of walls, windows, bathrooms, etc. Plans are broken up into many, many parts so it's make sure to look at the plan number (and North arrow) to help orient yourself. Always read the notes on a page! Some design details are easier to communicate via text so notes are included on the drawing or sometimes as additional pages.

There are many additional plans that supplement architectural plans: ceiling, roof framing, finish schedule (paint colors for each wall, flooring type and color, ceiling height, type, and color), door/window schedule, and many more. These plans contain important details, but we will cover those details in a future blog post. For now, hopefully this will help the next time you're trying to figure out how to read architectural plans. The table shows some of the architectural symbols that are always used.



Use of Computer Aided design

CAD stands for **C**omputer **A**ided **D**esign. CAD is used to design, develop and optimize products. While it is very versatile, CAD is extensively used in the design of tools and equipment required in the manufacturing process as well as in the construction domain. CAD enables design engineers to layout and to develop their work on a computer screen, print and save it for future editing. CAD (Computer Aided Design) is the use of computer software to design and document a product's design process. Computer-aided design (CAD) involves creating computer models defined by geometrical parameters. These models typically appear on a computer monitor as a three-dimensional representation of a part or a system of parts, which can be readily altered by changing relevant parameters. CAD systems enable designers to view objects under a wide variety of representations and to test these objects by simulating real-world conditions.

When it was introduced first, CAD was not exactly an economic proposition because the machines at those times were very costly. The increasing computer power in the later part of the twentieth century, with the arrival of minicomputer and subsequently the microprocessor, has allowed engineers to use CAD files that are an accurate representation of the dimensions / properties of the object.

CAD is used to accomplish preliminary design and layouts, design details and calculations, creating 3-D models, creating and releasing drawings, as well as interfacing with analysis, marketing, manufacturing, and end-user personnel.

CAD facilitates the manufacturing process by transferring detailed information about a product in an automated form that can be universally interpreted by trained personnel. It can be used to produce either two-dimensional or three-dimensional diagrams. The use of CAD software tools allow the object to be viewed from any angle, even from the inside looking out. One of the main advantages of a CAD drawing is that the editing is a fast process as compared to manual method. Apart from detailed engineering of 2D or 3D models, CAD is widely used from conceptual design and layout of products to definition of manufacturing of components. CAD reduces design time by allowing precise simulation rather than build and test physical prototypes. Integrating CAD with CAM (Computer Aided Manufacturing) streamlines the product development even more.

CAD is currently widely used for industrial products, animated movies and other applications. A special printer or plotter is usually required for printing professional design renderings. CAD programs use either vector-based graphics or raster graphics that show how an object will look.

CAD software enables

- Efficiency in the quality of design
- Increase in the Engineer’s productivity
- Improve record keeping through better documentation and communication

Today, the use of CAD has permeated almost all industries. From aerospace, electronics to manufacturing, CAD is used in all industry verticals. Since CAD encourages creativity and speeds up productivity, it is becoming more and more useful as an important tool for visualization before actually implementing a manufacturing process. That is also one of the reasons CAD training is gaining more and more importance.

6.2.2.4 Learning Activities
Project

Practical activities	**Knowledge**	**Special instruction**
1. Interpretation of installation drawing from a typical working drawing	Working drawings	
2. Apply and demonstrate knowledge of symbols and nomenclatures in accordance with British standards[BS 3939]	Standard electrical symbols	Draw and name all electrical symbols
3. Identify the drawing tools	Drawing instruments and equipment	Demonstrate how to use various drawing instruments, identify the paper sizes
4. Identify components and their ratings.	Electrical components and their ratings	
5. Clearly show cable sizes and lengths as provided in the workshop	Cable sizes	
6. Show power supply and draw distribution circuits using single line diagrams	• Line diagrams • Distribution circuits • Power supply	
7. Carry out phase balancing of loads as per usage on an existing domestic installation	Phase balancing of loads	
8. Clearly mark the cable routes.	Cable routing	
9. Prepare working drawings and share any deviations with relevant bodies.	Working drawings	

6.2.2.5 Self-Assessment

1. Draw the following types of lines.
   I. Outline
   II. Long break line
   III. Center line
   IV. Hidden line
   V. Dimension line

2. Which tools are used by a draftsperson when carrying out a task in Technical drawing?
3. Which type of a pencil are used while carrying out drawing assignment?
4. Below is an electrical symbol. Name of the symbol?

One way switch

5. Draw the symbol of the following electrical installation equipment and machines.

Name	Symbol
i. Motor	
ii. Transformer	
iii. Energy meter	
iv. Consumer control unit	
v. Fluorescent lamp	

6.2.2.6 Tools, Equipment, Supplies and Materials
Recommended Resources

Tools and equipment	**Materials and supplies**
➢ Cable Strippers ➢ Pliers ➢ Screw drivers ➢ Hammers ➢ Chisels ➢ Allen keys ➢ Electrician knives ➢ Crimping tools ➢ Bending springs ➢ Bending machine ➢ Steel tapes ➢ Draw wires ➢ Hack saws ➢ Drilling tools ➢ Stock and die ➢ Bench vice ➢ Machine vice ➢ PPE – hand gloves, dust coats, dust masks, helmets, ear muffs, industrial boots	• Stationery • Cables • Light fittings • Accessories • Conduits and fittings • Cable trays • Cable ducts • Trunkings • Computers • Drawing instruments • Screws
Reference materials • IEE regulations • Occupational safety and health act (OSHA) • Work injury benefits act (WIBA) • Manufacturers' catalogues • British standards • KEBS standards	

6.2.2.7 References

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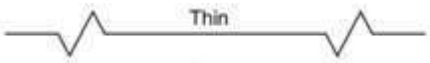
6.2.2.8 Model answers to self-assessment

1. Draw the following types of lines.
   I. Outline

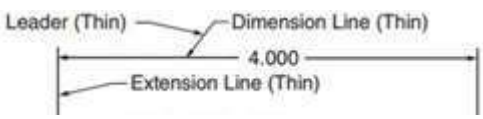
   II. Long break line



   III. Center line

   IV. Hidden line

   V. Dimension line



2. Which tools are used by a draftsperson when carrying out a task in Technical drawing?
   - T squares
   - Protractor

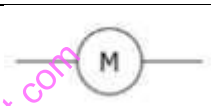
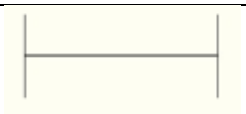
- Emery board

3. Which type of a pencil are used while carrying out drawing assignment?
    - HB
    - 3H
    - 2H
    - 4H

4. Below is an electrical symbol. Name of the symbol?

One way switch

5. Draw the symbol of the following electrical installation equipment and machines

Name	Symbol
vi. Motor	
vii. Transformer	
viii. Energy meter	
ix. Consumer control unit	
x. Fluorescent lamp	

6.2.3 Learning Outcome 3: Assemble tools, equipment and materials

6.2.3.1 Introduction to the learning outcome

In order to assemble tools, equipment and materials, the learner need check the tools, equipment and materials for proper functionality, assemble and store them as per established procedure.

6.2.3.2 Performance Standards

6.2.3.2.1 Check tools, equipment and materials for proper specifications and functionality.

6.2.3.2.2 Assemble and store tools, equipment and materials as per the established procedure

6.2.3.3 Information Sheet

Accessory- Any device other than a lighting fitting, associated with the wiring and current-using appliances of an installation, e.g. a switch, a fuse, a plug, a socket-outlet, a lamp holder or a ceiling rose.

Electrical equipment- means any apparatus, appliance, device, fitting, fixture or material used in distribution, supply or utilization of electric power

Electrical installation tools, equipment and their use

These are tools used in driving or pounding out nails they are made of hard steel, wood, plastic or rubber. The following are types of hammers; claw, mallet and Ball peen.

Hammers

Wire stripper

A tool used for removing insulation from insulated cables.

Side cutter

This is a tool used fine medium and big cables

Combination pliers

These are made of metal with insulated handles. They are used for cutting, twisted, bending, holding and gripping wires and cables

Long nose pliers

This is used for cutting and holding wires. It made to reach tight space and or small opening where other pliers cannot reach. It is also used in making terminal loops of copper wire

Star screw driver

It has a cross tip and is used to drive screws with cross slot heads.

Flat screw driver

It has a flat tip and is used to drive screws with straight slot heads.

Hacksaw

This is a tool used to cut metal conduit and armoured cable.

Fish/Draw tape

This tool is used to draw cables in the conduit

Measuring tools

To measure wire length and other items, the Technician finds considerable use of measuring tool

Soldering equipment

In installing electric wiring, joints made between wires should be soldered, unless you use solder less connectors. Typical equipment available

Drilling equipment

Drilling equipment is needed to make holes in building structure passages of Conduit sand wire

How to take care of your tools

Good tools can be quite an investment, but if you take good care of them, they'll return the favour. Keeping your tools properly stored, cleaned, and maintained will save you time and money and make your DIY endeavors that much more rewarding

In keeping the tools and equipment, you need to work with the space you have. Maybe you hang them on pegboards, maybe you store them in boxes, bags, or chests, or maybe you keep them in drawers or on shelves in your shop. Whatever works for you is best.

Toolboxes also make for great tool storage, offering the primary advantage of portability. While some people opt to store all their tools in toolboxes, for most, the toolbox is a way of carrying around your most-used tools while leaving the bulk safely stored on pegboards, shelves, or drawers.

Basic maintenance of electric tools

To ensure that your **electric tools** work when you need them to, you must take proper care of them. A good regimen of maintenance for your tools is one thing that you can do to make sure that the tool you need is working when you need it.

a) **Clean out the dust:** To make sure that your electric tools are ready to go when you are, keep them clean and free of dust. The housing intake on your electric tools and the exhaust are especially important areas to keep clean. Take some time to clean out the dust every once in a while, on your tools while they are sitting in storage.

b) **Check the cords:** Look for wear and tear on the power cords on your electric tools. There can be damage to the insulation and you should keep an eye out for loose wires. This will ensure that your electric tool can get the power that it needs to function without an accident. Wipe the cords down to keep them from becoming damaged from oil and grease. The prongs on the cords should be examined as well. Make sure that the casing is intact and the prongs are not loose.

c) **Oil some electric tools**: The electric tools in your toolbox that have a cutting surface should be lightly oiled to prevent rust. Examine the cutting surface for rust to make sure that your tools are kept in good condition.

d) **Storing your tools:** Keep your electric tools stored in their original cases and containers. This will keep them free of dust and dirt while they are not being used.

Electrical equipment

Some of the electrical equipment used are shown in figure 23.

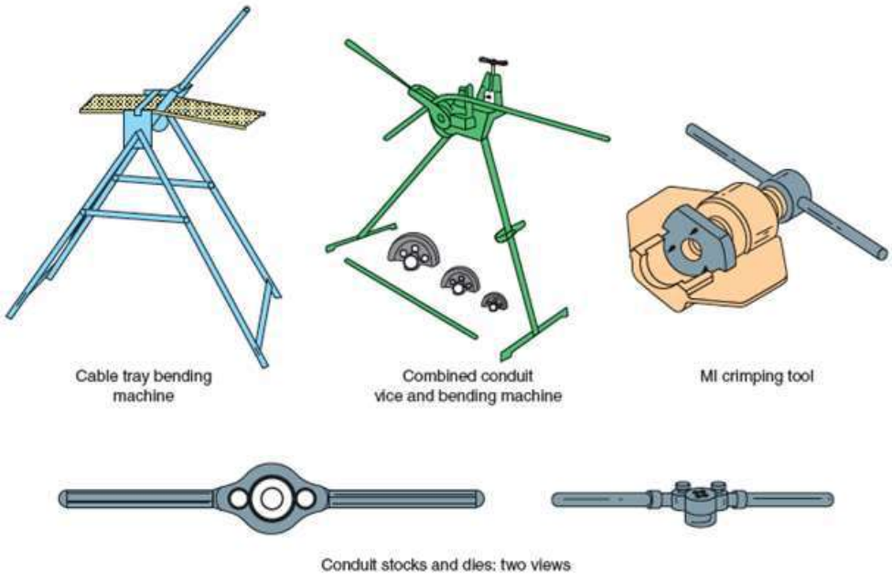


Figure 249 some of the electrical equipment

Accessories

Lamp Holders.

These are designed for quick removal and replacement of the lamp, and yet they must hold the lamp in firm metallic contact to prevent overheating.

There are three main sizes of lamp holder, namely;

i. The Bayonet-cap (B.C),
ii. The medium Edison Screw (E.S) and
iii. The Goliath Screw (G.E.S).

There are other variations such as the three-slot B.C for the smaller discharge lamps. For ordinary tungsten filament lamps of up to 150W, the lamp caps and thus the lamp holder are B.C, for lamps up to 200 W the caps are E.S, and those above 200W use G.E.S.

In every case where a lamp is to be installed, the appropriate size and type of holder must be fitted. Lamp holder may be either the insulated type of Bakelite or the brass type with porcelain interior.

B.C lamp holder should have solid plungers separately sprung by rust-proof steel plunger springs and in the insulated type a metal insert to reinforce the area around the bayonet sockets. An efficient cord grip is also necessary when the lamp is to be suspended from flexible cord.

Figure 24 shows an ***insulated*** cord-grip lamp holder, the section shows clearly the flexible wire securely fixed to the spring plunger, and also the method of gripping the flexible cord.

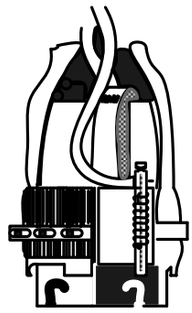


Figure 250 Insulated cord-grip

The type shown in figure 25 below is an ***insulated*** holder suitable for mounting directly on the ceiling.

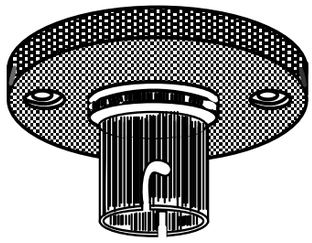


Figure 251 Insulated holder suitable for direct mounting

Figure 26 shows a cord grip and the flexible wired to a ***brass lamp holder*** terminal.

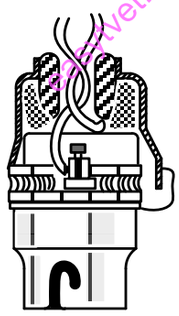


Figure 252 cord grip and flexible wired to a brass lamp holder terminal

Figure 27, shows internally threaded to screw to conduit or to a metal lamp bracket or the like.

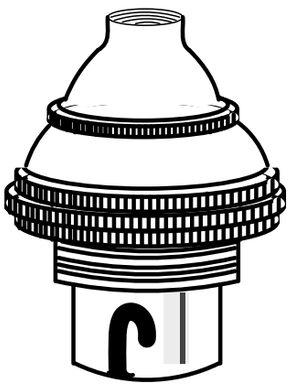


Figure 253 internally threaded lamp holder

Figure 28 is of a batten holder which may be screwed direct to a batten or back board.

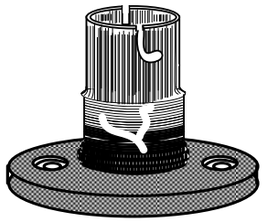


Figure 254 Batten holder

Figure 29 shows a push bar switch lamp holder.

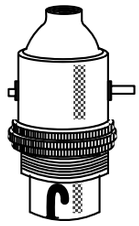


Figure 255 push bar switch lamp holder

A Goliath screw lamp-holder is shown exploded in figure 30. The outer contact is a screwed metal cylinder, and the inner contact is a metal stud. I.E.E. Regulation states that where centre contact bayonet or Edison-type screw lamp holders are connected to a source of supply having an earthed.

Figure 256 Exploded view of Goliath screw lamp holder

Neutral conductor, the outer or screwed contact shall be connected to that conductor. Where such lamp holders are used in circuits having neither pole connected with earth , or in any damp situation, or in any situation in which they can readily be touched by a person in contact with or standing on earthed metal , they shall be provided with a protective shield of insulating material complying with B.S.98, or shall be so placed or guarded that neither the lamp cap nor the outer or screwed contact of the lamp holder can be touched when the lamp cap is in contact with the lamp holder screw.

Regulations require that, every B.C lamp holder in a damp situation, or in a situation where it can be touched by a person in contact with or standing on earthed metal, shall be constructed of or be shrouded in insulating material, or shall be earthed. Where a lamp holder is likely to attain a working temperature of 135^0 C the lamp holder must be of the special heat-resisting type.

Celling roses

The great majority of ceiling roses already installed contain either two or three connection plates, each plate including a pillar terminal for the circuit wires, and a screw terminal with washer for flexible wire connection.

When wiring ceiling roses with terminal similar to those illustrated above, the flexible wire should be bent under the washer in a clockwise direction, otherwise, it will tend to be squeezed out when the screw is tightened. In some ceiling roses, pillar terminals are provided for both circuit wires and flexible wire.

I.E.E. Regulation requires;

i. That a ceiling rose shall not be installed in any circuit operating at a voltage normally exceeding low voltage.
ii. The shrouding of a live terminal in a ceiling rose.
iii. That not more than one flexible cord shall be attached to a ceiling rose unless the rose be designed for multiple pendants.
iv. That a ceiling rose shall be provided with an earthing terminal for compliance with I.E.E Regulation

Figure below shows a modern form of moulded ceiling rose which include the earth terminal required by Regulation, and a shrouded terminal for looping- in the live wire as required.

Figure 257 Ceiling rose

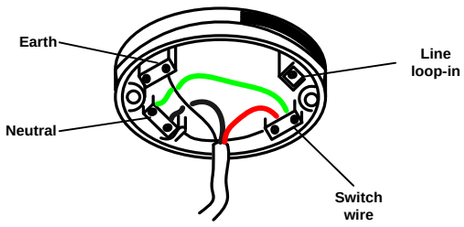


Figure 258 Modern form of moulded ceiling rose

Lighting circuit switches.

Figure 259 switches showing various plugs

The switches are for switching ON and OFF the lighting points. For direct current circuits, the quick-make- and-break switch is most suitable. The quick break is to prevent the arc formed at the instant of rupture from continuing and burning the contacts

Alternating current can efficiently be interrupted by the opening of a very small gap between silver contacts and most sub- circuit switches are now of this type. All switches should be mechanically robust to withstand the constant operation, and the contacts should be heavy and firm enough to carry the current without overheating.

Plugs and socket- outlets

Figure 260 switches showing various plugs

These are required to enable portable apparatus to be connected to the final sub-circuits. The socket –outlet is the fixed portion connected to the fixed wiring, and comprises two or three contact tubes and terminals. The plug is the movable part connected to the apparatus by flexible wire, and comprises two or three contact pins to fit into the contact tubes. Plugs and socket-outlets are made to British Standard Specifications, the standard sizes being 2 A, 5A, and 30 A. The plug pins are of phosphor- bronze or hard-drawn brass, solid or slotted down the length to form a spring contact in the tubes. The terminals are of substantial construction to clamp the flexible wire firmly. The plug cover, of hardwood or other tough incombustible material, is provided with a clamp to prevent the flexible from pulling out of the plug when in use, this clamp to be inside the cover. The socket-outlet base is of vitreous porcelain or tough insulating material and the contact tubes which must be self- adjusting to the pins are of phosphor-bronze or hard-drawn brass with sound terminals.

The exposed ends of the tubes are below the level of the base to prevent them from being touched accidentally. Figure 36 shows a 3 pin plug with cover

Plugs and sockets may be either of the 2-pin type or of the 3-pin type. Figure 37.shows a 3-pin socket –outlet for flush mounting. For direct current circuits the socket-outlet must be switch-controlled, and this is commonly provided for by a combined switch and socket-outlet.

Flat pin 13-A fused plug

I.E.E. Regulation allows the use of 13-A fused plugs under certain conditions, figure 1.38 shows a 3-pin fused plug made in accordance with B.S 1363.

The plug is suitable for use with alternating current only. The plug pins are clearly identified by ‘L’ for live ‘N’ for neutral and ‘E’ for earth... A 13 –A cartridge fuse fitted inside the plug.

I.E.E. Regulations require that every plug and socket- outlet shall comply with the following;

- It must not be possible for any one pin of a plug to be in live contact with the socket-outlet whole any other pin is exposed.
- No plug should fit any live contact of a socket- outlet, other than that of the socket-outlet for which it is designed

- With exceptions, every plug and socket-outlet must be non-reversible, with provision for earthing
- Every fuse plug is to be non-reversible , with no provision for a fuse in an earthed conductor

Fuses.

A fuse element consists essentially of a piece of copper or tin-lead alloy wire which will melt when carrying a predetermined current. This element with contact carrier, and base is called a fuse. It is placed in series with the circuit or sub-circuit to be protected, and automatically breaks the circuit when overloaded. In general, the regulations regarding fuses require that fuses shall be accessible, and shall be fitted either on the front of a switch board or in a protecting case. In most cases in installation work the fuses are fitted in a distribution board.

The current rating or normal current-carrying capacity of a fuse should not exceed the current rating of the smallest conductor in the circuit protected by the fuse, account being taken of the class of excess- current protection provided by the fuse, coarse or close. For electric motors, a higher fuse rating is allowable. The fusing values of normal duty fuses vary from 160 to 200 percent of the carrying capacity.

Rewireable fuses.

In this type, fuse wire is placed in a removable fuse link. The fuse link may be of porcelain or other suitable insulating materials, it is so constructed that there is no danger to the operator in removing the fuse link. The fuse wire is connected between two terminals and passes through an asbestos tube or is in intimate contact with a sheet of asbestos. The fuse link is push-fitted into the fuse base to make the connection through suitable contacts. Although the material cost of replacing a blown fuse wire in a Rewirable fuse is negligible, nevertheless this fuse had disadvantages, the chief being the deterioration of the fuse wire over a period, and another the possibility of renewal by the wrong size of fuse wire.

Cartridge fuses

The cartridge fuse consists of a sealed tube with metal end caps. The fuse wire passes through the tube from cap to cap and is welded or soldered to the inside of the cap. There is sometimes a blowout device in the side of the tube to indicate when the fuse is blown. When the fuse is blown the whole cartridge must be replaced. Cartridge fuses only are used in fused plugs, such as the common ring-circuit 13 –A plug.

High breaking capacity fuses.

The H.B.C fuse consists of a ceramic tube with metal end caps and fixing tags. The fuse is a silver strip of special shape with a low melting point rivet in the center. The strip is entirely surrounded by chemically purified silica. When an overload occurs breaking the fuse element, the silica prevents the formation of an arc, thus preventing overheating of the fuse and its surroundings.

Figure 261 HRC fuses

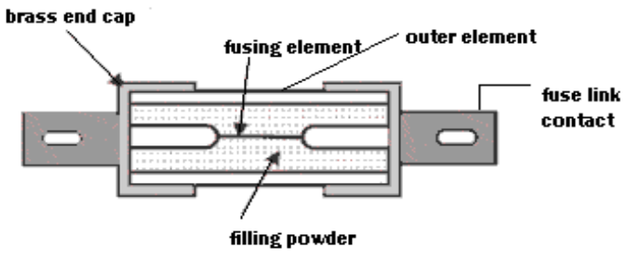


Figure 262 Construction of HRC fuse

Distribution boards.

The distribution board is an assemblage of parts, including one or more fuses or circuit-breakers arranged for the distribution of electrical energy to final sub–circuits or to other distribution boards.

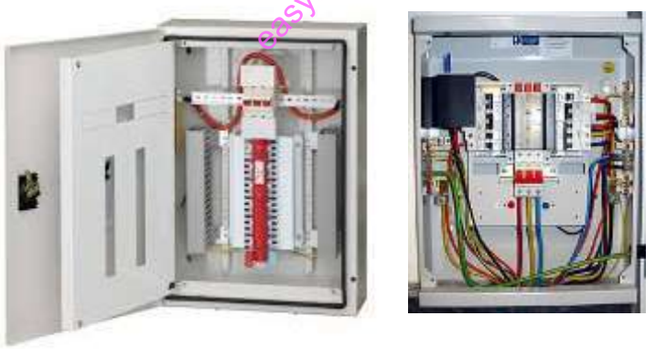


Figure 263 Distribution board

The boards are usually metal-cased in sheet steel, or hardwood- cased in oak, teak, or mahogany. The doors may be solid or glazed, and the case if fitted with an earthing terminal. Figure 1.38 shows a 1-pole and neutral, 6-way, distribution board with sheet steel body, fitted with Rewirable or H.B.C fuses. There is one fuse bank only, on the live side. One end of each of the six fuses is rigidly connected to a busbar, and the other end is arranged for connection to the circuit wire. The neutral wire of the circuit is connected to the neutral bar.

The regulations require that the neutral conductors for the different sub- circuits shall be connected in the same order as the live conductors to the fuses. Some distribution boards are designed to contain circuit – breakers instead of fuses. These however are more expensive than the equivalent Rewirable or H.B.C fuses.

Miniature circuit- breakers

These are being increasingly used to provide *close excess - current* protection in single phase, 250 V circuits. The circuit- breaker is essentially a switch which may be:

1. Opened and closed by hand
2. Opened automatically when overloaded

The tripping action may be either magnetic or thermal. In general both these actions are used in this type of circuit-breaker. Protection against sustained over current is given by the bending of a bi-metal strip with its time-lag affect, while high speed protection against a short- circuit is given by magnetic operation.

The circuit-breaker replaces both switch and fuses in the various circuits in which it is used. It can be obtained with plug-in contacts for insertion into a fuse base in a distribution board in place of a plug-in fuse carrier.

Main switch and fuses

The consumer's main switch and fuses may be combined in one case. With this type of switch and fuse gear, the switch cannot be operated when the case is open, nor can the case be opened while the switch is closed.

Consumer's control unit

In a single-phase installation whose current rating is not greater than 60A, the consumer's main switch and fuse may be combined with the distribution board as one combined unit. The unit comprises a 60A

2-pole main switch and up to 12 single-pole circuit fuses (12 way consumer unit). The fuses vary in size, e.g. 5A, 15 A and 30 A.

Obviously the maximum current to be taken from the unit at any one time must not exceed 60 A. either cartridge or Rewirable fuses may be employed. In addition to the fuses a neutral bar and an earthing bar are fitted. The whole is fitted in a suitable sheet steel case, or in a moulded case; figure 39 shows a connection diagram for this unit.

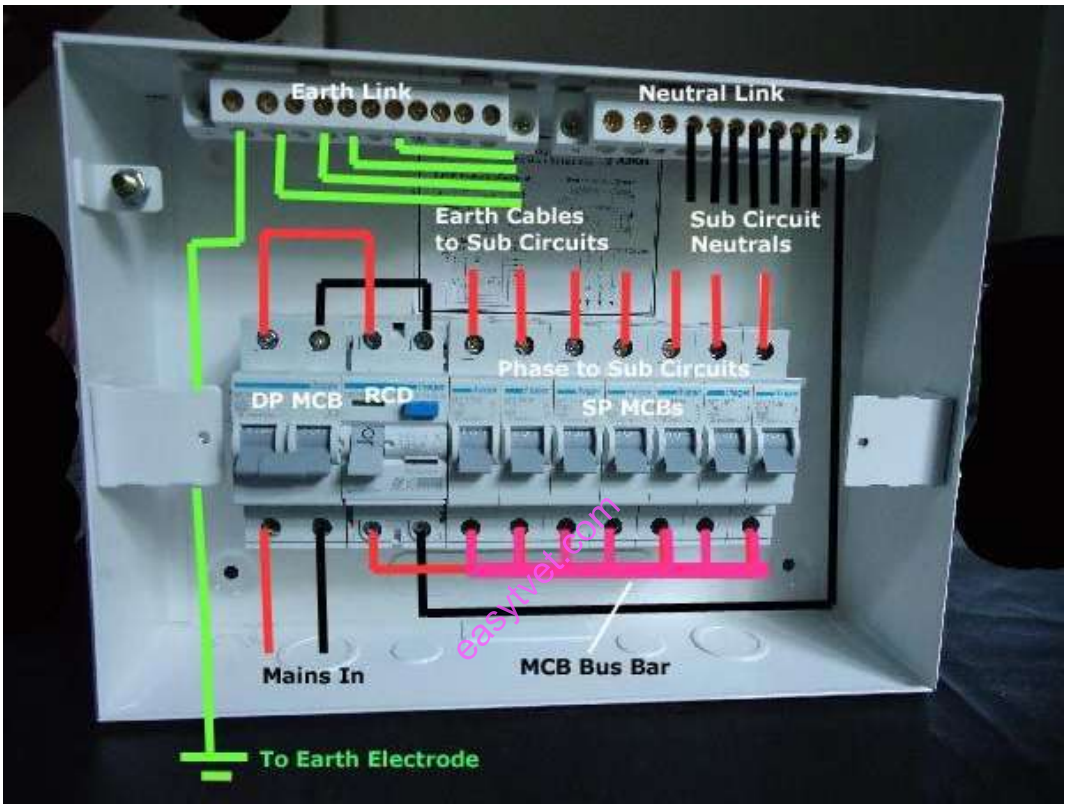


Figure 264 Consumer control unit

Types of Conductors

The most common electrical conductors used are copper and aluminum. Copper conductors are formed from a block of copper which is cold-drawn through a set of dies until the desired cross- sectional area is obtained. Aluminium wire is also drawn from a solid block

Characteristics of aluminium and copper as conductors

The table 4 show the summarized characteristics of Aluminium and copper

Table 16 Summary of characteristics of aluminum and copper

Aluminium	*Copper*
Smaller weight for similar resistance and current-carrying capacity	Can easily be drawn into wires
Easier to machine	Has better electrical and thermal conductivity
Greater current density because of larger surface	Has greater mechanical strength
High resistivity (2.845μΩ-cm)	Is corrosion resistant
Light in weight	Has high scrap value
	Easy to joint
	Lower resistivity (1.78 μΩ-cm)

The determining factor in the use of one type of metal for conductors is usually that of cost. Aluminium cables are used where weight is a factor like for overhead transmission.

Stranding of Conductors.

Stranding of conductors is done to make the completed cable more flexible. A set number of strands are used in cables: 1, 3, 7, 19, 37, 61, 91, and 127. Each layer of strands is spiraled on to the cable in opposite direction to the previous layer. This system increases the flexibility of the completed

cable and also minimizes the danger of **'bird caging'**, or the opening-up of the strands under a bending or twisting force.

Size of Stranded Conductors

The size of a stranded conductor is determined by the number of strands and the diameter of the individual strands. For example, a 7/0.85 mm cable consists of seven strands of wire, each strand having a diameter of 0.85 mm.

$$\text{The cross-sectional area will be} = 7 \times \frac{\pi D^2}{4} = 3.142 \times 7 \times \frac{0.85^2}{4} = 4.0 \text{ mm}^2$$

Figure 265 Stranded conductor

Cable

A cable is defined in the I.E.E. Regulations as: "A length of insulated single conductor (solid or stranded), or of two or more such conductors, each provided with its own insulation, which are laid up together. The insulated conductor or conductors may or may not be provided with an overall covering for mechanical protection." A cable consists of two basic parts*:*

- Conductors
- insulators

Construction of Cables

A cable derives its name from the type of insulation used.

Polyvinyl Chloride (P.V.C.) Cable.

This is also known as 'thermo-plastic' cable since the insulation is made from a synthetic resin which softens when heated. The process of manufacture is as follows:

Multi-core Cable.

This is cable which is made up of two or more insulated conductors. Multi-core cable is sheathed in a protective covering— for example, tough rubber for tough rubber-sheathed cables (t.r.s.) and p.v.c. for plastic cables.

Tough-Rubber-Sheathed (t.r.s.) Cable.

This is made of specially toughened rubber which is resistant to acids and alkalies.

Polychloroprene (p.c.p. or neoprene) Cable.

Uses an insulation somewhat similar to that of t.r.s. but capable of withstanding most weather conditions and particularly direct sunlight.

Heat-resisting, Oil-resisting and Flame-retardant (h.o.f.r.) Cables.

These cables are used in conditions damaging to p.v.c. cables such as high temperature and oil. The resistant qualities are developed by a vulcanizing (or curing) process which forms an elastomer capable of withstanding tough conditions and still retaining its flexibility.

Comparison OF T.R.S. AND P.V.C. cable

The table 5 shows the comparison between T.R.S cable and P.V.C cable

Table 17 Comparison between T.R.S and P.V.C cable

t.r.s. Cable	*p.v.c. Cable*
Affected by oil and water	Largely unaffected by oil, water, and corrosive chemicals
More flexible	Hardens at low temperatures and softens at high temperatures
Must be protected against direct sunlight	Does not support combustion

The maximum operating temperature for both rubber and p.v.c. insulated cables is 45°C.

Flexible cable

The I.E.E. Regulations define a flexible cable as: "A cable consisting of one or more cores, each containing a group of wires, the diameters of the wires and the construction of the cable being such as to afford flexibility."

Flexible cord

A flexible cord is defined as: "A flexible cable in which the cross-sectional area of each conductor does not exceed 4 mm^2".

Twisted Twin Flex Cable

This is made up of a multi-strand tinned-copper conductor with silicon rubber insulation. *Application:* lighting flex.

Figure 266 Twisted twin flex

Circular Flex. The rubber-insulated cores are formed into a circular section with cotton worming and contained in a cotton braiding.

Applications: connections to household appliances (iron boxes, kettles, etc.)

Circular Flex, Rubber Sheathed This flex is also packed with jute or cotton to form a circular cross-section but an outer sheath of rubber replaces the cotton braiding.

Applications: vacuum cleaner and portable drill leads (3-core).

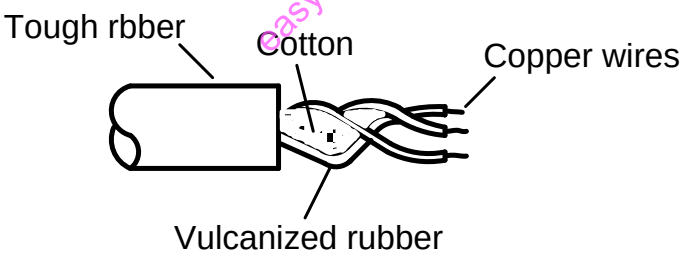


Figure 267 Circular flex, rubber sheathed

Workshop (or Industrial) Flex

This flex is similar in construction to the above, but has the addition of a compounded braiding. *Application:* connections to industrial lighting.

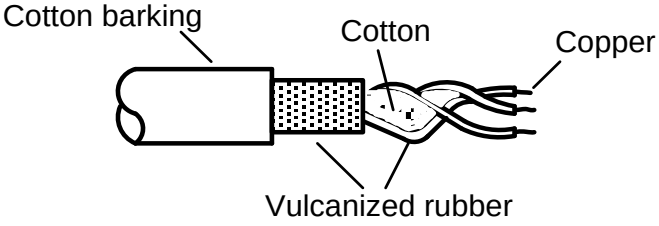


Figure 268 Workshop (or industrial) flex

Permissible Voltage Drop in Cable.

Voltage drop is an essential feature in the calculation of cable size. Low voltage at the consumer's equipment leads to the inefficient operation of lighting, power equipment, and heating appliances. The maximum voltage drop allowed between the consumer's terminals and any point in the installation is 2-5 per cent of the voltage supplied by the Electricity Supply Authority, including motor circuits.

Voltage Drop and the I.E.E. **Tables.**

The I.E.E. tables state the voltage drop across a section of cable when maximum current is flowing through it. If the current is halved, the voltage drop will also be halved. For example, a 4 mm^2 twin-core cable has a current rating of 24 A and a-voltage drop 10 mV per ampere per metre. If the current is halved (to 12 A) the voltage drop will be halved to 5 mV per ampere per metre.

The **I**.E.E. Regulations contain comprehensive information regarding the current-carrying capacity of cables under certain conditions.

These tables supply:

i. Cross-sectional area, number, and diameter of conductors;
ii. type of insulation;
iii. length of run for 1V drop;
iv. Current rating (a.c. and d.c.), for either single or bunched.

The following terms are used in the I.E.E. tables:

i. ambient temperature
ii. Rating factor.

Ambient Temperature. This is the temperature of the air surrounding the conductor. The current rating of a cable is decreased as the temperature of the surrounding air increases, and this changed current-carrying capacity can be calculated by using the relevant rating factor.

Rating Factor.

This is a number, without units, which is multiplied with the current to find the new current-carrying capacity as the operating conditions of the cable change. For example, a twin-core 10 mm^2 (7/1.35 mm) p.v.c. cable will carry a maximum current of 40 A at an ambient temperature of 25 °C, but if the ambient temperature is increased to 65 °C the maximum current allowed will now be:

$$40A \times 0.44 \text{ (rating factor)} = 17.6A$$

The rating factor is also dependent on the type of excess current protection. If cables are bunched together, their current-carrying capacity will decrease; a rating factor is therefore supplied for the bunching, or grouping, of cables.

Current Density and Cable Size.

The current density of a conductor is the amount of current which the conductor can safely carry without undue heating per unit cross-sectional area. For example, if a copper conductor has a current density of 300 A/cm^2 a copper conductor of cross-sectional 0.5 cm^2 will be capable of carrying one half of 300 A, that is, 150 A.

To calculate the current-carrying capacity of a cable (given cross-sectional area (cm^2) and current density (A/cm^2) :

Current-carrying capacity = current density x cross-sectional area

Example.

Calculate the current-carrying capacity of a 0.1 cm^2 conductor if the current density of the conductor is 400 A/cm^2.

Current-carrying capacity = 400A/cm^{2}x0.1cm^2 = 40 A

Fittings

Power is relevant to electricians because it says that reasonable provision shall be made to provide lighting systems with energy-efficient lamps and sufficient controls so that electrical energy can be used efficiently. The two methods of compliance with these Regulations for both internal and external lighting. It says:

- A reasonable number of internal lighting points should be wired that will only take energy-efficient lamps such as fluorescent tubes and compact fluorescent lamps, CFLs.
- External lighting fixed to the building, including lighting in porches but not lighting in garages or carports, should provide reasonable provision for energy-efficient lamps such as fluorescent tubes and CFLs.

These lamps should automatically extinguish in daylight and when not required at night, by being controlled by Passive infra-red (PIR) detectors. The traditional light bulb, called a GLS (general lighting service) lamp is hopelessly bad in energy efficiency terms, producing only 14 lumens of light output for every electrical watt input. Fluorescent tubes and CFLs produce more than 40 lumens of light output for every watt input.

Different types of lamp.

a) GLS lamps

GLS lamps produce light as a result of the heating effect of an electrical current. Most of the electricity goes to producing heat and a little to producing light. A fi ne tungsten wire is first coiled and coiled again to form the incandescent fi lament of the GLS lamp. The coiled coil arrangement reduces filament cooling and increases the light output by allowing the fi l-ament to operate at a higher temperature. The light output covers the visible spectrum, giving a warm white to yellow light with a colour rendering quality classified as fairly good. The efficacy of the GLS lamp is 14 lumens per watt over its intended lifespan of 1000 h. The filament lamp in its simplest form is a purely functional light source which is unchallenged on the domestic market despite the manufacture of more efficient lamps. One factor which may have contributed to its popular-ity is that lamp designers have been able to modify the glass envelope of the lamp to give a very pleasing decorative appearance, as shown by figure 43.

Figure 269 some decorative GLS lamp shapes

b) Tungsten Halogen Dichroic Reflector Miniature Spot Lamps

Tungsten Halogen Dichroic Reflector Miniature Spot Lamps such as the one shown in Fig. 44 are extremely popular in the lighting schemes of the new millennium. Their small size and bright white illumination makes them very popular in both commercial and domestic installations. They are available as a 12 V bi-pin package in 20, 35 and 50 W and as a 230 V bayonet type cap (called a GU10 or GZ10 cap) in 20, 35 and 50 W. At 20 lumens of light output over its intended lifespan of 2000 h they are more energy efficient than GLS lamps. However, only lamps offering more than 40 lumens of light output are considered energy efficient by the Government's criteria.

Figure 270 Tungsten Halogen Dichronic Lamp

c) Discharge lamps

Discharge lamps do not produce light by means of an incandescent fi lament but by the excitation of a gas or metallic vapour contained within a glass envelope. A voltage applied to two terminals or electrodes sealed into the end of a glass tube containing a gas or metallic vapour will excite the contents and produce light directly. Fluorescent tubes and CFLs operate on this principle.

d) Fluorescent tube

A fluorescent lamp is a linear arc tube, internally coated with a fluorescent powder, containing a low-pressure mercury vapour discharge. The lamp construction is shown in Fig. 45 and the control circuit in Fig 46.

Fluorescent luminaire is equipment which supports an electric lamp and distributes or filters the light created by the lamp. It is essentially the 'light fitting'. A lamp is a device for converting electrical energy into light energy. There are many types of lamps. General lighting service (GLS) lamps and tungsten halogen lamps use a very hot wire filament to create the light and so they also become very hot in use. Fluorescent tubes operate on the 'dis-charge' principle; that is, the excitation of a gas within a glass tube. They are cooler in operation and very efficient in converting electricity into light. They form the basic principle of most energy efficient lamps. Fluorescent lamps are linear arc tubes, internally coated with a fluorescent powder, containing a little low pressure mercury vapour and argon gas.Passing a current through the electrodes of the tube produces a cloud of electrons that ionize the mercury vapour and the argon in the tube, arc radiates much more UV than visible light: almost all the visible light from a fluorescent tube comes from the phosphors Glass, internally coated with fluorescent phosphor, cut away to reveal cathode-pin cap Tube filled with argon and mercury vapour Cathode coated with electron emitting material and fitted with cathode shield producing invisible ultraviolet light and some blue light. The fluorescent powder on the inside of the glass tube is very sensitive to ultraviolet rays and converts this radiation into visible light. Fluorescent luminaires require a simple electrical circuit to initiate the ionization of the gas in the tube and a device to control the current once the arc is struck and the lamp is illuminated.

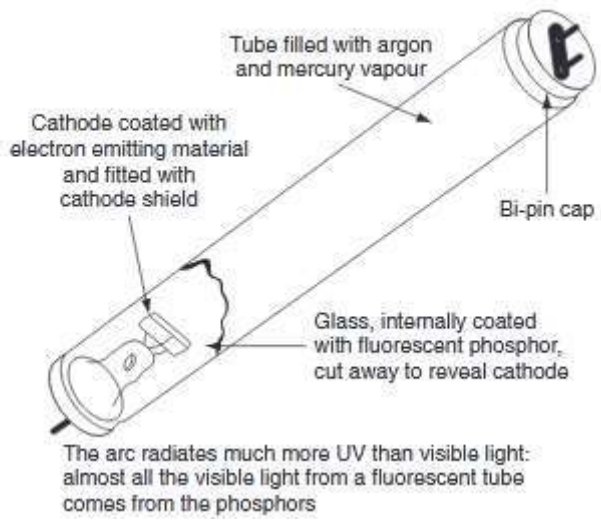


Figure 271 Fluorescent lamp construction

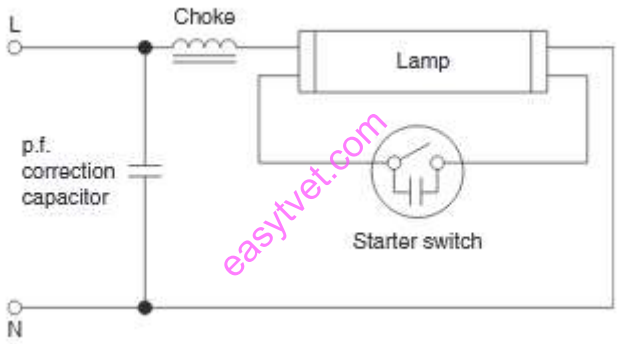


Figure 272 Fluorescent Lamp circuit arrangement

e) Compact fluorescent lamps CFLs

These are miniature fluorescent lamps designed to replace ordinary GLS lamps. They are available in a variety of shapes and sizes so that they can be fitted into existing light fittings. Figure 46 shows three typical shapes. The 'stick' type gives most of their light output radially while the flat 'double D' type give most of their light output above and below. Energy efficient lamps use electricity much more efficiently than an equivalent GLS lamp. For example, a 20 W energy efficient lamp will give the same light output as a 100 W GLS lamp. An 11 W energy-efficient lamp is equivalent to a 60 W GLS lamp. Energy efficient lamps also have a lifespan of about eight times longer than a GLS lamp and so, they do use energy very efficiently. However, energy efficient lamps are expensive to purchase and they do take a few minutes to attain full brilliance after switching on. They cannot always be controlled by a dimmer switch and are unsuitable for incorporating in an automatic presence detector because they are usually not switched on long enough to be worthwhile, but energy-efficient lamps are excellent for outside security lighting which

is left on for several hours each night. The electrical contractor, in discussion with a customer, must balance the advantages and disadvantages of energy-efficient lamps compared to other sources of illumination for each individual installation

Figure 273 Energy efficient lamps

Inventory management

If your business uses a lot of tools and equipment, keeping track of inventory will be no easy task. From small tools like hammers to saws and big equipment like rollers/cement mixers, individual equipment tracking becomes a huge concern for the organization. Deviations from the record can cause a delay in project completion.

Tool data irregularity can cause Shutdowns, Turnarounds, and Outages (STO's) where the cost of project completion becomes 3-4 times the actual cost.

This may lead to inaccurate decision making, inefficient planning, and an inability to stick to the contract. To complete the project on time, most stakeholders just reorder the equipment rather than locating it, which further increases project costs.

The main reasons you cannot find your tools are:

1. **Tools are not there and/or they have arrived in the wrong quantity**: if the tools that are supposed to be shipped haven't reached the designated location or they are shipped to another, you will have a missing tool report.
2. **Tools have been moved**: maybe the tool is still in the warehouse. But someone moved elsewhere without anyone knowing or they have placed it in the wrong location after using it, so it will classify as missing.
3. **Theft/Misplacement:** one of the most common reasons for missing tools is theft. Someone took the tool to work and didn't return it. Or after using it, they misplaced it.

4. **The log is not recorded correctly**: if the log sheet says that someone has issued the tool while it's actually still on the premises, it won't be used if there is a requirement. Conversely, if someone is using the tool but the log sheet says that the tool is available, people will look for it. That will cause confusion, halt work, and waste precious time.

However, there are some tips and tricks you can implement to make sure you keep a good track of your tools and equipment.

Track all inventory

Tracking your inventory is the best thing that you can do.

A good inventory tracking system means it is accurate and up to date. You can do cycle checks instead of daily tracking to reduce the time and effort required for inventory checking.

You may also have a central database where you list everything you own. That will reduce theft, as everyone will know if something's missing.

Inventory checks also make sure you allocate an appropriate budget for the inventory. Most of the time, businesses have much more inventory than they need.

Even if that's not your case, when tracking your inventory, you will be on top of work requirements and order equipment correctly the next time you need it.

Categorize Tools and Equipment

Categorizing tools and equipment can help you identify where similar tools are kept and which ones can be used interchangeably.

While you can categorize your inventory granularly in a program, you can place interchangeable tools in the same location for easier access.

You can divide tools into various categories, in a way that suits your business model best.

For example, you can organize tools by site and divide small and large tools. Other categories can be:

- Type of tool (hand tool, power tool)
- Tool brand
- Use for that tool (indoor, outdoor)

Organize tools as you see fit, but it would be wise to include information on equipment's status, purchase date, and warranty expiration date.

Tag individual items

Tagging items in your inventory will enable you to track, identify and locate each tool you have. You can tag equipment in many ways, barcodes and RFID chips being the most common.

We will explain the benefits of each option later.

Track tool usage

You should know which tool is being used more, how much is it being used, who is using it, and how much does it cost to ship it.

These insights will help you prioritize tools by requirement and transport price so you don't spend an extra dime on tools than you absolutely have to.

If a tool is collecting dust in a warehouse while it's needed somewhere—the business suffers.

Most importantly, if a tool gets stolen, you'll have the record of who was the last person handling it, when they used it, and the last location they used the tool. This is important as over time, the cost of lost tools adds up.

Checking in and checking out tools will help make a strategy for further equipment management.

Track Repairs and Warranties

If you're using one tool daily and another one once a month, the tool you use every day requires more maintenance, and it's more likely to break.

Also, when you have information about the equipment usage, you can plan maintenance for idle tools or machines due for checkups. Being well organized will not affect business processes, and will keep your equipment up and running.

Monitor which tools are under the warranty as you could maintain/fix them free of cost. This will make sure you spend money and time only on that tools/equipment that really need it.

What happens if the tool breaks?

Track which tools are regularly out of commission. If something breaks, try to understand the reason behind it, especially if it happens more often than it should. You can do that by collecting data and conducting trend analysis.

Answer the following questions and you'll have a better understanding of why something breaks:

- Is the equipment not being used properly (handling error)?
- Are they not being used according to correct voltage specifications?
- Does it require a resting period before reuse?

Not only does a broken tool costs time and money to fix it, but your workers would also be idle while it's getting fixed if there's no replacement available.

To save money in the long run, try to buy quality equipment from a trustworthy brand.

Determine optimum utilization

When categorizing tools, you can gather more data for each one.

For instance, you can find out which tools employees like better and which ones are the most effective in getting the job done.

Compare that with the cost and find information on how many companies are making it. Then, try to research which brand has the most durable equipment. Do a cost analysis to figure out which tools drain

you most financially, either by physical issue (breaking too early) or logistical issue (too much requirement?)

With that intelligence, you'll be able to make smarter decisions.

Equipment usage accountability

Making individual workers accountable for the equipment they use is a sure-fire way to reduce thefts and counting errors.

Here's what you can do.

- **Use technology**: use a tool management system instead of a manual record and make sure your employees know how to use it. That way they can self-check-in or check-out the required tools.
- **Bring your employees up to speed** about the tool tracking system you chose and explain how everything functions. You can also put a tool handling and usage chart in the workplace for a better understanding.
- **Create a tool handling agreement** to make sure your workers understand accountability associated with issuing that tool. Tell them about established laws related to the theft of tools and remind them of the consequences.
- **Establish rewards and fines**: for an exceptional tool handling, you can also issue rewards. This will motivate people to handle the tools better. Fines can be given to those who don't follow the rules. Workers who "lose" tools frequently can pay for the equipment out of their paycheck, if this will be your p.

Asset management system

Pen and paper tracking can work for small organizations; however, an asset management system/inventory management system should be used to manage tools in a large organization. It reduces inventory errors and increases safety for tools.

Along with the tagging system, you can formulate a real-time asset tracker for more precise information.

You might think, "I can manage my tools with a logbook and RFID tags. Why should I pay for software to do that?"

Well, there are huge advantages to using a dedicated software solution for tool tracking. Pen and paper solutions or spreadsheets are nowhere near good enough then the software method.

Here are some advantages of professional tool and asset management software over paper tracking/spreadsheets:

So now that you know the benefits of a professional tracking solution—how do you choose a tracking solution?

There are many available on the market. Most of them cater to different needs. We'll explore the features you need to be on the lookout for.

There are a few things you should consider before choosing a tool tracking solution.

Cloud connectivity

Storing your data on a single disk is a big security risk.

Cloud-based solutions allow users to access data from anywhere (flexibility). Also, cloud-native architecture has firewalls and encryption settings that add another layer of security.

Scanning device

You can use either a smartphone scanner or a dedicated hand-held scanner for equipment scanning.

A handheld scanner is an extra piece of hardware that you have to buy which is why most companies implement smartphone scanners that offer more flexibility for check-in and checkout.

6.2.3.4 Learning Activities

Workshop Practice

Practical activities	Knowledge	Special instruction
6. Check and identify tools, equipment and materials for proper specifications and functionality (in the workshop)	Electrical tools and equipment	Name and draw the electrical tools and equipment
7. Store and assemble tools equipment and materials as per the established procedure after a project	Tool's storage and inventory management	

6.2.3.5 Self-Assessment

1. What are the most commonly used types of conductors?
2. Which electrical accessories are use when carrying out electrical installations
3. Cables consists of three major parts. Name the parts
4. Below are tools and equipment used when preparing steel conduit for installation. What is the function of each?

6.2.3.6 Tools, Equipment, Supplies and Materials

Recommended Resources

Tools and equipment	**Materials and supplies**
➢ Cable Strippers ➢ Pliers ➢ Screw drivers ➢ Hammers ➢ Chisels ➢ Allen keys ➢ Electrician knives ➢ Crimping tools ➢ Bending springs ➢ Bending machine ➢ Steel tapes ➢ Draw wires ➢ Hack saws ➢ Drilling tools ➢ Stock and die ➢ Bench vice ➢ Machine vice ➢ PPE – hand gloves, dust coats, dust masks, helmets, ear muffs, industrial boots	• Stationery • Cables • Light fittings • Accessories • Conduits and fittings • Cable trays • Cable ducts • Trunkings • Computers • Drawing instruments • Screws
Reference materials • IEE regulations • Occupational safety and health act (OSHA) • Work injury benefits act (WIBA) • Manufacturers' catalogues • British standards • KEBS standards	

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6.2.3.8 Model answers to self-assessment

1. What are the most commonly used types of conductors?
   - Copper
   - Aluminium
2. Which electrical accessories are use when carrying out electrical installations
   - Lamp holders
   - Conduits
   - Ceiling roses
   - Patress
3. Cables consists of three major parts. Name the parts
   - Conductor
   - Insulator
   - Mechanical protection or sheath

4. Below are tools and equipment used when preparing steel conduit for installation. What is the function of each?
    b. Stock and die; **threading**
    c. Hacksaw; **cutting**

6.2.4 Learning Outcome 4 Install electrical system

6.2.4.1 Introduction to the learning outcome

To install electrical system, one requires to apply appropriate installation procedures and technical standards, implement working drawing, adhere to IEE regulations during installations, adhere to safety procedures for each activity, install cables, conductors, conduits, enclosures and support systems to specifications and label installation for identification.

6.2.4.2 Performance Standards

6.2.4.2.1 Apply appropriate installation procedures and technical standards
6.2.4.2.2 Implement working drawing
6.2.4.2.3 Adhere to IEE regulations during installation
6.2.4.2.4 Adhere to safety procedures for each activity
6.2.4.2.5 Install cables, conductors, conduits, enclosures and support systems to specifications.
6.2.4.2.6 Label installation for identification

6.2.4.3 Information Sheet

Cables

A cable is a length of single conductor having one or several wires stranded together, or two or more such conductors each provided with its own insulation and laid together. The insulated conductors may or may not be further covered with an overall protective sheath to prevent mechanical damage. The insulated conductors are referred to as the cores of the cable.

Sometimes bare or insulated conductors are used for overhead installations, or they are enclosed in a metal casing for rising (vertical) and lateral (horizontal) main supplies in buildings.

Cable consist of three essential parts:

- **Conductor** – to carry the current
- **Insulation (dielectric)** – to provide the means to prevent leakage of current
- **External overall protection** against mechanical damage, chemical attack, fire or other external damaging factors to the cable.

Cable layouts and wiring systems

Because of the complexity and hazards involved in the installation of cables in the many types of building and their surroundings, there are quite a number of different types of cables and wiring systems in use. Each is designed to meet and withstand the elements it will encounter and at the same time fit with the overall building construction in terms of convenience and appearance.

It is the responsibility of the contractor, designer or sometimes electrician, himself to study carefully the building specification and decide upon the type of cables and wiring systems most suitable.

Wiring system

A wiring system consist of conductors, insulators, means of mechanical protection and all accessories associated with installation.

Factors affecting choice of wiring system

1. **Type of building construction –** is it permanent or temporary structure, hospital, workshop, office or dwelling house will help to decide the routing, fixing and terminations
2. **Flexibility of the system –**change of location of equipment such as machine shops and temporary buildings i.e. must be flexible to needs of future alterations and modifications.
3. **Installation conditions/special adverse conditions –** protection against mechanical damage requirements and working heights. Also, conditions that are harmful to the wellbeing of a wiring system must be considered e.g. presence of flammable vapours risk of mechanical damage and presence of corrosive environment such as dampness.
4. **Appearance of finished installation (aesthetics) –** can be run on surface or concealed e.g. exposed conduit system cannot be used in an executive office.
5. **Durability** – life of the installation
6. **Economics/ Cost** – Cost of installation and money available. The cost of the wiring system must be compared to get the relative cheap system without compromising on the safety of the wiring.
7. **Type of load to be supplied** –should be made to the level of voltage expected in the circuit e.g. low voltage, medium voltage or extra high voltage.

Terminating and Jointing P.V.C. Cables

Stripping P**.V.C. Cables.**

A single-core p.v.c. cable should be stripped by holding the cutting knife at an angle to the cable and cutting away from the hand holding the cable. Multi-core cable is stripped by running the cutting knife along the centre of the cable and then nicking the end of the cable to give two finger grips. This allows the sheathing to be pulled down the cable with the thumb and forefinger of each hand. The sheath is then folded on top of the cable and cut by drawing the knife between the sheathing and the cable.

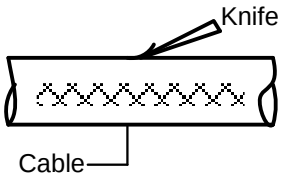


Figure 274 Stripping cable

There are two basic methods of joining electrical conductors: (a) mechanical joints; and (b) soldered joints.

Mechanical Jointing.

This is done by using connector blocks. These consist of one-way or multi-way brass terminal blocks enshrouded with porcelain or plastic insulation. The connector must be capable of containing all the strands of the conductor.

Another method, usually used with larger cables, is **mechanical crimping**. This is done by placing a sleeve over the conductors to be jointed and crimping (squeezing) the connection with a manual or hydraulically operated crimping jack.

Soldered Joints.

Materials required: pliers, sharp knife, soldering bit, flux, blowlamp (or butane gas cylinder), solder, p.v.c. tape and black insulating tape.

Soldering Bit. Every joint which is made by twisting strands together must be soldered. Where a lot of single-core jointing is being carried out, it is often convenient to use a heavy bit which has a slot filed in it to take cables. The soldering bit should be heated until a green flame appears and must always be kept clean. Always' tin' the bit with flux and solder before using. *Flux.* The purpose of the flux is to remove the oxide film from the surface of the conductor and prevent it from re-forming.

Blowlamp. This should be operated as follows:

1. The lamp should not be more than two-thirds full.
2. Leave the valve open when starting.
3. Start lamp with small rag dipped in methylated spirits.
4. When the lamp is hot, the valve should be closed and the pump operated.
5. The pump forces the paraffin through the heated vaporizing tube and out of the nozzle where it is ignited under pressure.
6. The blowlamp should be played against an asbestos sheet until the flame is fully established.

Solder. Two basic types of solder are used in electrical work: fine solder (tinman's solder), which is **60** parts tin and **40** parts lead, and plumber's metal, which is **30** parts tin and **70** parts lead. Fine solder melts more easily, as tin has a lower melting point than lead, and so it is commonly used for electrical

joints. Plumber's metal is used for 'plumbing' joints in armoured cables, as it remains in a plastic state, allowing it to be shaped, longer than fine solder.

Methods of Soldering.

There are three methods used for soldering conductors:

(a) soldering bit,

(b) 'stick' method

(c) (metal) pot and ladle method.

Soldering Bit. The conductors to be jointed are first smeared with a resinous flux. The tinned bit is then applied under the joint until the heat penetrates it. The stick of solder is then applied to the joint until the solder flows freely through it.

'Stick' Method. In this method, the joint is first heated with a blowlamp, flux being applied. The solder is then applied by pressing the stick of solder against the heated joint until it penetrates the joint. Care should be taken to protect the insulation against the blowlamp flame.

Pot and Ladle Method. This method is commonly used by jointers when jointing heavy conductors. A solder pot is heated until the solder is running freely. The solder should not be overheated as this will burn the tin and a dross will form on the surface of the solder. When the solder has reached working temperature it is taken from the pot with a ladle. The solder is then poured over the prepared joint and is caught by another ladle placed under the joint. This action is repeated until the solder penetrates the joint.

Soldering Aluminium.

The following special points should be noted when soldering aluminium:

- All surfaces must be scrupulously clean.
- When making a joint between stranded conductors ' step' the strands to increase the surface area.
- The surface must be heated *before* the flux is applied as the flux will only take when the temperature is high enough.
- Apply aluminum solder until the complete surface is bright.
- Joints in aluminum should be protected from contact with the atmosphere. This can be done by painting, taping, or compounding.

Soldering a Socket (or Lug). The method used is as follows

5. Strip insulation back about 5 cm.
2. Tin the socket.
3. Smear both the socket and the bared conductor with flux.

4. Fit the socket to the conductor. The socket should be a hammer fit.

If the socket is too large, the conductor can be enlarge with a tinned- wire binding or. Better still, by pressing a strand of cable into the centres of the conductor**.**

5 Play the blowlamp in the top of the socket until the heat has penetrated the conductor, and then apply a stick of solder to the lip of the socket. The completed connection should have a rim of solder showing round the lip the socket; this can be done by applying plumber's metal as the joint is cooling

6 When the termination is cooled, cut back damaged insulation and apply p.v.c or cambric tape

7 Tape is used to replace insulation which has been removed prior to jointing

Do not attempt to cool a soldered joint by pouring water over it. This can lead to an effect joint known as a dry joint. Never smooth the joint with a file but use a dry cloth before it sets.

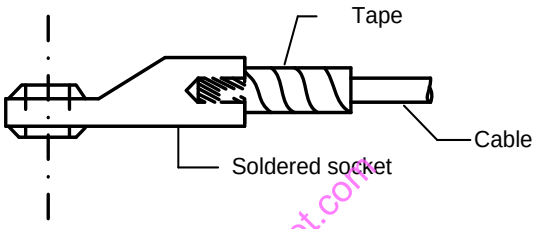


Figure 275 section through soldered socket

Through joint

This joint is made by using mechanical connectors, compressor ferrules or grip-type (weak back) soldered sleeves.

The completed joint is wrapped with p.v.c. tap. The joint can further be protected by the use of a cold pouring of resin compound to fill the protection box.

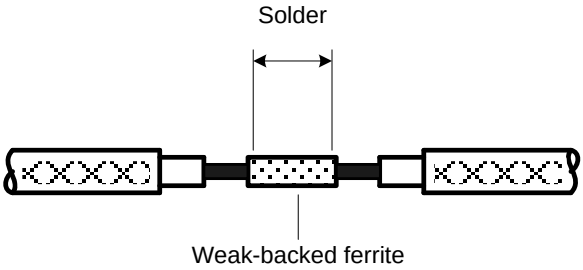


Figure 276 Straight-through joint using weak-backed ferrule

Straight-through joint using weak-backed ferrule

A weak-backed ferrule is a tubular piece of tinned-copper opened along the top and weakened at the bottom thus allowing it to be closed or opened easily.

Procedure of making the joint

1. Strip insulation back from both of the conductors.
2. Clean and tin ferrule
3. Place ferrule on cable. Butt cables together before tightening the ferrule
4. Wind small pieces of cloth at each end of the ferrule to contain the molten metal
5. Solder the connection
6. Remove damaged insulation and apply tape.

Tee (breeches) Joint

This joint is used to tee-off a service from an armoured cable. The weak-backed ferrule is often used. Mechanical connectors or compression ferrule can also be used

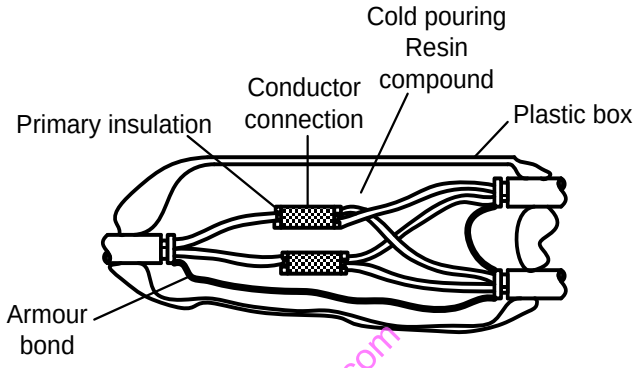


Figure 277 Tee (breeches) joint

Armoured cable

This cable is used where there is a likelihood of the insulation or conductor being subjected to mechanical damage. This can occur when the cable is run underground.

There are two main types of armoured cables:

a) Paper insulated lead covered steel wire or steel tape armoured cables, abbreviated as P.I.L.C.S.W.A. and P.I.L.C.S.T.A cables respectively
b) P.V.C.armoured cable

P.I.L.C.S.W.A.

The cable has the following parts

a) An inner core of jute used to keep the cable circular.
b) Copper or aluminium conductors insulated with mineral oil-impregnated paper.
c) A lead sheath which contains the insulation and is also used as an earth continuity conductor
d) Jute bedding tape impregnated with bitumen that protects the lead from armouring
e) Galvanized steel wire (one layer) or steel tape (two layers).
f) Bitumen impregnated jute serving

Termination of P.I.L.C.S.W.A. cable

1. Place binder 1m from end of cable
2. Remove serving to this point
3. Bend steel wire armouring back until it is clear to lead sheath
4. Remove about 13cm of lead sheath and clean the remainder
5. Place brass gland on cable, leaving approximately 10cm of lead sheath showing. Wedge gland with wood to keep it central on cable
6. Use plumber's metal to plumb the joint
7. Clean galvanized wire paraffin rag and shape the wire over the plumb
8. Clamp wires on the gland and bolt the gland on sealing chamber
9. Cut back paper insulation on conductors and make through-joint to V.R.I conductors, using weak-back ferrule
10. Assemble sealing chamber and pour in hot bitumen to seal oil-impregnated paper against moisture

P.V.C. Armoured Cable

This is made up of p.v.c insulated cores packed with p.v.c. to give a circular cross section. An outer p.v.c. sheath covers the galvanized steel wire.

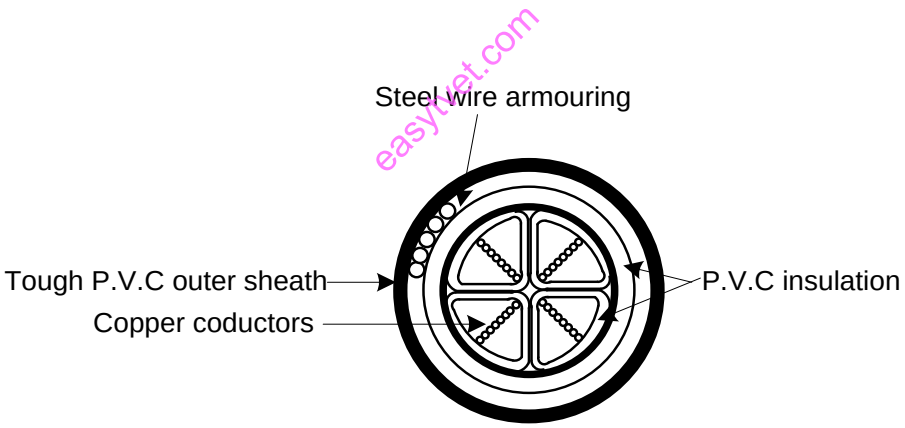


Figure 278 P.V.C armoured cable

Termination of P.V.C. armoured cable

The following must be taken into consideration when terminating

1. P.v.c. must be protected from heat
2. P.v.c. tapes must be used for insulating the conductors
3. Care must be taken when clamping and cleaning the galvanized wire so that it is not broken as it is the sole earth continuity conductor
4. The temperature of the hot pouring compound should not melt the p.v.c. insulation of conductors. Dip a piece of scrap p.v.c. into the compound before pouring to test the temperature.

Mineral Insulated Metal Sheathed (M.I.M.S.) Cable

This cable consists of three parts. These are:

Copper or aluminium conductors

Each core consists of a single copper conductor. Common core numbers are 1,2,3,4and 7

Insulation

The insulation between the cores is magnesium oxide. It can withstand high temperatures but is absorbent to moisture

Outer sheath

Is a seamless copper or aluminium tube

Advantages and disadvantages OF M.I.M.S. CABLE (table 6)

Table 18 advantages and disadvantages of M.I.M.S

Advantages	Disadvantages
Heat resistant. Can withstand temperatures up to 250^0C	Expensive
The sheath provides an excellent earth continuity conductor	Termination takes time
Is mechanically strong must be protected against shape edges	Has greater voltage drop per metre at the same current rating
High current density	
Does not deteriorate with age	

Cable Termination

- Termination is the entry of a cable end into an accessory. In case of a stranded conductor, the strands should be twisted tightly together before termination. Great care must be taken not to damage the wires. The I.E.E. Regulation requires that a cable termination of any kind shall securely anchor all the wires of the conductor and shall not impose any mechanical stress on the terminal or socket. If a soldering socket is used, then it must contain all the strands of the conductor.
- A termination under mechanical stress is liable to disconnection. When current is flowing in a cable, certain amount of heat is developed, and the consequent expansion and contraction may force the cable out of the terminal or socket.
- If one or more strands of the cable were to be left out of the terminal or socket, there would be a reduction in the effective cross-sectional area of the conductor at the point. When terminating rubber insulated cable, the technician should avoid exposing the rubber insulation and conductors to the atmosphere. In conditions of heat or moisture, the terminations should be sealed.

- Mineral insulated copper sheathed cables are terminated in *sealed glands*. A common arrangement is the screw-on pot-type seal, in which a small metal pot is screwed on to the copper sheath. Cold plastic compound is then pressed into the pot and a fibre cap and insulating sleeves and threaded over conductors and crimped into position.
- If an insulation test indicates that moisture has entered the mineral insulation, the gland must be undone, the moisture driven out using a blowlamp and the seal re-made.

Types of terminal.

The most commonly used methods of securing conductors in accessories are:

Pillar terminals,

A pillar terminal has a hole through its side into which the conductor in inserted and then secured by a set screw. If the conductor is small in relation to the hole, it should be doubled back. When two or more conductors are to go into the same terminal, they should first be tightly twisted together. In the case of flexible cord terminations, the strands must be twisted up (and then bent back if room permits) before being entered into the terminal.

- screw head, and
- Nuts and washers.

When fastening conductors under screw heads or nuts, it is best to form the conductor end into an eye by means of the round-nosed pliers. The eye should be slightly larger than the screw shank, but smaller than the outside diameter of the screw head, nuts or washers. The eye should be placed in such a way that rotation of the screw head or nut tends to close the joint in the eye. If the eye is put the opposite way round, the motion of the screw or nut will tend to untwist the eye, and will probably result in imperfect contact.

The importance of good contact cannot be over-stressed. Poor contact introduces resistances at the termination and leads to over-heating eventually leading to fire.

Solder less lug connections are now being used to some extent in the electrical contracting industry, particularly for terminating small sized cables. Lugs of this type are made from solid copper and are tinned. They are fastened to cable ends by crimping. Hand crimping tools usually accommodate several cable sizes in a fixed head.

For the larger sized lugs, there are hydraulic crimping machines with capacities of several tonnes

Termination Tools

- The following tools are required while terminating an electrical cable
- A sharp knife,
- A pair of side-cutters and
- A soldering iron.

- The knife should be sharpened periodically. The cutting edge of pliers and side-cutters should not be used for purposes other than that for which they are intended. The bit of the soldering iron should be kept clean.

- For compliance with the I.E.E. Regulations, joints in cables must be;
- Made by soldering or by mechanical clamps
- Mechanically and electrically sound
- Provided with insulation not less effective than that of the cable cores,
- Protected against moisture and mechanical damage
- Accessible for inspection (except in the case of buried cables)

Soldering

- The type of solder to be used for twist-joints is called' tin man's solder.' It is a soft solder consisting of 60 parts tin to 40 parts leads, with a melting point of 200^0C (about one-fifth of the melting point of copper). To make the solder flow readily over a surface, a *flux* is required. The function performed by the flux is largely that of cleaning the surface and of reducing any oxide to the metallic state.

- For electrical work, pure amber resin is the safest flux to use, because it does not cause any corrosion of the metal. Soldering fluxes containing acid or other corrosive substances, such as zinc chloride solution (killed spirits) must not be used for this work

***The* Soldering iron**

- When the soldering iron is heated, the surface should be cleaned, a small quantity of resin is applied and then the stick of solder lightly touched. The surface should then have a bright silvery appearance. Powdered resin is applied to the joint which is then laid in a shallow pool of solder. After a short period, the solder will run up into the strands, at which point joint can be removed from the iron and allowed to cool. Sometimes, soldering bits are grooved so that the portion of joint to be soldered can be placed in the groove, thus giving a larger area of surface contact between the two.

- A well-soldered joint should present a smooth, bright appearance. It is important to remember that wiping the join before it cools destroys this appearance and is liable to roughen the surface and become detrimental to the insulation.

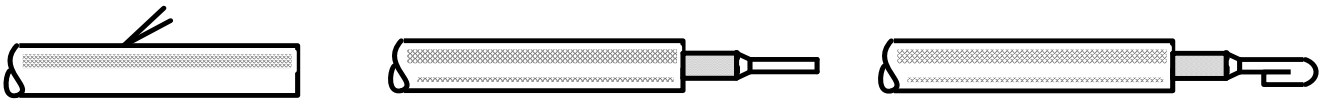
- To avoid damaging the cable insulation near the joint the soldering process should be carried out as quickly as possible. The tendency to burn the insulation is less with a really hot soldering iron than with a cooler one which takes longer to do the job. It is sometimes possible to roll back some of the insulation before soldering and to unroll it afterwards.

- *The metal pot and ladle.* An iron metal pot about three quarters full of solder, together with the ladle, is heated until the solder is fluid. Any impurities can then be skimmed off the surface. The joint is held over the pot and sprinkled with resin a small amount being allowed to fall into the solder. The ladle should be filled with solder and this should be poured heavily over the joint so as to raise its temperature as rapidly as possible, thereby avoiding damage to the insulation. Pouring is repeated, adding resin as necessary, until the required coating is achieved; at the same time any points that may form are carefully brushed off.
  - In the case of a termination, both the lug and the cable end must be heated and 'tinned' before any attempt is made to insert cable end in position.
  - *The blowlamp.* Before starting to solder, see that the blow lamp is about two- thirds full of paraffin. For pouring, it is best to fit a funnel in the filler cap. A piece of cotton waste s then placed in the annular trough, soaked in methylated spirit, and ignited. It is possible to use paraffin for this purpose, but methylated spirit gives a cleaner flame and starts the lamp quicker. By operating the pump, the pressure inside the reservoir can be increased. This pump reaches nearly to the bottom of the reservoir and is provided with a non- return valve. AS the pressure increases, paraffin will be forced up the tube and becomes vaporized by the heat from the burning waste. Vapour, so formed, will then issue from the orifice (or jet) at high velocity and after mixing with air drawn in through holes at the side of the chamber, will burn at the nozzle.
  - To enable the blowlamp to work continuously after it has once started, the tube conveying paraffin from the reservoir to the jet is led near the flame, so that the paraffin is vaporized by the heat of the lamp itself. The pressure inside the reservoir is also maintained by the heat of the lamp. As this pressure is high, the base of the lamp is curved inward to give additional strength.
  - To stop the blowlamp working, the valve is opened. The flow of paraffin then stops due to the reduction in pressure. When using the blowlamp to solder a joint, the flame should be directed into the middle of the joint. As the conductor attains the melting temperature of solder, resin and solder, are rubbed into it alternately until it becomes saturated with solder.
  - Because of the risk of causing damage, it is advisable to wrap the ends of the insulation with dampened cloth tape before soldering joints with the aid of a blowlamp. Before sweating a cable socket using a blowlamp the interior of the socket must be cleaned. The inside if then tinned by heating and introducing solder and resin. After almost filing the socket with molten solder, the cable end, rubbed with resin, is pushed into it. The solder should run up into the strands of the cable, and should be evenly dispersed round the conductor. The blowlamp jet should always be kept clear by using the pricker as necessary. It is bad practice to operate the pump to clean the jet, if the flame has gone out.

- Blowpipes utilizing propane or butane gases are gradually superseding paraffin blowlamps. Special soldering techniques are used for alluminium.

EXERCISE 1

Stripping and preparing 1/1.13mm cable end for entry into an accessory



Correct angle of knife blade | Braid and tape removed | Conductor bent over

Procedure;

- Remove braid, tape and rubber from the end 25mm of cable
- Remove braid and tape (if any) for a further 15mm
- Bend exposed conductor in two.
- Make a drawing of the cable and its full size, giving actual dimension

EXERCISE 2

A Britannia joint between two pieces of 1/1 .78 mm cable

Producer:

- Strip and clean one end of each piece for 75mm.
- Strip off braid and tape for a further 15mm on each piece
- Bend the end 6mm of each conductor at right angles
- Clamp the two conductors together so that the ends project outwards.
- Tightly bind both conductors with a tinned copper wire, carrying the binding about 6mm past each end.
- Solder the whole length of the binding.
- Make a drawing of the joint twice its full size, giving actual dimensions.

EXERCISE 3

A Bellhangers' joint between two pieces of 1/1.13mm cable.

Procedure

- Strip and clean one end of each piece for 90mm.

- Strip off braid and tape (if any) for a further 15mm on each piece.
- Cross the conductors at about 25mm from the insulation, keeping the left-hand conductor in front.
- With the pliers grip the crossed conductors together just to the left of the point of crossing.
- Bend the two conductors at right-angles to the crossing.
- Twist the left-hand conductor tightly round the right-hand one for six turns.
- Twist the right-hand conductor tightly round the left-hand one for six turns.
- Cut off surplus conductors on the bevel with side-cutters and smooth over with pliers.
- Solder the whole length of the joint.
- Make a drawing of the joint twice its full size, giving actual dimensions.

EXERCISE 4

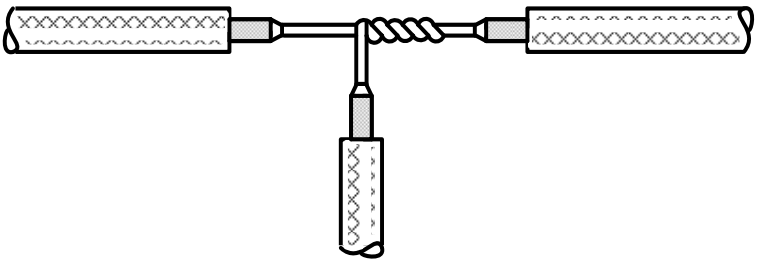
A Telegraph joint between two pieces of 1/1.38 mm cable

Procedure

- Strip and clean one end of each piece for 100mm
- Strip off braid and tape (if any) for a further 25mm on each piece.
- Cross the conductors at about 30mm from the insulation, keeping the left-hand conductor in front.
- With the pliers grip the crossed conductors together just to the left of the point of crossing
- Twist the left-hand end and the right-hand main portion tightly together equally round a common axis at a high pitch (that is, not too sharply) for six turns.
- In a similar way twist the right-hand end and the left-hand main portion tightly together equally round a common axis for six turns.
- Cut off surplus conductors on the level with side-cutters and smooth over with pliers.

EXERCISE 5

A T-JOINT BETWEEN TWO PIECES OF 1/1.38MM CABLE



Procedure

- Strip and clean the through piece for a distance of 37 mm in the center.

- Strip off braids and tape (if any) for 15mm at each side.
- Strip and clean one end of the t-piece for 100mm
- Strip off braids and tape (if any) for a further 15mm.
- Place t-piece at right angles to left-hand side of bared through piece and tightly bind t-piece round through piece.
- Cut off surplus conductor on the level and smooth over with pliers.
- Soldier the right-hand half of the binding.
- I.E.E. regulation to be studied:
- Number b6 and b19
- Question to be answered:
- What should be the minimum voltage rating of every cable in accordance with the appropriate British standard
- What is meant by the expression of the voltage rating of cable as: (a) 600/1000, (b) 600?
- To what type of installation is twist-joining of smaller sized conductors mainly confined?
- State the I.E.E. requirements for the insulation of cables for fixed wiring.

- Make a drawing of the joint twice its full size, giving actual dimensions.

EXERICE 6

USING A MICROMETER TO MEASURE CONDUCTOR DIAMETERS

Procedure:

- Place the wire with its diameter between the anvil of the micrometer and the spindle head.
- Turn the ratchet stud until the ratchet slips to close the head on the wire.
- Note the barrel reading to the nearest 0.5 millimeter under.
- Note the number of thimble divisions and multiply by 0.01
- Obtain the complete measurement by adding the results of operations 3 and 4.
- Repeat operation 1 to 5 for each sample of wire.
- Make a drawing of a micrometer thimble and barrel twice full size to illustrate a reading of 3.18mm

EXERCISE 7

Connecting a flexible pendant

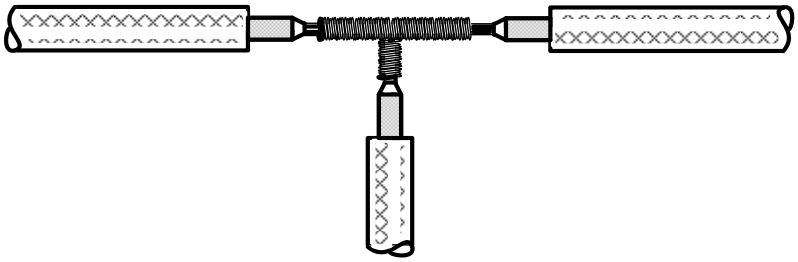
Procedure:

- Strip the ends of the cable cores and connect the conductors in the appropriate terminals of the ceiling rose.

- Strip both ends of the flexible cord, unscrew the lamp-holder cap, and connect the conductors at one end to the lampholder terminals.
- Thread the flexible cord through the lampholder cap and screw on the cap.
- Unscrew the ceiling rose cover, thread the flexible cord through it, connect the flexible cord conductors to the appropriate terminals of the ceiling rose, and then screw on the cover.
- Make a sectional drawing of the flexible pendant about twice full size (omitting most of the flexible cord), showing connections

EXERCISE 8

A T-JOINT BETWEEN TWO PICES OF 7/0.85 MM CABLE.



- *Procedure*
- Strip and clean the through piece for a distance of 37mm in the centre.
- Strip off braids and tape (if any) for 15mm at each side.
- Strip and clean one end of the t-piece for 230mm.
- Strip off braids and tape (if any) for a further 15mm.
- Twist strands of through piece and first 6mm of t-piece
- Untwist remainders of t-piece strands and straighten.
- Placing t-piece at right angles to centre of through piece, tightly bind t-piece strands round through piece against the lay of the cable one at a time; four strands round left-hand half of through piece , and three strands round right hand half.
- Cut off surplus strands on the level and smooth over with pliers.
- Soldier joint ends.
- Make a dewing of the joint twice its full size giving actual dimensions.

EXERCISE 9

A married joint between two pieces of 7/0.85mm cable.

- *Procedure:*
- Strip and clean one end of each piece for 230mm.
- Strip off braids and tape (if any) for a further 15mm on each piece.
- Twist strands of each piece for 37 mm from the insulation
- Untwist remainder of strands and straighten
- Cut out centre strands of each conductor.
- Intersperse the strands and butt the twisted portions together.
- Lightly bind the strands on the left-hand side round twisted strands
- Tightly bind the strands on the right-hand side the tightly bind them round twisted strands in the same direction as the left-hand strands.
- Cut off surplus strands on the level and smooth over wit pliers.
- Soldier joint at ends.
- Make a drawing of the joint twice its full size giving actual dimensions.

EXERCISE 10

Soldering a 30 ampere cable socket on piece of 7/1.04mm cable, using a blowlamp

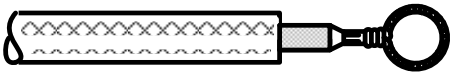
Procedure

- Strip and clean one end of cable for about 25mm
- Strip off braids and tape (if any) for a further 15mm
- Twist strands of conductor to tighten
- Cut conductor to length just sufficient to much bottom of cable socket.
- Roll up rubber insulation for about 15mm.
- Clean inside of cable socket and edge and introduce small quantity of resin and solder. Apply resin to conductor
- Gripping socket firmly in gas pliers hold it in blowlamp flame until soldier is molted.
- Push conductor down into molten solder and hold for a short time taking care not to allow flame too near to cable insulation. Apply further resin as necessary until solder runs up into the strands of conductor.
- Remove termination from blowlamp flame, and allow to coll.
- Unroll rubber insulation back into place.
- Apply cord whipping tightly over the edge of braids and tape starting with a loop through which the end can be threaded and pulled.

- Make a drawing of the cable socket termination twice its full size giving actual dimensions.

EXERCISE 11

Making off a 7-strands cable at a straining point.



Procedure:

- Strip and clean a piece of 7/1.04m cable for about 180mm at one end.
- Bend all 7 strands tightly round a cylindrical object of suitable diameter (eg 20mm conduits) so as to form a loop.
- Unwind one strands up to the end of the loop then tightly bind round the 13 strands for 6mm
- Unwind each of the other strands in turn up to the binding and bind round the remaining strands for 6mm.
- Cut off the surplus portion of each binding strands at a level
- Tightly press the ends of the strands into the binding so that the finish of one strands butts on to the start of the next then smooth over with pliers.
- Solder the whole of the binding using the blowlamp.
- Make a drawing of the made off cable end twice its full size giving actual dimensions.

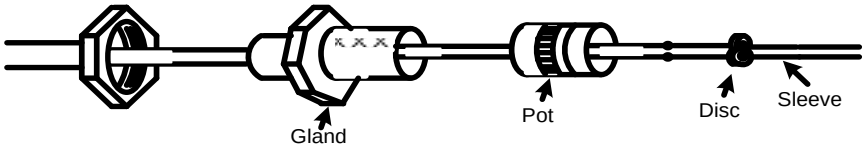
EXERCISE 12

- Soldering a cable socket on a piece of cable, using a metal pot and a ladle.
- Procedure:
- Strip and clean one end of cable for about 37mm.
- Strip off braids and tape (if any) for a further 15mm.
- Twist strands of conductor to tighten.
- Cut conductor to length just sufficient to touch bottom of cable socket.
- Apply protective tape or string for about 20 mm.
- Clean inside of cable socket and edge and introduce small quantity of resign and solder. Apply resin to conductor.
- Gripping socket firmly in gas pliers, hold it over metal containing molten solder and pour solder from ladle heavily into the socket.
- Tin the conductor by inserting in the socket, applying resin as necessary until solder runs up into the strands of conductor when in position.

- Hold termination firmly in position and allow to cool.
- Remove protective tape or string
- Make a drawing of the cable socket termination twice its full size, giving actual dimension.

EXERCISE 15

Terminating a mineral-insulted copper-sheathed cable by means of a screw on pot type seal



Procedure:

- Mark the cable sheath at its terminating position the make a circumferential cut with the ringing tool.
- Start a helical tear in the sheath with either side-cutters or fork-ended stripper and continue in a series of tears holding the tool at about 45 to the cable. Finish with the cutters in line with the cable so as to run out the tear along the cut.
- Remove any burrs in the terminating edge of the sheath, trim back the insulating level with the edge and clean insulation from conductors.
- Pass the pot, internally-threaded are first over the conductors until the thread engages the sheath. Screw on the pot squarely until sheath is level with shoulder of pot.
- Remove any dirt and metal from pot, press in a small quantity of plastic compound then add and compress further compound until pot is filled.
- Select sleeves to suit the conductors pass the through the holes in the sealing cap after anchoring with wedges and thread the assembly over the conductors.
- Use the special tool provided to compress compound and to Crip the rim of the sealing pot. Wipe off surplus compound.
- Test for insulation resistance.
- Make a drawing of a cable termination twice its full size giving actual dimensions.

Conduit installations

A **conduit** is a tube, channel or pipe in which insulated conductors are contained. The conduit, in effect, replaces the PVC outer sheath of a cable, providing mechanical protection for the insulated conductors. A conduit installation can be rewired easily or altered at any time, and this flexibility, coupled with mechanical protection, makes conduit installations popular for commercial and industrial applications. There are three types of conduit used in electrical installation work: steel, PVC and flexible.

i. Steel conduit

Steel conduits are made to a specification and are either heavy gauge welded or solid drawn. Heavy gauge is made from a sheet of steel welded along the seam to form a tube and is used for most electrical installation work. Solid drawn conduit is a seamless tube which is much more expensive and only used for special gas-tight, explosion-proof for flameproof installations. Conduit is supplied in 3.75 m lengths and typical sizes are 16, 20, 25 and
32 mm. Conduit tubing and fittings are supplied in a black enamel finish for internal use or hot galvanized finish for use on external or damp installations.

A wide range of fittings is available and the conduit is fixed using saddles or pipe hooks, as shown in Fig. 48.

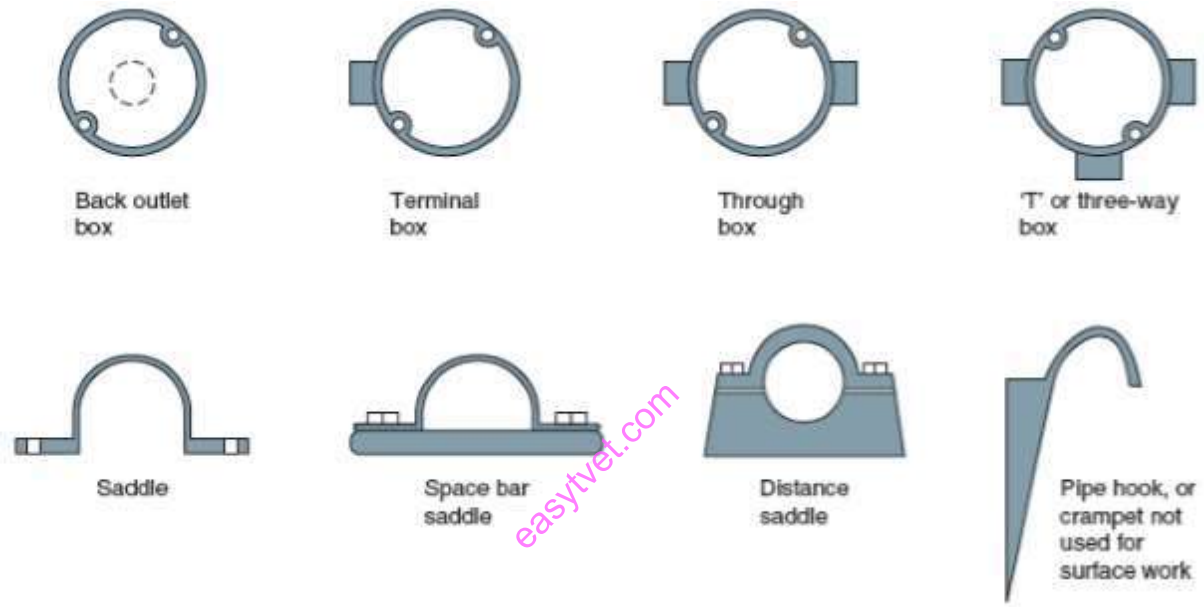


Figure 279 conduit fittings and saddles

Metal conduits are threaded with stocks and dies and bent using special bending machines. The metal conduit is also utilized as the CPC and, therefore, all connections must be screwed up tightly and all burrs removed so that cables will not be damaged as they are drawn into the conduit. Metal conduits containing a.c. circuits must contain phase and neutral conductors in the same conduit to prevent eddy currents flowing, which would result in the metal conduit becoming hot.

ii. P.V.C. Conduit

PVC conduit used on typical electrical installations is heavy gauge standard impact tube. The conduit size and range of fittings are the same as those available for metal conduit. PVC conduit is most often joined by placing the end of the conduit into the appropriate fitting and fixing with a PVC solvent adhesive. PVC conduit can be bent by hand using a bending spring of the same diameter as the inside of the conduit.

The spring is pushed into the conduit to the point of the intended bend and the conduit then bent over the knee. The spring ensures that the conduit keeps its circular shape. In cold weather, a little warmth applied to the point of the intended bend often helps to achieve a more successful bend.

The advantages of a PVC conduit system are that it may be installed much more quickly than steel conduit and is non-corrosive, but it does not have the mechanical strength of steel conduit. Since PVC conduit is an insulator it cannot be used as the CPC and a separate earth conductor must be run to every outlet. It is not suitable for installations subjected to temperatures below 25°C or above 60°C. Where luminaires are suspended from PVC conduit boxes, precautions must be taken to ensure that the lamp does not raise the box temperature or that the mass of the luminaire supported by each box does not exceed the maximum recommended by the manufacturer. PVC conduit also expands much more than metal conduit and so long runs require an expansion coupling to allow for conduit movement and help to prevent distortion during temperature changes.

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All conduit installations must be erected first before any wiring is installed. The radius of all bends in conduit must not cause the cables to suffer damage, and therefore the minimum radius of bends given. All conduits should terminate in a box or fitting and meet the boxes or fittings at right angles. Any unused conduit-box entries should be blanked off and all boxes covered with a box lid, fitting or accessory to provide complete enclosure of the conduit system. Conduit runs should be separate from other services, unless intentionally bonded, to prevent arcing occurring from a faulty circuit within the conduit, which might cause the pipe of another service to become punctured.

When drawing cables into conduit they must first be run off the cable drum. That is, the drum must be rotated as shown in Fig. 49 and not allowed to spiral off, which will cause the cable to twist.

Figure 280 Cable drum

iii. Flexible conduit

Flexible conduit is made of interlinked metal spirals often covered with a PVC sleeving. The tubing must not be relied upon to provide a continuous earth path and, consequently, a separate CPC must be run either inside or outside the flexible tube. *Flexible conduit* is made of interlinked metal spirals often covered with a PVC sleeving.

Flexible conduit is used for the final connection to motors so that the vibrations of the motor are not transmitted throughout the electrical installation and to allow for modifications to be made to the final motor.

Conduit capacities

Single-PVC insulated conductors are usually drawn into the installed conduit to complete the installation. Having decided upon the type, size and number of cables required for a final circuit, it is then necessary to select the appropriate size of conduit to accommodate those cables.

Table 19 conduit factors adapted from IEE regulations

Cable factors for runs incorporating bends and long straight runs

Length of run (m)	Conduit diameter (mm)															
	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32
	Straight				One bend				Two bends				Three bends			
1	Covered by				188	303	543	947	177	286	514	900	158	256	463	818
1.5					182	294	528	923	167	270	487	857	143	233	422	750
2	Tables				177	286	514	900	158	256	463	818	130	213	388	692
2.5					171	278	500	878	150	244	442	783	120	196	358	643
3	A and B				167	270	487	857	143	233	422	750	111	182	333	600
3.5	179	290	521	911	162	263	475	837	136	222	404	720	103	169	311	563
4	177	286	514	900	158	256	463	818	130	213	388	692	97	159	292	529
4.5	174	282	507	889	154	250	452	800	125	204	373	667	91	149	275	500
5	171	278	500	878	150	244	442	783	120	196	358	643	86	141	260	474
6	167	270	487	857	143	233	422	750	111	182	333	600				
7	162	263	475	837	136	222	404	720	103	169	311	563				
8	158	256	463	818	130	213	388	692	97	159	292	529				
9	154	250	452	800	125	204	373	667	91	149	275	500				
10	150	244	442	783	120	196	358	643	86	141	260	474				

Additional factors: For 38 mm diameter use 1.4 × (32 mm factor)
For 50 mm diameter use 2.6 × (32 mm factor)
For 63 mm diameter use 4.2 × (32 mm factor)

Trunking installations

A trunking is an enclosure provided for the protection of cables which is normally square or rectangular in cross-section, having one removable side. Trunking may be thought of as a more accessible conduit system and for industrial and commercial installations it is replacing the larger conduit sizes. A trunking system can have great flexibility when used in conjunction with conduit; the trunking forms the background or framework for the installation, with conduits running from the trunking to the point controlling the current-using apparatus. When an alteration or extension is required it is easy to drill a hole in the side of the trunking and run a conduit to the new point. The new wiring can then be drawn through the new conduit and the existing trunking to the supply point.

Trunking is supplied in 3 m lengths and various cross-sections measured in millimetres from 50 _ 50 up to 300 _ 150. Most trunking is available in either steel or plastic.

i. Metallic trunking

Metallic trunking is formed from mild steel sheet, coated with grey or silver enamel paint for internal use or a hot-dipped galvanized coating where damp conditions might be encountered and made to a specification. A wide range of accessories is available, such as 45° bends, 90° bends, tee and four-way junctions, for speedy on-site assembly. Alternatively, bends may be fabricated in lengths of trunking, as shown in Fig. 55 This may be necessary or more convenient if a bend or set is non-standard, but it does take more time to fabricate bends than merely to bolt on standard accessories.

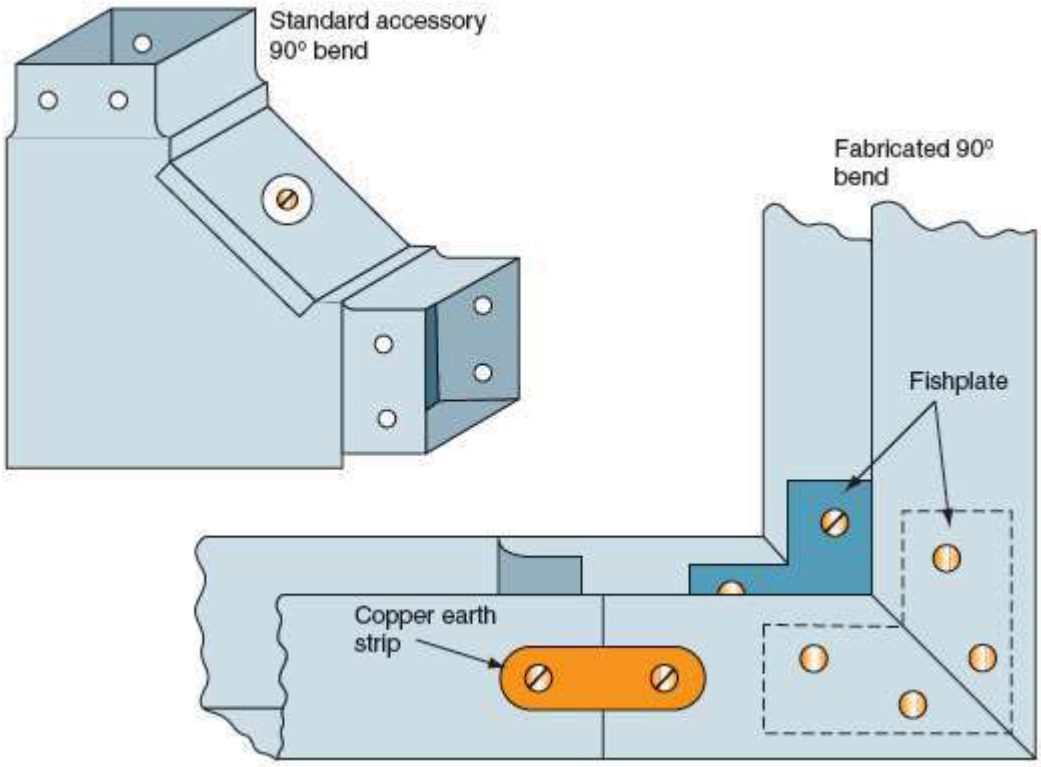


Figure 281 Alternative trunking bends

When fabricating bends the trunking should be supported with wooden blocks for sawing and fi ling, in order to prevent the sheet-steel vibrating or becoming deformed. Fish plates must be made and riveted or bolted to the trunking to form a solid and secure bend. When manufactured bends are used, the continuity of the earth path must be ensured across the joint by making all fixing screw connections very tight, or fitting a separate copper strap between the trunking and the standard bend. If an earth continuity test on the trunking is found to be unsatisfactory, an insulated CPC must be installed inside the trunking. The size of the protective conductor will be determined by the largest cable contained in the trunking, if the circuit conductors are less than 16 mm 2, then a 16 mm 2 CPC will be required.

Non-metallic trunking

Trunking and trunking accessories are also available in high-impact PVC. The accessories are usually secured to the lengths of trunking with a PVC solvent adhesive. PVC trunking, like PVC conduit, is easy to install and is non-corrosive. A separate CPC will need to be installed and non-metallic trunking may require more frequent fixings because it is less rigid than metallic trunking. All trunking fixings should use round-headed screws to prevent damage to cables since the thin sheet construction makes it impossible to countersink screw heads.

Mini-trunking

Mini-trunking is very small PVC trunking, ideal for surface wiring in domestic and commercial installations such as offices. The trunking has a cross-section of 16 _ 16 mm, 25 _ 16 mm, 38 _ 16 mm or 38 _ 25 mm and is ideal for switch drops or for housing auxiliary circuits such as telephone or audio

equipment wiring. The modern square look in switches and sockets is complemented by the mini-trunking which is very easy to install (see Fig. 46).

Skirting trunking

Skirting trunking is a trunking manufactured from PVC or steel and in the shape of a skirting board is frequently used in commercial buildings such as hospitals, laboratories and offices. The trunking is fitted around the walls of a room at either the skirting board level or at the working surface level and contains the wiring for socket outlets and telephone points which are mounted on the lid, as shown in Fig. 56.

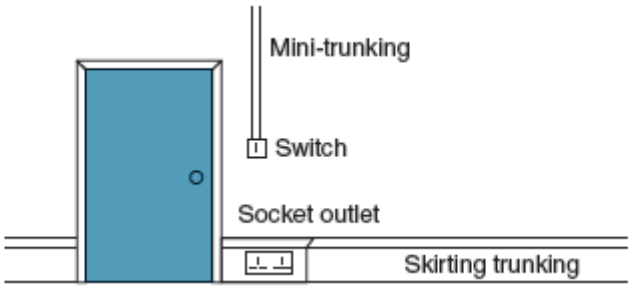


Figure 282 Typical installation of skirting trunking and mini-trunking

Where any trunking passes through walls, partitions, ceilings or floors, short lengths of lid should be fitted so that the remainder of the lid may be removed later without difficulty. Any damage to the structure of the buildings must be made good with mortar, plaster or concrete in order to prevent the spread of fi re. Fire barriers must be fitted inside the trunking every 5 m, or at every floor level or room dividing wall, if this is a shorter distance, as shown in Fig. 57 (a). Where trunking is installed vertically, the installed conductors must be supported so that the maximum unsupported length of non-sheathed cable does not exceed 5 m. Figure 57 (b) shows cables woven through insulated pin supports, which is one method of supporting vertical cables. PVC insulated cables are usually drawn into an erected conduit installation or laid into an erected trunking installation.

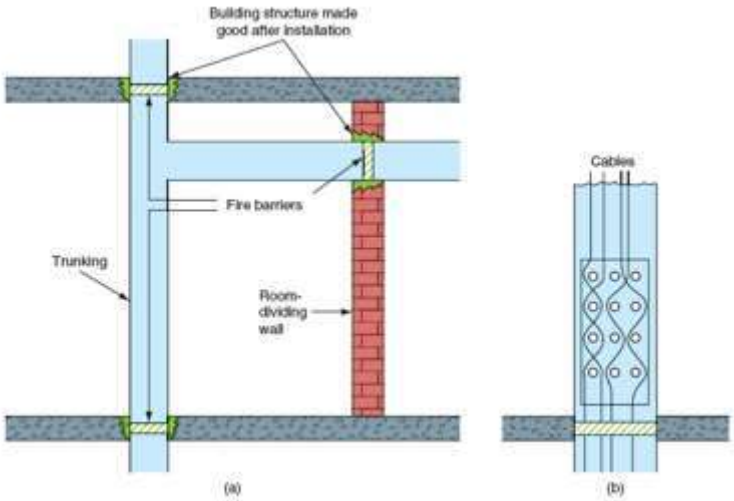


Figure 283 Installation of trunking (a) fire barriers in trunking (b) cable support in vertical trunking

Trunking capacities

The ratio of the space occupied by all the cables in a conduit or trunking to the whole space enclosed by the conduit or trunking is known as the space factor. Where sizes and types of cable and trunking are not covered by the tables in the *On Site Guide* a space factor of 45% must not be exceeded. This means that the cables must not fill more than 45% of the space enclosed by the trunking. The tables take this factor into account.

To calculate the size of trunking required to enclose a number of cables:

- Identify the cable factor for the particular size of conductor, see Table 8.
- Multiply the cable factor by the number of conductors to give the sum of the cable factors.
- Consider the factors for trunking and shown in Table 9.

The correct size of trunking to accommodate the cables is that trunking which has a factor equal to or greater than the sum of the cable factors.

Table 20 Trunking cable factors adapter from the IEE on site guide by kind permission of the Institution of Electrical Engineers

Cable factors for trunking

Type of conductor	Conductor cross-sectional area (mm^2)	PVC BS 6004 Cable factor	Thermosetting BS 7211 Cable factor
Solid	1.5	8.0	8.6
	2.5	11.9	11.9
Stranded	1.5	8.6	9.6
	2.5	12.6	13.9
	4	16.6	18.1
	6	21.2	22.9
	10	35.3	36.3
	16	47.8	50.3
	25	73.9	75.4

Notes: These factors are for metal trunking and may be optimistic for plastic trunking where the cross-sectional area available may be significantly reduced from the nominal by the thickness of the wall material.
The provision of spare space is advisable; however, any circuits added at a later date must take into account grouping. Appendix 4, BS 7671.

Table 21 Trunking cable factor. Adapted from the IEE On site Guide by Kind Permission of institution of Electrical Engineers

Factors for trunking

Dimensions of trunking (mm × mm)	Factor	Dimensions of trunking (mm × mm)	Factor
50 × 38	767	200 × 100	8572
50 × 50	1037	200 × 150	13001
75 × 25	738	200 × 200	17429
75 × 38	1146	225 × 38	3474
75 × 50	1555	225 × 50	4671
75 × 75	2371	225 × 75	7167
100 × 25	993	225 × 100	9662
100 × 38	1542	225 × 150	14652
100 × 50	2091	225 × 200	19643
100 × 75	3189	225 × 225	22138
100 × 100	4252	300 × 38	4648
150 × 38	2999	300 × 50	6251
150 × 50	3091	300 × 75	9590
150 × 75	4743	300 × 100	12929
150 × 100	6394	300 × 150	19607
150 × 150	9697	300 × 200	26285
200 × 38	3082	300 × 225	29624
200 × 50	4145	300 × 300	39428
200 × 75	6359		

Space factor – 45% with trunking thickness taken into account.

Cable tray installations

Cable tray is a sheet-steel channel with multiple holes. The most common finish is hot-dipped galvanized but PVC-coated tray is also available. It is used extensively on large industrial and commercial installations for supporting MI and SWA cables which are laid on the cable tray and secured with cable ties through the tray holes. Cable tray should be adequately supported during installation by brackets which are appropriate for the particular installation. The tray should be bolted to the brackets with round-headed bolts and nuts, with the round head inside the tray so that cables drawn along the tray are not damaged. Cable tray should be adequately supported during installation by brackets which are appropriate for the particular installation. The tray should be bolted to the brackets with round-headed bolts and nuts, with the round head inside the tray so that cables drawn along the tray are not damaged.

The tray is supplied in standard widths from 50 to 900 mm, and a wide range of bends, tees and reducers is available. Figure 58 shows associated cable tray installations. The tray can also be bent using a cable tray bending machine to create bends. The installed tray should be securely bolted with round-headed bolts where lengths or accessories are attached, so that there is a continuous earth path which may be bonded to an electrical earth. The whole tray should provide a firm support for the cables and therefore the tray fixings must be capable of supporting the weight of both the tray and cables.

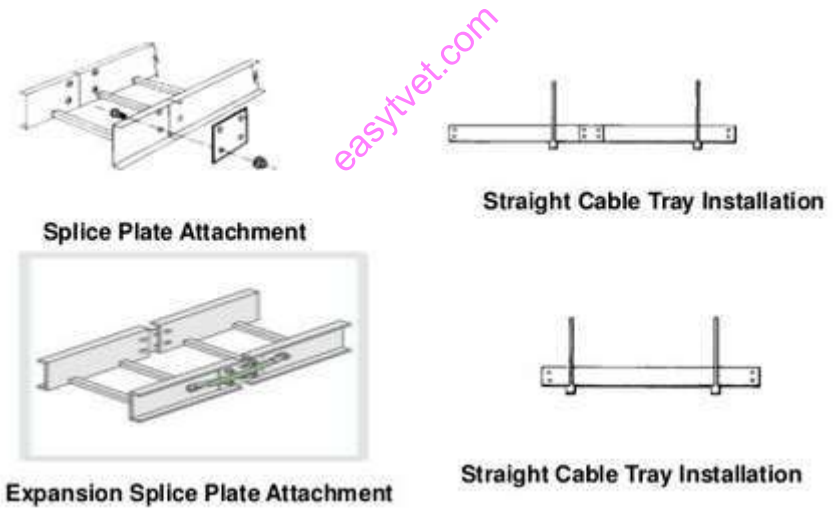


Figure 284 Cable tray installations

Cable ducts

This is another method of concealing electrical and other services used mainly in large industrial type buildings. The services routes are marked out on plans so that during construction mainly of floor, ducts are precast so that at a later date the services may be installed. The cables which are normally of larger sizes and mainly PILCSWA type are supported by cable cleats fixed either to sides or bottom of the duct. Suitable covers are then placed over the duct so that it hides and protects the services and makes them easily accessible to installers and maintenance staff. Figure 59 shows an image of duct.

Figure 285 Cable ducts

Installation of final circuits

Definition

A final sub-circuit is an outgoing circuit connected to a distribution board and intended to supply electrical energy to current-using apparatus, either directly or through socket outlets or fused spur-boxes. Examples of final sub-circuits includes; lighting, socket-outlets, cooker and water heater. A final sub-circuit originates from the consumer control unit (CCU) or distribution board (DB). Each final sub-circuit is protected by an appropriate fuse or circuit breaker mounted in the consumer control unit.

IEE Regulations

i) Where an installation comprises more than one final sub-circuit, each shall be connected to a separate way in a distribution board.

ii) The wiring of each final sub-circuit shall be electrically separate from that of every other final sub-circuit.to facilitate disconnection of each final sub-circuit for testing.

iii) Every final sub circuit shall have means of protection against excess current

iv) The neutral conductor shall never be connected in the same order as that in which the live conductors are connected to the fuses or circuit breakers.

v) The neutral conductor shall never be connected to fuses, switches or circuit breakers.

Terms and Definitions

Circuit- an electric circuit is an arrangement of electrical conductors and associated devices for the purpose of carrying electricity.

Live conductor- It is that conductor which carry current towards the appliance from the source.

Live- means that under working condition a difference in voltage exists between the conductor and earth.

Neutral conductor- The conductor which carries current from the appliances to the source.

Earth- This is the conductive mass of the earth whose electric potential at any point is electrically taken to be zero.

Earth conductor- The conductor that has the same potential with the earth.

Phase conductor-A conductor of an AC system for the transmission of electrical energy other than a neutral.

Potential- The level of electric pressure.

Dead- At or about earth potential zero and disconnected from any live system.

Fuse- A device for opening a circuit by means of a fuse element designed to melt when excess current flows.

Insulation- suitable non-conducting material enclosing or surrounding or supporting a conductor.

Switch- A mechanical device for making and breaking non automatically a circuit carrying current.

Need For Switching

i. Used to put a circuit in use or out of use.
ii. Emergency switching.
iii. Isolating a circuit from the supply for maintenance.

Types of switches

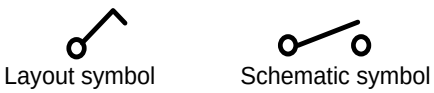
1. Single pole switch
2. Double pole switch
3. Triple pole switch.

I.E.E regulation on switches

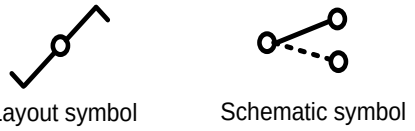
i) All single pole switches should always be connected in the live (phase) conductor only.
ii) Fuses shall also be inserted in the live only.

TYPES OF SINGLE POLE SWITCHES

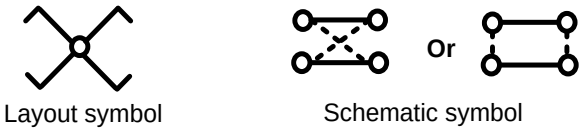
1. One-way switch - This has one path only for current.



2. Two-way switch - This has two alternative paths for current (change over switch).



3. Intermediate switch – This has two double alternative current paths.



SWITCHING OF LIGHTING POINTS

One-way switching.

In the one-way switching, the lamp or set of lamps is switched from one particular point. An example is the switching at the entry of a room with one entry only. The figure 60 shows one-way switch. The ON and OFF control of the lighting point is only at one position.

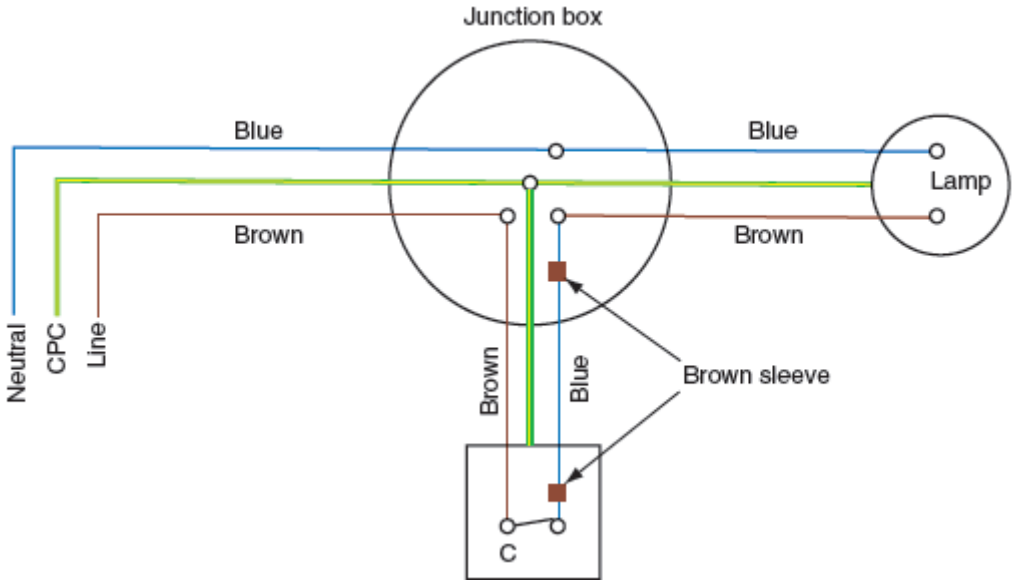


Figure 286 one-way switch

Two – Way Switching

Where it becomes necessary to have the lamp or set of lamps switched from two separate positions. An example is a long corridor or in a room with two entries. Figure 61 shows a to-way switch. The ON and OFF control of the lighting point is from two positions.

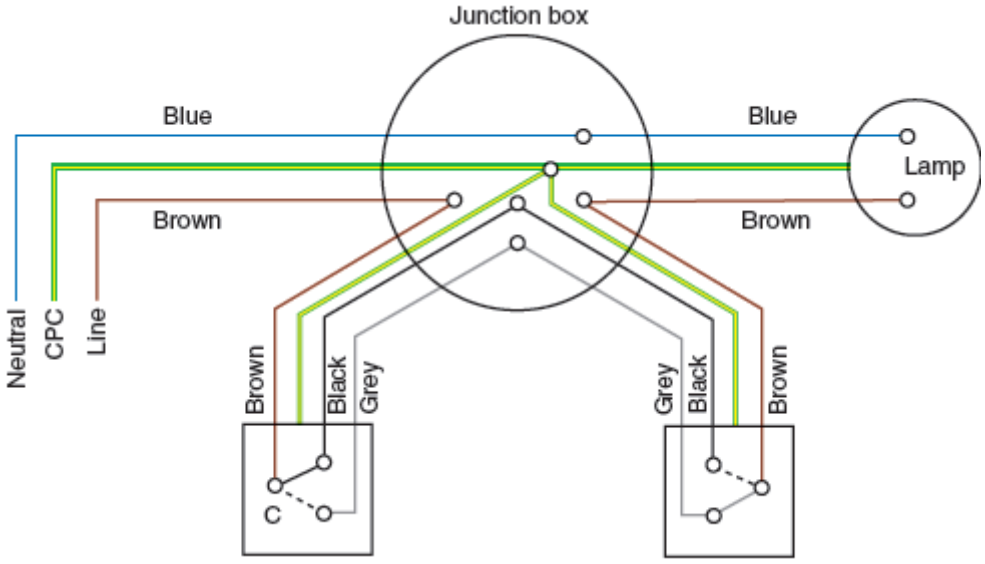


Figure 287 Two-way switches

Intermediate switching

This is used in conjunction with the *Two-way* switching where the switching of the lamps is from more than two points. All the other points of switching between the two two-way switches will be fitted with intermediate switches. An example of lamp controlled from THREE positions is shown in figure 62

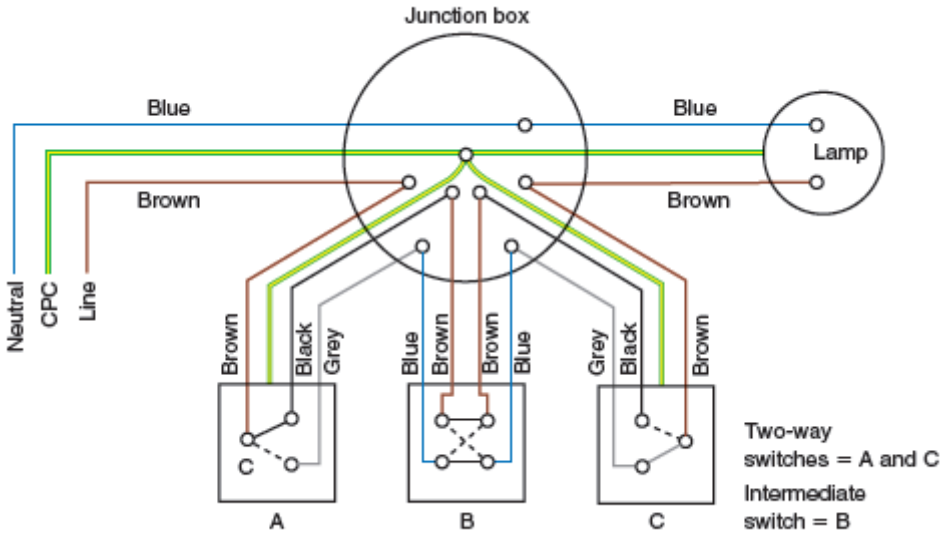


Figure 288 Intermediate switch control

Note

A lamp or set of lamps may be controlled from any number of positions provided we have 2 two-way switches and the rest of the switches been intermediate

Types of circuit connections

1. Series connection
2. Parallel connection

Series Connection

The current using equipment are connected in series or one after the other. One end of the equipment is connected to the other end *(End to End)* in series connection, the current flowing is the same and the voltage a cross each equipment will depend on the rating and its resistance

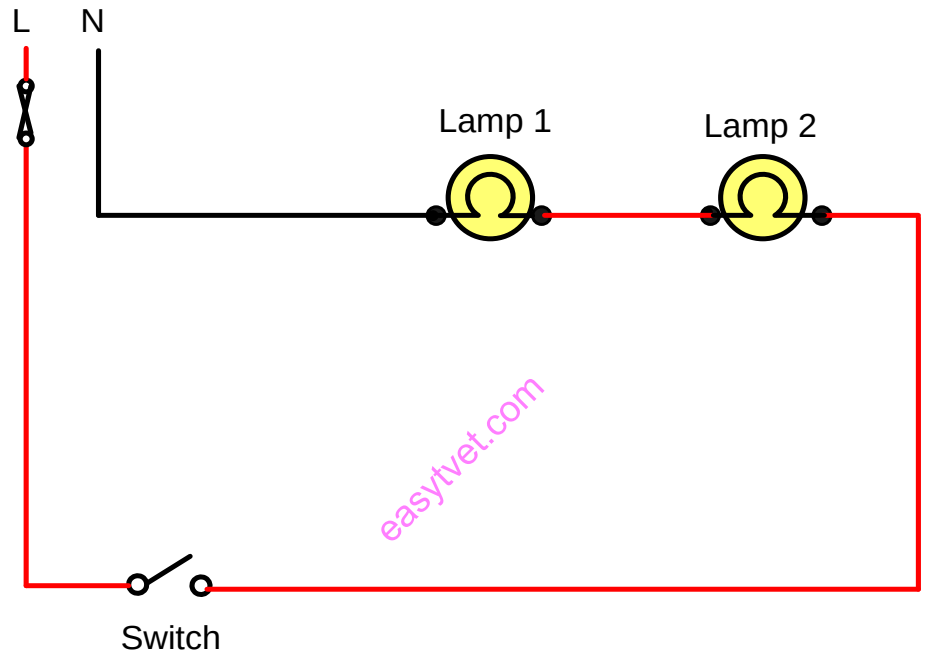


Figure 289 Series connection

The supply voltage is dropped individually across each lamp and depending on the ratings the voltage across each equipment will vary but the current flowing through all the equipment is the same. That is, if two lamps of equal resistance are connected in series to a $240\ V$ supply, the voltage which will appear across each lamp will be $120\ V$ and the current will be the same in all lamps

N.B

The lamps in above example may not produce light or be dim because the light produced is equal to:

$$Power = V^2/R$$

And, V is below rated voltage

For a series connection to work, all lamps have to be good working condition in order to provide continuity of the circuit.

Disadvantages of series connection

1. If one lamp blows, all lamps go off.

2. Lamps will be dim (will not produce enough light) or may fail to light
3. Not reliable- Therefore for practical purposes series circuits are not used

Parallel connection

This is the most common arrangement for lighting circuits.

All lamps are connected across the supply and each lamp receives the supply voltage a cross it.

Each lamp can be controlled separately. If one lamp blows out, all the other will continue working.

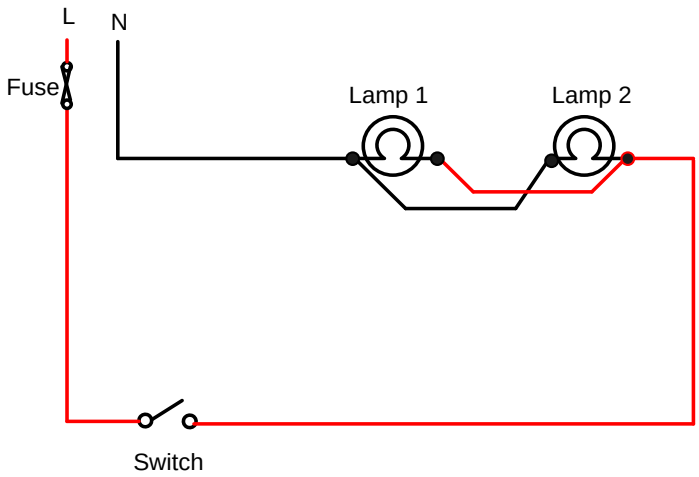


Figure 290 Parallel connection

Note:

If separately controlled, all switches are to be connected in the live conductor and that No wire goes directly to the lamp by –passing the switch.

Advantages of parallel

i) All lamps receive rated voltage
ii) All lamps are bright
iii) If one lamp fails, other will not be affected
iv) Lamps can be controlled individually (separately)

Looping-In System

Looping-in of wires helps in saving materials and provides a clean piece of work. Looping – in can be done at:

i) Switches
ii) Lamp Holders
iii) Junction Boxes
iv) Ceiling Roses

If more than one lamp is to be switched from the same switch, it becomes cheaper to loop-in at the lamp holder for the second lamp. Figure 65 shows the theoretical diagram of a final sub-circuit of seven lamps, two controlled separately by 1-way switches, three controlled as a group by a 1-way switch, and

two controlled by a 1-way switch. If the circuit were to be wired exactly as in the diagram, a large number of joints would be necessary. Figure 66 shows the same circuit as wired by the looping-in system. No joints are required except dry twisted joints in the terminals of the two-plate ceiling roses and of the single-pole one-way switches.

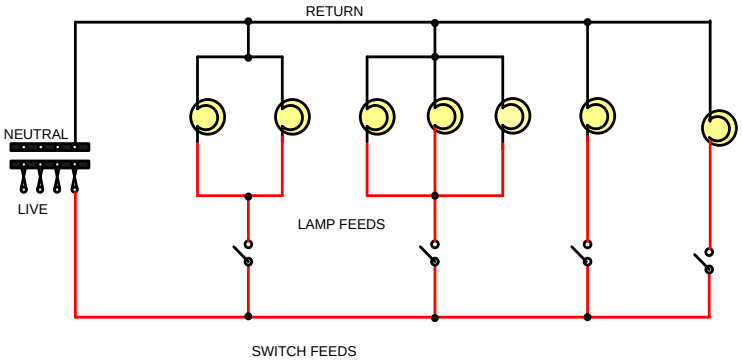


Figure 291 Lighting final circuit

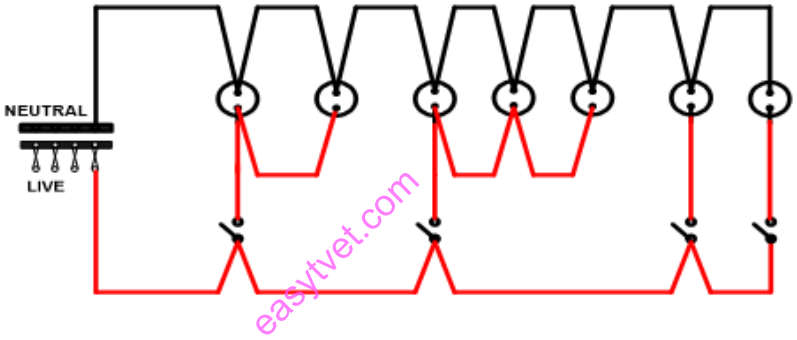


Figure 292 Looping-in method of wiring

Looping in from a switch.

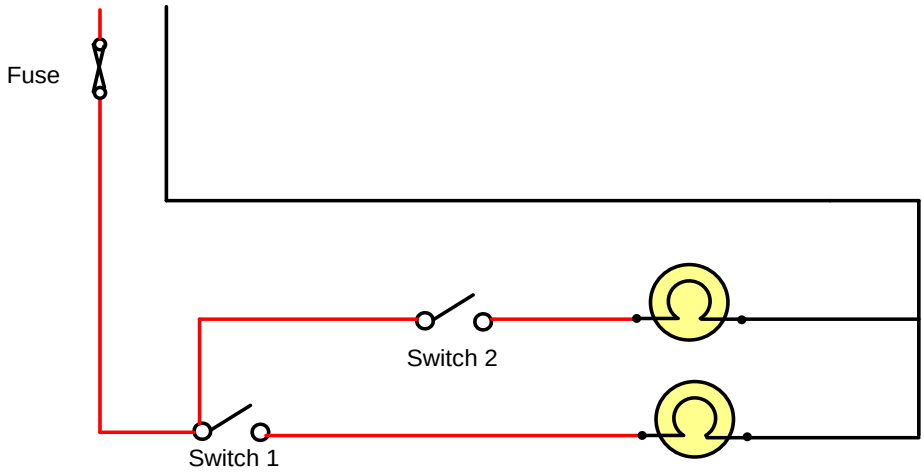


Figure 293 Looping-in from a switch

In this system the Live to switch S_2 is normally looped from S_1.

Looping-in from a three-plate ceiling rose

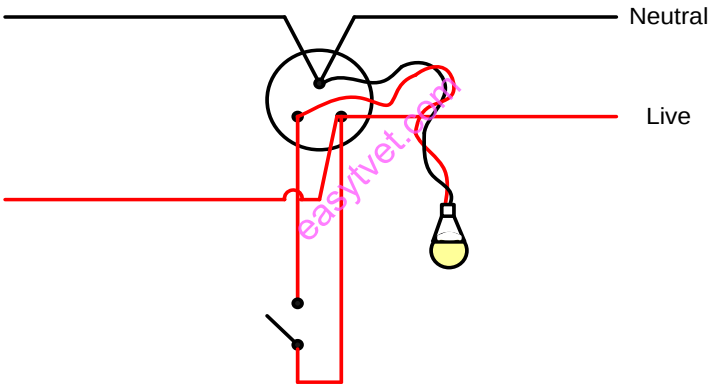


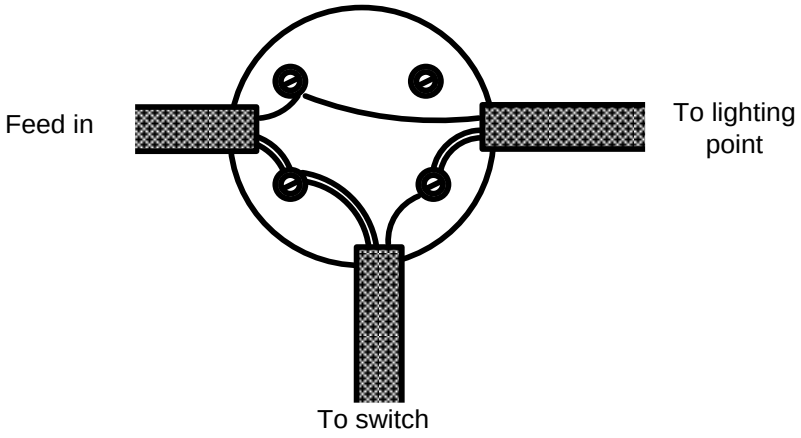
Figure 294 Looping -in from a three-plate ceiling rose

A ceiling rose must not be connected in such a manner that one that one terminal remains alive when the associated switch is OFF, unless that terminal cannot be touched when the ceiling rose is partially dismantled to allow flexible cord replacement.

Looping-in At Junction Boxes

In this method, all the circuit wires are brought to a common Box and distributed to the switches, ceiling roses, lamp holder's etc.

This method of lopping in is only used where there are few lamps and more so where there is service wiring using twin core cables.



COLOUR IDENTIFICATION OF CABLES

Single phase

Live - Red

Neutral- Black

Earth - Green or green /yellow

Three Phase

L_1 - Red - phase

L_2 - yellow - phase

L_3 - blue - phase

Neutral- black

Size of cables and rating of protective devices

Cables are manufactured in different sizes and compositions and each is designed to carry a maximum amount of current.

The current a cable can carry are given in the I.E.E Regulation tables of current ratings.

For lighting circuits, the cable commonly used is the $1mm^2$ *or* $1.5\ mm^2$ which is rated 18A depending on the type of cable.

The most common cable used is single core and Twin flat and Twin with earth. Most lighting circuits will be rated at either 5A or 10A because most switches are rated 5A or 10A.

The table gives 10 I.E.E Regulations protective ratings of different types of lamps.

Table 22 IEE regulations showing the protective ratings for different types of lamps

Type of Holder	Maximum Rating of fuse or Circuit Breaker.
Small Bayonet type	5A
Small Edison –type screw	5A
Bayonet type	15A
Bi- pin type	15A

I.E.E Regulations on switches

1. Every switch or Circuit Breaker the purpose of which is not obvious shall be labelled to indicate the apparatus it controls.
2. All single pole switches shall be always connected to the live conductor.
3. Every switch or other electric control shall be placed so as to be out of reach of a person in contact with bath, shower unit etc.
4. In a two-wire installation connected to a supply having neither pole connected with the earth, switch or circuit breaker shall be of double pole linked type and the fuses shall be installed in both poles.
5. In a two-wire installation connected to a supply having one pole earthed, switches shall be connected in the live conductor only.

POWER CIRCUITS

Final power sub-circuits

A final power sub-circuit is a circuit that allows electrical appliances to access electrical power.

All final sub-circuits must be electrically separate that is there must be no "bunching" of neutral conductors. All neutral conductors must be connected at the distribution board in the same order as the line conductors.

Socket Outlet

Definition.

A socket outlet is a device provided with female contacts which is intended to be fitted with the fixed wiring and intended to receive a plug.

A device with protected current carrying contacts intended to be mounted in a fixed position and permanently connected to a fixed wiring of an installation to enable the connection to it of a flexible cord or flexible cable by means of a plug.

Or

Is an accessory with 3 terminals marked *L*- live, *N*- Neutral and *E* – Earth fitted with the fixed wiring ready to receive a plug.

Plug

Definition

A device intended for connection to a fixed cord or flexible cable which can be engaged manually with a socket outlet and which has current carrying contact pins which may be exposed when not engaged.

Socket outlet will be wired such that the terminal marked *L* will receive the live wire, the terminal marked *N* will receive the Neutral and the one marked *E* will receive the earth wire. Socket outlets must be installed in a place to wait for a plug but not the vice-versa. The figure 69 shows a diagram of a plug.

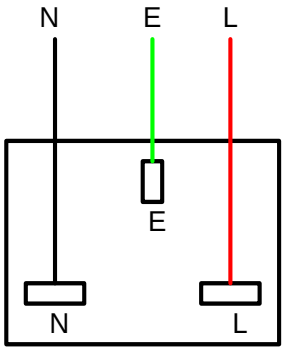


Figure 295 Plug

Note;

Sometimes the earth terminal is marked with the Earth symbol

There are two ways in which socket outlets may be wired

1. Radial circuit
2. Ring circuit

Radial Circuit

A radial circuit is a circuit in which the live, neutral and earth conductor start from the distribution board to sockets connected in series and terminate at the last socket.

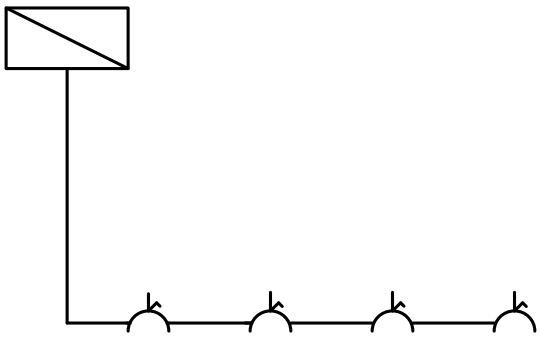


Figure 296 Layout diagram of a radial circuit

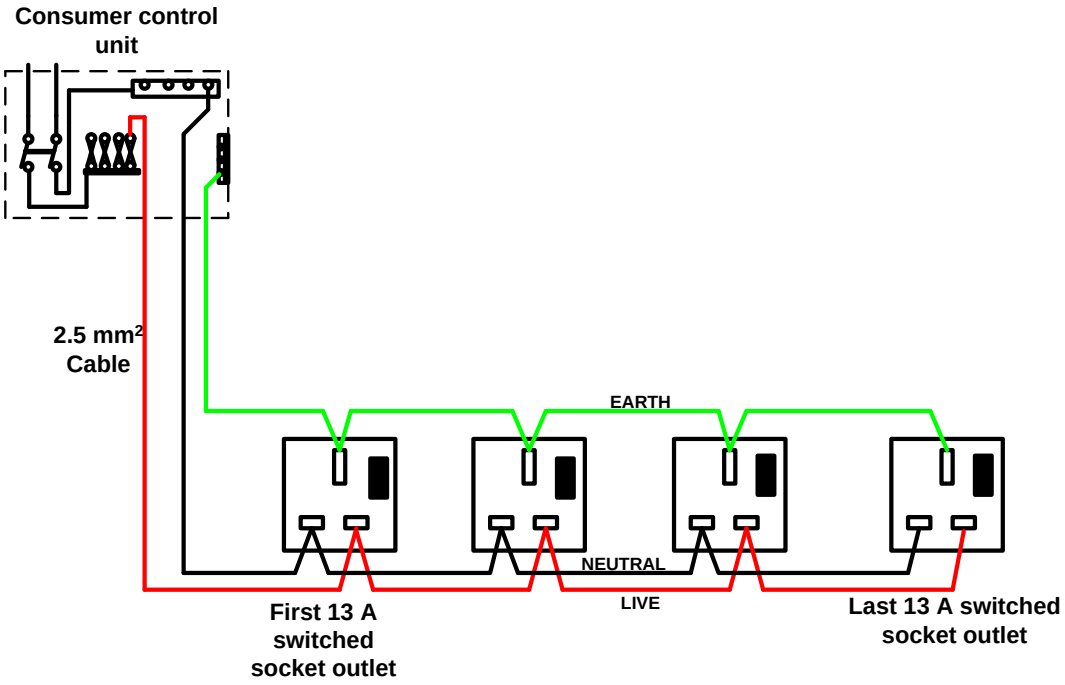


Figure 297 wiring diagram for radial circuit

Ring Circuits

A ring circuit is defined in the I.E.E. Regulations as “a final sub-circuit in which the current-carrying and the earth-continuity conductors are connected in the form of a loop, both ends of which are connected to a single way in a distribution board or its equivalent.

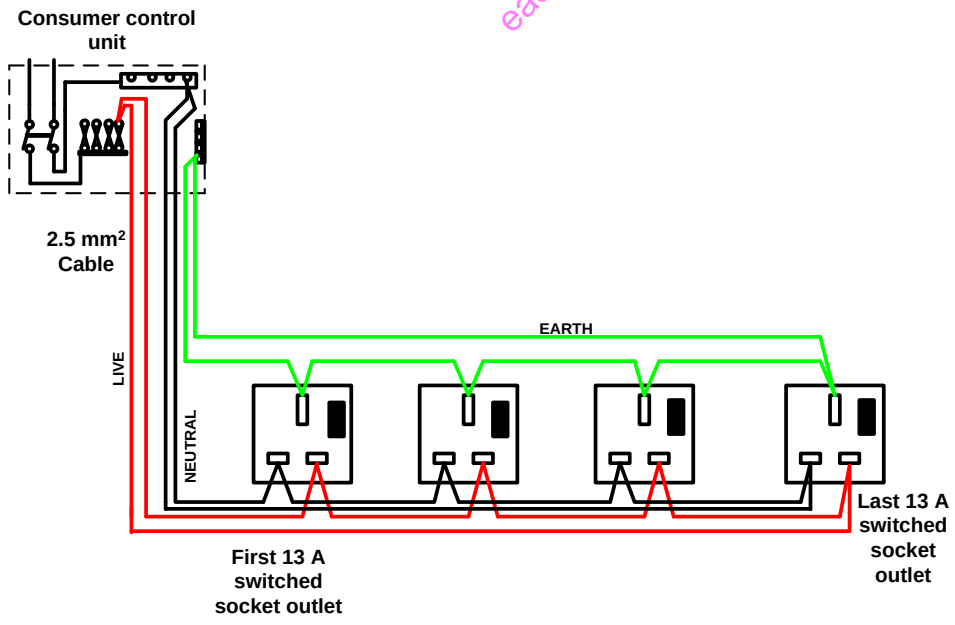


Figure 298 wiring diagram for a ring circuit.

Spur

A spur is a socket that branches off a ring circuit. The number of spurs fed from a ring circuit must not exceed the number of sockets in the ring. The cables connecting the spur must be of the same size as that of the ring circuit. The minimum cable size for ring and radial circuit is 2.5mm^2.

Advantages of a ring circuit over a Radial circuit

1. There is total safety in ring circuit than in Radial for the circuit is in form of a ring
2. An open circuit point in the Ring circuit will not affect any other socket in the system
   This is because there are two paths of current and is one path is open the current will flow through the other
3. Smaller sizes of cables may be used in Ring than in a Radial. This is because the Ring has two parallel current paths
4. More loads may be fed or connected to a Ring circuit than a Radial circuit of the same capacity

Disadvantages of Ring over Radial

1. More cables lengths require in a Ring than in Radial therefore becomes more expensive
2. It consumes more time to install a Ring circuit than Radial because more cables have to be installed.

I.E.E Regulations on Ring and Radial circuit

1. A Ring circuit it may serve an unlimited number of points but shall not serve an area of more than $100m^2$
2. For a Ring final sub-circuit, the total number of spurs shall not exceed the total number of socket outlets and stationary appliances connected directly in the ring circuit.
3. Where two or more ring final sub circuit are installed, the socket outlet to be served shall reasonably be distributed among the separate ring circuit
4. For a Radial or Ring final sub circuit the Rating of the fuse or circuit breaker at the circuit breaker shall not exceed 30A
5. Each circuit conductor of a ring final sub circuit shall be run in the form of a Ring commencing and returning to the same way in the circuit breaker.
6. Except where Ring is run throughout in metallic conduct, Ducts or Trunking, Earth continuity conductor shall run in form of a ring originating and returning to same point in the circuit breaker.
7. For a Radial circuit the current rating of the circuit conductors shall not be less than Rating of the fuse or circuit breaker protecting the final sub- circuit

Water heating circuits

A small, single-point over-sink type water heater may be considered as a permanently connected appliance and so may be connected to a ring circuit through a fused connection unit. A water heater of

the immersion type is usually rated at a maximum of 3 kW, and could be considered as a permanently connected appliance, fed from a fused connection unit.

However, many immersion heating systems are connected into storage vessels of about 150 litres in domestic installations, and the *On-Site Guide* states that immersion heaters fitted to vessels in excess of 15 litres should be supplied by their own circuit. Therefore, immersion heaters must be wired on a separate radial circuit when they are connected to water vessels which hold more than 15 litres. Figure 73 shows the wiring arrangements for an immersion heater.

Every switch must be a double-pole (DP) switch and out of reach of anyone using a fixed bath or shower when the immersion heater is fitted to a vessel in a bathroom. Supplementary equipotential bonding to pipework *will only be required* as an addition to fault protection if the immersion heater vessel is in a bathroom that *does not have:*

a. all circuits protected by a 30 mA RCD
b. Protective equipotential bonding,

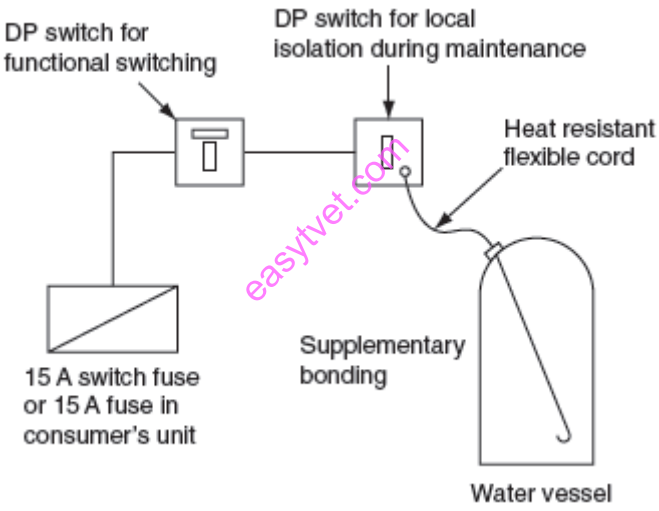


Figure 299 Immersion water wiring

Cooker circuit

A cooker with a rating above 3 kW must be supplied on its own circuit but since it is unlikely that in normal use every heating element will be switched on at the same time, a diversity factor may be applied in calculating the cable size, as detailed in the *On Site Guide*.

Consider, as an example, a cooker with the following elements fed from a cooker control unit incorporating a 13 A socket:

$$4 \times 2 \text{ kW fast boiling rings} = 8000 \text{ W}$$
$$1 \times 2 \text{ kW grill} = 2000 \text{ W}$$
$$1 \times 2 \text{ kW oven} = 2000 \text{ W}$$
$$\text{Total loading} = 12\,000 \text{ W}$$

When connected to 230 V

$$\text{Current rating} = \frac{12\,000}{230} = 52.17 \text{ A}$$

Applying the diversity factor of Table 1A

$$\text{Total current rating} = 52.17 \text{ A}$$
$$\text{First 10 amperes} = 10 \text{ A}$$
$$30\% \text{ of } 42.17\text{A} = 12.65 \text{ A}$$
$$\text{Socket outlet} = 5 \text{ A}$$
$$\text{Assessed current demand} = 10 + 12.65 + 5 = 27.65 \text{ A}$$

Therefore, a cable capable of carrying 27.65 A may be used safely.

A cooking appliance must be controlled by a switch separate from the cooker but in a readily accessible position. Where two cooking appliances are installed in one room, such as split-level cookers, one switch may be used to control both appliances provided that neither appliance is more than 2 m from the switch.

Conductor size calculations

The size of a cable to be used for an installation depends upon:

- the current rating of the cable under defined installation conditions and
- the maximum permitted drop in voltage

The factors which influence the current rating are:

1. *Design current:* cable must carry the full load current.
2. *Type of cable*: PVC, MICC, copper conductors or Aluminium conductors.
3. *Installed conditions:* clipped to a surface or installed with other cables in a trunking.
4. *Surrounding temperature*: cable resistance increases as temperature increases and insulation may melt if the temperature is too high.
5. *Type of protection*: for how long will the cable have to carry a fault current?

Regulation states that the drop in voltage from the supply terminals to the fixed current-using equipment must not exceed 3% for lighting circuits and 5% for other uses of the mains voltage. That is a maximum of 6.9 V for lighting and 11.5 V for other uses on a 230 V installation.

Fire alarm circuits

Through one or more of the various statutory Acts, all public buildings are required to provide an effective means of giving a warning of fire so that life and property may be protected. An effective system is one which gives a warning of fire while sufficient time remains for the fire to be put out and any occupants to leave the building.

Fire alarm circuits are wired as either normally open or normally closed. In a normally open circuit, the alarm call points are connected in parallel with each other so that when any alarm point is initiated the circuit is completed and the sounder gives a warning of fire. The arrangement is shown in Fig.74. It is essential for some parts of the wiring system to continue operating even when attacked by fi re. For this reason, the master control and sounders should be wired in MI or FP200 cable. The alarm call points of a normally open system must also be wired in MI or FP200 cable, unless a monitored system is used. In its simplest form this system requires a high-value resistor to be connected across the call-point contacts, which permits a small current to circulate and operate an indicator, declaring the circuit healthy. With a monitored system, PVC insulated cables may be used to wire the alarm call points.

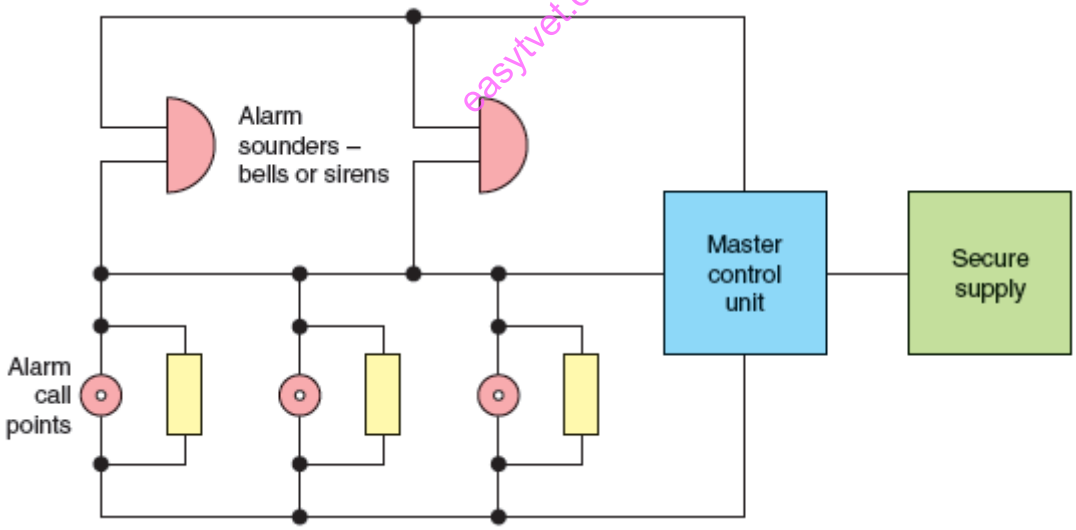


Figure 300 A simple normally open fire alarm

In a normally closed circuit, the alarm call points are connected in series to normally closed contacts as shown in Fig. 75. When the alarm is initiated, or if a break occurs in the wiring, the alarm is activated. The sounders and master control unit must be wired in MI or FP200 cable, but the call points may be wired in PVC insulated cable since this circuit will always ‘fail safe’

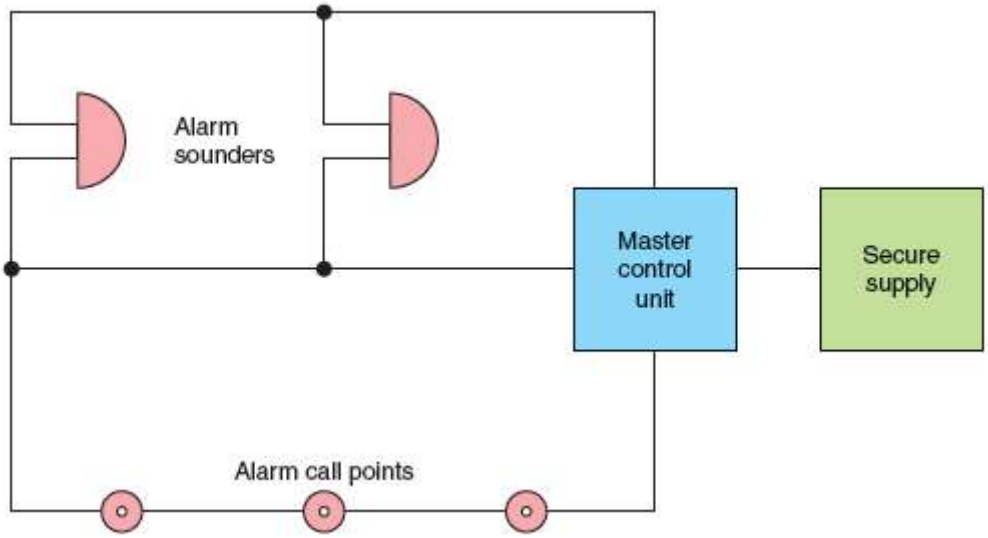


Figure 301 A simple normally closed fire alarm circuit

Alarm call points

Manually operated alarm call points should be provided in all parts of a building where people may be present, and should be located so that no one need walk for more than 30 m from any position within the premises in order to give an alarm. A breakglass manual call point is shown in Fig. 76. They should be located on exit routes and, in particular, on the floor landings of staircases and exits to the street. They should be fixed at a height of 1.4 m above the floor at easily accessible, well illuminated and conspicuous positions.

Figure 302 Break glass manual call point

Sounders

The positions and numbers of sounders should be such that the alarm can be distinctly heard above the background noise in every part of the premises. The sounders should produce a minimum of 65 dB, or 5 dB above any ambient sound which might persist, for more than 30 s. If the sounders are to arouse sleeping persons then the minimum sound level should be increased to 75 dB at the bedhead. Bells, hooters or sirens may be used but in any one installation they must all be of the same type. Examples of sounders are shown in Fig. 77. Normal speech is about 5 dB.

Figure 303 Typical fire alarm sounders

Bell and bell circuits

The electric bell converts the magnetic effect of an electric current into sound it therefore enables audible warnings or signals to be transmitted as current over long distances by running of electric conductor cables figure 78 shows a single stroke bell. For most bell circuits, the use of lower voltages is employed which necessitates the installation of a bell transformer. Bells can be operated from manually-operated push-buttons or automatic switching from alarm devices such as door or window devices for burglar-alarm systems or detection devices for fire outbreaks.

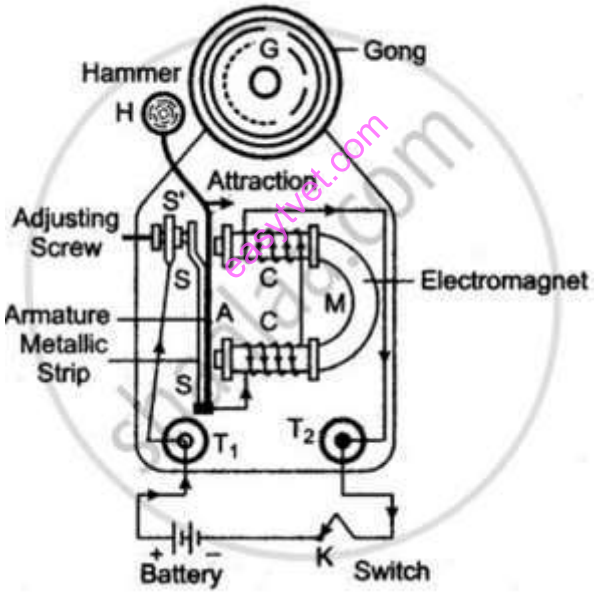


Figure 304 Single stroke bell/trembler bell

Direct on Line (DOL)

A DOL starter connects the three main lines (L1, L2 and L3) directly to the motor terminals when the start button is pressed. The drawing of a DOL starter is generally done in two separate stages. These are called the Power Circuit and the Control Circuit. Power Circuit the power circuit shows all the components or parts of components required to handle the load current of the motor. Remember that the motor in question may be a small 1.5 kW (2 HP) or a large 225 kW (300 HP). As the motor power rating increases so too must the current rating of the contactor, overload relay and supply cables. The control circuit shows all the components or parts of components required to control the motor. These components are basically the same regardless of the power rating of the motor in question. Note that when wiring circuits, the supply should be fed in on the low number terminal and out on the high number terminal. The figure 79 shows a complete schematic diagram of Direct On line (DOL) starter

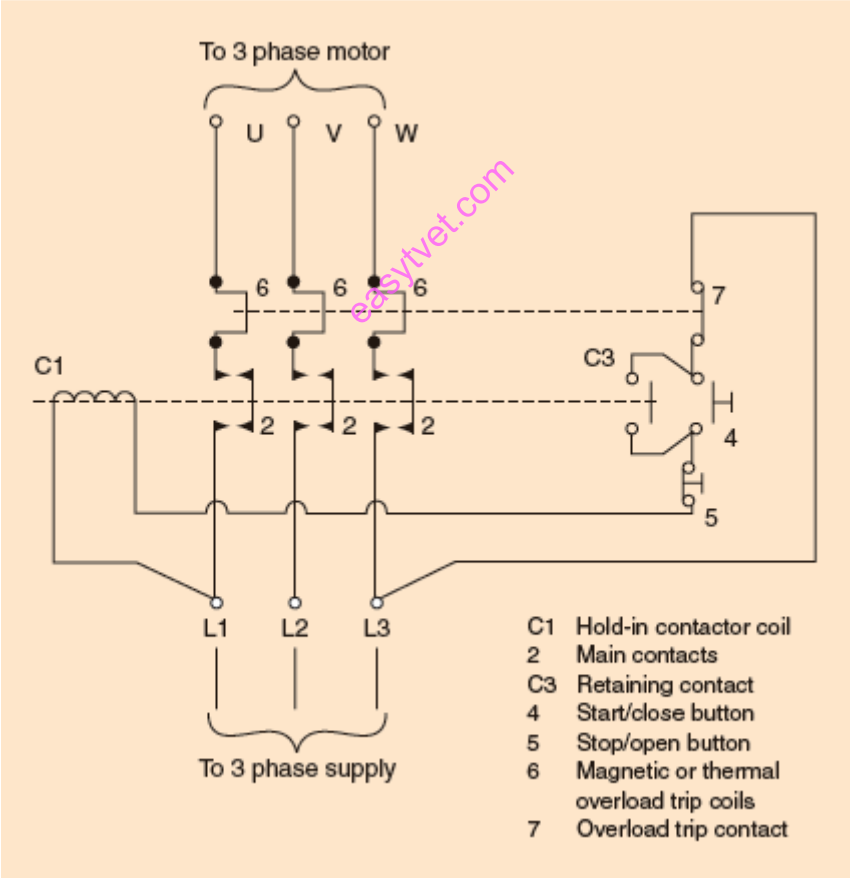


Figure 305 Direct On Line starter

Star Delta Starter

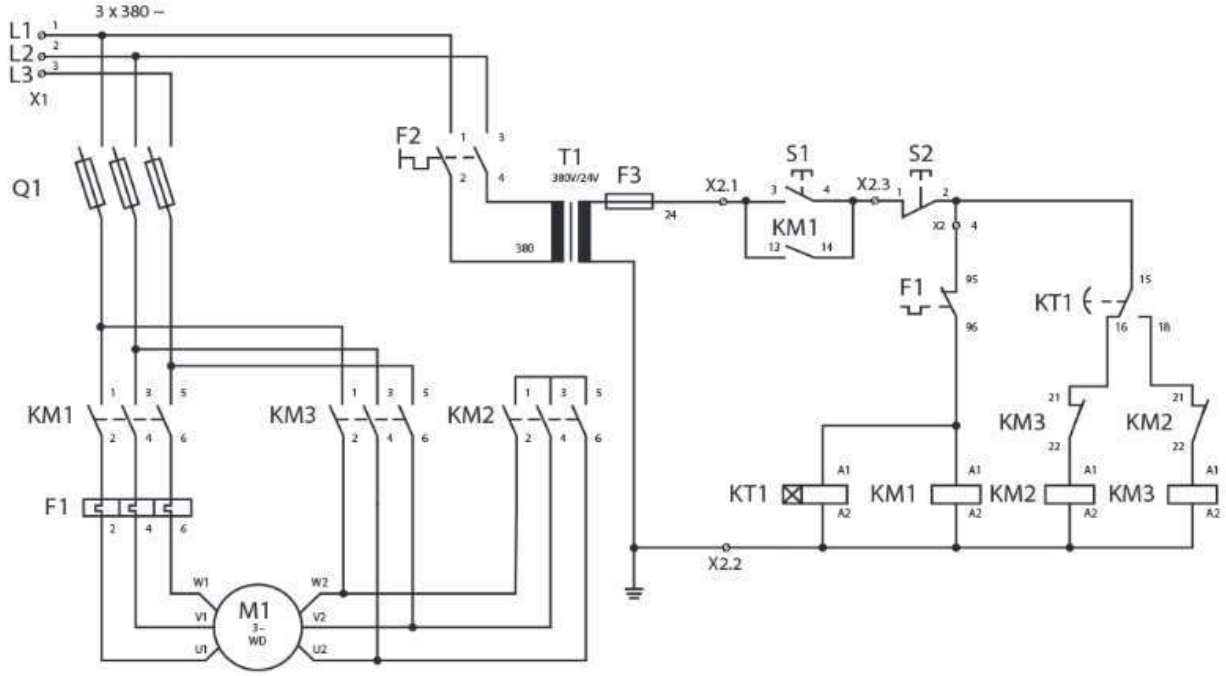


Figure 306 Schematic diagram for star delta starter

Compared to the other types of starters, the star delta starter is used on a large scale. As the name suggests, the three windings are connected in a star connection in the star delta starters. A certain time is set by the timer or any other controller circuit. After this time is passed, the windings are then connected in the delta connection. The phase voltage in the star connection is reduced to 58%, and the total current drawn is 58% of normal current. This results in a reduced torque. The figure 75 shows a schematic diagram for star delta starter. The Advantages of Using Star Delta Motor Starters:

- They are ideal for long acceleration times.
- They have a lower input surge current when compared to other starters.
- They have a simpler construction as compared to other starters

6.2.4.4 Learning Activities

Industrial attachment/workshop practice/project

Practical activities	knowledge	Special instructions
5. Apply appropriate installation procedures and technical standards while carrying out electrical installations	• Single phase systems • Wiring systems and accessories • Electrical installations final circuits	

6. Implement electrical installations as per the working drawing	7. Single phase systems 8. Wiring systems and accessories Electrical installations final circuits	
9. Adhere to IEE regulations during installation	IEE regulations	
10. Adhere to safety procedures for each activity	Electrical safety procedures	
11. Install cables, conductors, conduits, enclosures and support systems to specifications.	Cables, conduits, enclosures and support systems	
12. Label installation for identification	Cable labelling for identification	

6.2.4.5 Self-Assessment

1. What are the precautions necessary to observe when installing sheathed wiring systems
2. (a). What two advantages do plastic conduit have over metallic conduit.
   (b). what two advantages do metallic conduit have over non- metallic conduit.
3. Mechanical protection of cables in an electrical installation defines the type of wiring system. What factors are to be considered when determining the choice of a wiring system?
4. What are the types of PVC conduits?
5. Conduit installation must meet the IEE regulation; what any two IEE regulation do you think must be observed when installing steel conduits.

6.2.4.6 Tools, Equipment, Supplies and Materials
Recommended Resources

Tools and equipment	**Materials and supplies**
➢ Cable Strippers ➢ Pliers ➢ Screw drivers ➢ Hammers ➢ Chisels ➢ Allen keys ➢ Electrician knives ➢ Crimping tools ➢ Bending springs ➢ Bending machine ➢ Steel tapes ➢ Draw wires ➢ Hack saws ➢ Drilling tools ➢ Stock and die ➢ Bench vice ➢ Machine vice ➢ PPE – hand gloves, dust coats, dust masks, helmets, ear muffs, industrial boots	• Stationery • Cables • Light fittings • Accessories • Conduits and fittings • Cable trays • Cable ducts • Trunkings • Computers • Drawing instruments • Screws
Reference materials • IEE regulations • Occupational safety and health act (OSHA) • Work injury benefits act (WIBA) • Manufacturers' catalogues • British standards • KEBS standards	

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6.2.4.8 Model answers to self-assessment

1. What are the precautions necessary to observe when installing sheathed wiring systems
   i. When concealed in walls, they should further be protected by a channel or tube
   ii. When run under floors, they should be at a depth sufficient to prevent damage from floor fixings
   iii. At termination, sheath should enter the terminal housing enclosure
2. (a). What two advantages do plastic conduit have over metallic conduit.
   i. **cheap**
   ii. **non corrosive**
   iii. **easy to install**
   iv. **provides total insulation to cables**

   (b). what two advantages do metallic conduit have over non- metallic conduit.
   i. **Provides better protection against mechanical damage.**
   ii. **Provides earth return path**
   iii. **Durability if properly installed**
   iv. **Low fire risk**
   v. **Can be easily extended**
3. Mechanical protection of cables in an electrical installation defines the type of wiring system. What factors are to be considered when determining the choice of a wiring system?

i. **Type of the building**

ii. **Durability**

iii. **Cost**

iv. **Flexibility**

v. **Time taken**

4. What are the types of PVC conduits?

   i. **Heavy gauge conduit**

   ii. **Light gauge conduit**

5. Conduit installation must meet the IEE regulation; what any two IEE regulation do you think must be observed when installing steel conduits.

   i. **Steel conduits must always be earthed.**

   ii. **Conduits must always be installed before drawing in the cables.**

   iii. **Radius of the bend should not exceed 2½ from the diameter of the conduit.**

   iv. **Space factor of cable in conduit should not exceed 40% or 0.04.**

6.2.5 Learning Outcome 5 Facilitate other service providers

6.2.5.1 Introduction to the learning outcome

To facilitate other service providers, it is important to identify other service providers on site, apply communication protocols and procedures, communicate to other providers during and after the installation as necessary, obtain and agree upon the requirements of other service providers and make provision for other services according to the design.

6.2.5.2 Performance Standard

6.2.5.2.1 Identify other service providers on site.

6.2.5.2.2 Apply communication protocols and procedures.

6.2.5.2.3 Communicate to other providers during and after the installation as necessary.

6.2.5.2.4 Obtain and agree upon the requirements of other service providers

6.2.5.2.5 Make provision for other services according to the design.

6.2.5.3 Information Sheet

Communication

When you work in the construction industry you are a member of a team involving many different job roles on site. For a project to run smoothly, there must be effective communication so that everybody does what is required, at the right time, in the right way and with the right materials.

Communications is about transferring information from one person to another both quickly and accurately. We do this by talking to other people, looking at drawings and plans and discussing these with colleagues from the same company and with other professionals who have an interest in the same project. The technical information used within our industry comes from many sources. The IEE Regulations is the 'electrician's bible' and forms the basis of all our electrical design calculations and installation methods. British Standards, European Harmonized Standards and Codes of Practice provide detailed information for every sector of the electrotechnical industry, influencing all design and build considerations. The communication can generally be between:

a) Employers and supervisors

Many building companies are quite big and you may never actually see or meet the main boss of the company. Communication passes down through the organization to the tradespeople via managers and supervisors.

Larger construction sites may have a project manager who is responsible for the overall running of the project. There will also be a building supervisor or foreperson who liaises with the project manager and directs the daily activities. Alternatively, you may work for a contractor and most of the information and instructions you are given will come directly from your boss.

b) Contractors

Many of the tradespeople you interact with will be contractors; that is, they run their own business and provide their services to the building company. Contractors have to communicate effectively with each other, as they are often working in the same area at the same time. For example, the plumber and the electrician may both be working on the same section of the site, and the bricklayer may need one or both of them to have finished their part of the job before s/he starts. If you're working for or with a contractor, you'll need to be able to share information and negotiate coordination and scheduling issues throughout a construction project.

c) Co-workers

Most of your workplace communication is likely to be with members of your team and other co-workers. Together, you'll be organizing and completing tasks, giving and receiving instructions, helping each other and solving problems.

d) Others

On construction projects there are lots of other people involved at various stages. You may need to communicate with the following people as part of your work responsibilities:

- designers and architects
- safety officers
- union representatives
- clients
- delivery drivers
- Suppliers
- office staff

Types of communication

Communication can be grouped into four main types – verbal, non-verbal, written and Visual

a) Verbal communication

Verbal communication is probably the most used form of communication. It relies on sharing spoken words that the communicator and the receiver both understand.

b) Non-verbal communication

Non-verbal communication is when you communicate with others without using words.

Body language – gestures, facial expressions, posture – can tell other people a lot about what you really mean that might not be communicated by the actual words you use.

Have a look at the body language of the three people below. Which one do you think really does feel happy? What do the other two really think?

Non-verbal communication is often sent unintentionally; that is, you don't deliberately send it as part of your message, but it is still received by the other person. However, sometimes we deliberately use non-verbal communication to create or reinforce a particular meaning in our messages. For example, if you ask, 'What are you doing?' in an angry tone of voice, you're probably expressing displeasure rather than curiosity.

c) Written communication

Written communication means using the written word to send information. This could be on paper, a screen, a billboard or even a T-shirt.

There are many different types of written communication used regularly in the construction industry and some examples are listed in the following table. Each type is more suited to some situations, audiences or purposes than others.

d) Visual communication

Visual communication covers all types of communication we see rather than read or hear. It is usually pictorial, although there could be a few words present as well, such as on a sign or poster. Workers in the construction industry use a lot of visual communication, for example, plans and diagrams, safety signs, warning lights and hand signals.

e) Formal and informal communication

The way we speak to different people depends on who they are, how well we know them and the situation we are in. We don't use the same words and tone of voice to speak to a teacher or boss as we do when we're chatting to our mates.

We are likely to speak quite formally to people in authority like teachers or police officers but we can be far more relaxed and spontaneous with family and friends. In the workplace we usually use formal communication with our employers and supervisors, and informal communication with our workmates. Formal and informal communication can also relate to the way we write. An email to a workmate would probably be quite casual but a job application would definitely be written more formally

Sources of technical information

Equipment and accessories available to use in a specific situation can often be found in the very comprehensive manufacturer's catalogues and the catalogues of the major wholesalers that service the electrotechnical industries.

All of this technical information may be distributed and retrieved by using:

- conventional drawings and diagrams which we will look at in more detail below

- sketch drawing to illustrate an idea or the shape of say a bracket to hold a piece of electrical equipment
- the Internet can be used to download British Standards and Codes of Practice
- The Internet can also be used to download health and safety information from the health and safety.
- CDs, DVDs, USB memory sticks and email can be used to communicate and store information electronically
- The facsimile (Fax) machine can be used to communicate with other busy professionals, information say about a project you are working on together.

If you are working at your company office with access to online computers, then technical information is only a fingertip or mouse click away. However, a construction site is a hostile environment for a laptop and so a hard copy of any data is preferable on site.

6.2.5.4 Learning Activities

Practical activities	**Knowledge**
3. Identify other service providers on site.	Other service providers in the construction site.
4. Apply communication protocols and procedures.	Communication
5. Communicate to other providers during and after the installation as necessary	Communication
6. Obtain and agree upon the requirements of other service providers	communication
7. Make provision for other services according to the design.	Design

6.2.5.5 Self-Assessment

1. What are the five ways in which you can make your communication efforts as effective as possible?
2. Communication can be grouped into four main types. What are these groups?
3. What method would you use to let the office know that the materials you were expecting have not yet arrived?
4. In what ways can technical information be retrieved?
5. What are the advantages of written communication?

6.2.5.6 Tools, Equipment, Supplies and Materials
Recommended Resources

Tools and equipment	**Materials and supplies**
➢ Cable Strippers ➢ Pliers ➢ Screw drivers ➢ Hammers ➢ Chisels ➢ Allen keys ➢ Electrician knives ➢ Crimping tools ➢ Bending springs ➢ Bending machine ➢ Steel tapes ➢ Draw wires ➢ Hack saws ➢ Drilling tools ➢ Stock and die ➢ Bench vice ➢ Machine vice ➢ PPE – hand gloves, dust coats, dust masks, helmets, ear muffs, industrial boots	• Stationery • Cables • Light fittings • Accessories • Conduits and fittings • Cable trays • Cable ducts • Trunkings • Computers • Drawing instruments • Screws
Reference materials • IEE regulations • Occupational safety and health act (OSHA) • Work injury benefits act (WIBA) • Manufacturers' catalogues • British standards • KEBS standards	

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6.2.5.8 Model answers to self-assessment

1. What are the five ways in which you can make your communication efforts as effective as possible?

- **Being a keen listener: Effective communication depends on listening skills since it would allow both parties to understand each other.**
- **Paying attention to non-verbal communication: Communication is often accompanied by non-verbal cues. Every party in a conversation has to identify and understand the non-verbal cues and how to use them to ensure that the information delivered is accurate.**
- **Making a keen choice of language use: The choice of words hugely impacts the information being delivered during communication and the overall perception of the recipient on the information.**
- **Efficiently expressing oneself: During a communication, an individual has to share their thoughts and feelings on the topic at hand as honestly as possible, while still acknowledging other people's opinions.**

- **Control of emotions: During a conversation, one must prevent emotions from running the conversation**

2. Communication can be grouped into four main types. What are these groups?

    - **Verbal**
    - **non-verbal**
    - **written**
    - **Visual**

3. What method would you use to let the office know that the materials you were expecting have not yet arrived?

    - **Email**
    - **Telephone call**

4. In what ways can technical information be retrieved?

    - **conventional drawings and diagrams which we will look at in more detail below**
    - **sketch drawing to illustrate an idea or the shape of say a bracket to hold a piece of electrical equipment**
    - **the Internet can be used to download British Standards and Codes of Practice**
    - **The Internet can also be used to download health and safety information from the health and safety.**
    - **CDs, DVDs, USB memory sticks and email can be used to communicate and store information electronically**
    - **The facsimile (Fax) machine can be used to communicate with other b**usy **professionals, information say about a project you are working on together.**

5. What are the advantages of written communication?

    - **It is suitable for long distance communication and repetitive standing orders.**
    - **It creates permanent record of evidence.**
    - **It gives the receiver sufficient time to think, act and react.**
    - **It can be used as legal document.**
    - **It can be sent to many persons at a time**

6.2.6 Learning Outcome 6

6.2.6.1 Introduction to the learning outcome

To maintain housekeeping, prepare safety checklist for electrical equipment and machines, carry out regular follow up according to the prepared checklist, and follow up workplace procedures to deal with any accidents and damage of equipment occurring during the cleaning process and record and report activities as per the established procedures.

6.2.6.2 Performance Standard

6.2.6.2.1 Prepare safety checklist for electrical equipment and machines

6.2.6.2.2 Carry out regular follow up according to the prepared checklist

6.2.6.2.3 Follow up workplace procedures to deal with any accidents and damage of equipment occurring during the cleaning process

6.2.6.2.4 Record and report activities as per the established procedures.

6.2.6.3 Information Sheet

Housekeeping

Electrical workshops must be kept clean and dry. If spills or leaks occur, they must be cleaned up promptly to avoid the risk of electrocution. Additionally, walking and working surfaces should be as free from debris as possible to minimize slips, trips and falls. Slipping, tripping and falling into electrical equipment in a workshop can cause severe injuries. The elements of an effective housekeeping program are:

a) Maintenance

The maintenance of buildings and equipment may be the most important element of good housekeeping. Maintenance involves keeping buildings, equipment and machinery in safe, efficient working order and in good repair. It includes maintaining sanitary facilities and regularly painting and cleaning walls. Broken windows, damaged doors, defective plumbing and broken floor surfaces can make a workplace look neglected; these conditions can cause incidents and affect work practices. So it is important to replace or fix broken or damaged items as quickly as possible. A good maintenance program provides for the inspection, maintenance, upkeep and repair of tools, equipment, machines and processes.

b) Dust and dirt removal

Enclosures and exhaust ventilation systems may fail to collect dust, dirt and chips adequately. Vacuum cleaners are suitable for removing light dust and dirt that is not otherwise hazardous. Industrial models have special fittings for cleaning walls, ceilings, ledges, machinery, and other hard-to-reach places where dust and dirt may accumulate.

Special-purpose vacuums are useful for removing hazardous products. For example, vacuum cleaners fitted with HEPA (high efficiency particulate air) filters may be used to capture fine particles of asbestos or fibreglass.

Dampening (wetting) floors or using sweeping compounds before sweeping reduces the amount of airborne dust. The dust and grime that collect in places like shelves, piping, conduits, light fixtures, reflectors, windows, cupboards and lockers may require manual cleaning.

Compressed air should not be used for removing dust, dirt or chips from equipment or work surfaces.

c) Employee facilities

Employee facilities need to be adequate, clean and well maintained. Lockers may be necessary for storing employees' personal belongings. Washroom facilities require cleaning once or more each shift. They also need to have a good supply of soap, towels plus disinfectants, if needed.

If workers are using hazardous products, employee facilities should provide special precautions as needed such as showers, washing facilities and change rooms. Some facilities may require two locker rooms with showers between. Using such double locker rooms allows workers to shower off workplace contaminants and reduces the chance of contaminating their "street clothes" by keeping their work clothes separated from the clothing that they wear home.

Smoking, eating or drinking in the work area should be prohibited where hazardous products are handled. The eating area should be separate from the work area and should be cleaned properly each shift.

d) Surfaces

Floors: Poor floor conditions are a leading cause of incidents so cleaning up spilled oil and other liquids at once is important. Allowing chips, shavings and dust to accumulate can also cause incidents. Trapping chips, shavings and dust before they reach the floor or cleaning them up regularly can prevent their accumulation. Areas that cannot be cleaned continuously, such as entrance ways, should have anti-slip flooring. Keeping floors in good order also means replacing any worn, ripped, or damaged flooring that poses a tripping hazard.

Walls: Light-coloured walls reflect light while dirty or dark-coloured walls absorb light. Contrasting colours warn of physical hazards and mark obstructions such as pillars. Paint can highlight railings, guards and other safety equipment, but should never be used as a substitute for guarding. The program should outline the regulations and standards for colours.

e) Maintain Light Fixtures

Dirty light fixtures reduce essential light levels. Clean light fixtures can improve lighting efficiency significantly.

f) Aisles and Stairways

Aisles should be wide enough to accommodate people and vehicles comfortably and safely. Aisle space allows for the movement of people, products and materials. Warning signs and mirrors can improve sight-lines in blind corners. Arranging aisles properly encourages people to use them so that they do not take shortcuts through hazardous areas.

Keeping aisles and stairways clear is important. They should not be used for temporary "overflow" or "bottleneck" storage. Stairways and aisles also require adequate lighting.

g) Spill Control

The best way to control spills is to stop them before they happen. Regularly cleaning and maintaining machines and equipment is one way. Another is to use drip pans and guards where possible spills might occur. When spills do occur, it is important to clean them up immediately. Absorbent materials are useful for wiping up greasy, oily or other liquid spills. Used absorbents must be disposed of properly and safely.

h) Tools and Equipment

Tool housekeeping is very important, whether in the tool room, on the rack, in the yard, or on the bench. Tools require suitable fixtures with marked locations to provide an orderly arrangement. Returning tools promptly after use reduces the chance of it being misplaced or lost. Workers should regularly inspect, clean and repair all tools and take any damaged or worn tools out of service.

i) Waste Disposal

The regular collection, grading and sorting of scrap contribute to good housekeeping practices. It also makes it possible to separate materials that can be recycled from those going to waste disposal facilities. Allowing material to build up on the floor wastes time and energy since additional time is required for cleaning it up. Placing scrap containers near where the waste is produced encourages orderly waste disposal and makes collection easier. All waste receptacles should be clearly labelled (e.g., recyclable glass, plastic, scrap metal, etc.).

j) Storage

Good organization of stored materials is essential for overcoming material storage problems whether on a temporary or permanent basis. There will also be fewer strain injuries if the amount of handling is reduced, especially if less manual material handling is required. The location of the stockpiles should not interfere with work but they should still be readily available when required. Stored materials should allow at least one metre (or about three feet) of clear space under sprinkler heads.

Stacking cartons and drums on a firm foundation and cross tying them, where necessary, reduces the chance of their movement. Stored materials should not obstruct aisles, stairs, exits, fire equipment, emergency eyewash fountains, emergency showers, or first aid stations. All storage areas should be clearly marked.

Flammable, combustible, toxic and other hazardous materials should be stored in approved containers in designated areas that are appropriate for the different hazards that they pose. Storage of materials should meet all requirements specified in the fire codes and the regulations of environmental and occupational health and safety agencies in your jurisdiction.

Use the following checklist as a general workplace guide.

Floors and Other Areas

- Are floors clean and clear of waste?
- Are signs posted to warn of wet floors?
- Are floors in good condition?
- Are there holes, worn or loose planks or carpet sticking up?
- Is anti-slip flooring used where spills, moisture or grease are likely?
- Are there protruding objects such as nails, sharp corners, open cabinet drawers, trailing electrical wires?
- Are personal items, such as clothing and lunch boxes, in assigned lockers or storage areas?
- Is the work area congested?
- Are floors well-drained?

Aisles and Stairways

- Are aisles unobstructed and clearly marked?
- Are mirrors installed at blind corners?
- Are aisles wide enough to accommodate workers and equipment comfortably?
- Are safe loading practices used with hand and power trucks, skids, or pallets?
- Is the workplace lighting adequate? Are stairs well lit?
- Are stairs covered with an anti-slip tread? Are faulty stair treads repaired?

Spill Control

- Are all spills wiped up quickly?
- Are procedures followed as indicated on the material safety data sheet?
- Are spill absorbents used for greasy, oily, flammable or toxic materials?
- Are used rags and absorbents disposed of promptly and safely?
- Is a spill area surrounded by a barrier to prevent a spill from spreading?

Equipment and Machinery Maintenance

- Is equipment in good working order, with all necessary guards or safety features operational or in place?
- Is equipment damaged or outdated?
- Are tools and machinery inspected regularly for wear or leaks?

- Is equipment repaired promptly?
- Are drip pans or absorbent materials used if leaks cannot be stopped at the source?
- Is a machine that splashes oil fitted with a screen or splash guard?
- Are machines and tools cleaned regularly?

Waste Disposal

- Are there adequate number of containers?
- Are there separate and approved containers for toxic and flammable waste?
- Are waste containers located where the waste is produced?
- Are waste containers emptied regularly?
- Are toxic and flammable waste chemicals handled properly?

Storage

- Are storage areas safe and accessible?
- Is material stacked securely, blocked or interlocked if possible?
- Are materials stored in areas that do not obstruct stairs, fire escapes, exits or firefighting equipment?
- Are materials stored in areas that do not interfere with workers or the flow of materials?
- Are bins or racks provided where material cannot be piled?
- Are all storage areas clearly marked?
- Do workers understand material storage and handling procedures?

Fire Prevention

- Are combustible and flammable materials present only in the quantities needed for the job at hand?
- Are combustible and flammable materials kept in safety cans during use?
- Are hazardous materials stored in approved containers and away from ignition sources?
- Are sprinkler heads clear of stored material?
- Are fire extinguishers inspected and located along commonly travelled routes, and close to possible ignition sources?

Are oily or greasy rags placed in metal containers and disposed of regularly?

6.2.6.4 Learning Activities

Industrial attachment/workshop Practice

Practical activities	knowledge	Special instruction

5. Prepare safety checklist for electrical equipment and machines	Safety and electrical tools, materials and equipment	
6. Carry out regular follow up according to the prepared checklist		
7. Follow-up workplace procedures to deal with any accidents and damage of equipment occurring during the cleaning process		
8. Record and report activities as per the established procedures.		

6.2.6.5 Self-Assessment

1. What does the team housekeeping mean?
2. What are some benefits of good housekeeping practices?
3. What are the elements of an effective housekeeping program?
4. What would you include in your checklist to ensure waste are disposed appropriately?

6.2.6.6 Tools, Equipment, Supplies and Material

Recommended Resources

Tools and equipment	**Materials and supplies**
➢ Cable Strippers ➢ Pliers ➢ Screw drivers ➢ Hammers ➢ Chisels ➢ Allen keys ➢ Electrician knives ➢ Crimping tools ➢ Bending springs ➢ Bending machine ➢ Steel tapes	• Stationery • Cables • Light fittings • Accessories • Conduits and fittings • Cable trays • Cable ducts • Trunkings • Computers • Drawing instruments

➢ Draw wires ➢ Hack saws ➢ Drilling tools ➢ Stock and die ➢ Bench vice ➢ Machine vice ➢ PPE – hand gloves, dust coats, dust masks, helmets, ear muffs, industrial boots	• Screws
Reference materials • IEE regulations • Occupational safety and health act (OSHA) • Work injury benefits act (WIBA) • Manufacturers' catalogues • British standards • KEBS standards	

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6.2.6.8 Model answers to self-assessment

1. What does the team housekeeping mean?

   Housekeeping is not just cleanliness. It includes keeping work areas neat and orderly, maintaining halls and floors free of slip and trip hazards, and removing of waste materials (e.g., paper, cardboard) and other fire hazards from work areas. Good housekeeping is also a basic part of incident and fire prevention.

2. What are some benefits of good housekeeping practices?

   - reduced handling to ease the flow of materials
   - fewer tripping and slipping incidents in clutter-free and spill-free work areas
   - decreased fire hazards
   - lower worker exposures to hazardous products (e.g. dusts, vapours)
   - better control of tools and materials, including inventory and supplies
   - more efficient equipment cleanup and maintenance
   - better hygienic conditions leading to improved health
   - more effective use of space
   - reduced property damage by improving preventive maintenance
   - less janitorial work
   - improved morale
   - improved productivity (tools and materials will be easy to find)

3. What are the elements of an effective housekeeping program?

   - Dust and dirt removal
   - Maintenance
   - Surfaces
   - Light fixtures
   - Aisles or stairways
   - Spill control
   - Tools and equipment
   - Waste disposal storage

4. What would you include in your checklist to ensure waste are disposed appropriately?

   - Availability of adequate number of containers
   - separate and approved containers for toxic and flammable waste
   - waste containers location

- emptying of the waste containers
- proper handling of toxic and flammable waste chemicals