CHAPTER ONE: PVC SHEATHED CABLING, CONDUITING, TRUNKING AND CABLE TRAYS LAYING

Unit Code ENG/LG/EI/CR/01/3/A

Relationship to Occupational Standards

This unit addresses the Unit of Competency: Perform PVC sheathed cabling, conduiting, trunking and cable trays laying

Introduction

This unit describes the competencies required by an electrician in order to safely install electrical metallic and non-metallic conduits, trunking, cable trays, wire ways and distribution board frames based on the required performance standards.

Summary of Learning Outcome

1. Apply workplace safety
2. Perform basic metal works
3. Install PVC Sheathed cables
4. Install electrical metallic/non- metallic (PVC) conduits
5. Install wire ways, trunking and cable trays
6. Install distribution board frames and auxiliary components

1.0. Apply workplace safety

Introduction

This learning outcome specifies the competences required to apply work place safety, learn causes of accidents and how to prevent them.

Performance Standard

- ❑ Correct PPE are identified and selected in line with safety requirements.
- ❑ Workshop safety are applied in line with the workshop rules and regulations
- ❑ First Aid is carried out according to the standard operating procedures
- ❑ Workshop hazards are classified in accordance with OSHA

Information Sheet

Personal Protective Equipment (PPE)

Meaning and purpose of PPE

Personal protective equipment (PPE) is protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection. The hazards

addressed by protective equipment include physical, electrical, heat, chemicals, biohazards, and airborne particulate matter.

Types of PPE

Depending on the job task to be performed, PPE for the electric power industry generally includes safety glasses, face shields, hard hats, safety shoes, insulating (rubber) gloves with leather protectors, insulating sleeves, and flame-resistant (FR) clothing

Figure 1: Basic PPE for Electrical Operator

Safe and correct handling of different types of PPE

The PPE must be inspected for defects every time it is put on. Look for symmetry; does each side look like a mirror image of the other or is one side distorted? Are there any broken, bent, frayed or torn pieces? Are the lenses scratched so they are hard to see through? Is the elastic still springy or is it stretched out? In addition to visual inspection as above, insulating gloves, sleeves and blankets for electrical workers must be electrically tested. All must be tested prior to initial use, and then every 6 months thereafter for gloves, and every 12 months for sleeves and blankets. PPE should be clean. If dirty, clean it with soap and warm water. Do not use solvents or abrasives to clean it. Store it out of sunlight in an area where it will be protected and kept clean. Replace reusable PPE every 2-5 years, earlier if recommended by the manufacturer or if there is a major impact. Replace any defective parts with parts made by the same manufacturer for that equipment. Do not make makeshift repairs. If it cannot be repaired properly, replace it. Do not use paint or glue on PPE. Use decals or stickers to mark it.

Safety and Environmental Regulations

Workshop safety

The safety in Workshops has been written not only to provide appropriate safety procedures but also to assist trained workshop personnel with the provision of a reference document outlining the general principles of safe working practices relevant to the mechanical engineering aspects. It relates to specific areas where definite safety measures are required for workshop operations

Factories Act and Accident

Various acts relating to accidents are spelt out in workmen's compensation Act-1923. The factories act-1948 and Fatal Accidents Act-1855. These acts describe the regulations for fencing and guarding the dangerous machinery, items and employer's liabilities.

Introduction to workshop safety

A workshop is where you learn to use tools and machines to make things; It can be a dangerous place, so you must learn the safety rules for the workshop.

The safety rules tell you how to dress appropriately and how to behave whilst working with tools that may cause harm. You must never play in the workshop, run around or throw equipment to one another.

Personal safety:

The basic dress rules that you should always follow are:

i. Proper clothing.
   You must not wear loose clothes that can be caught in moving machinery. You must wear tight fitting overalls.

ii. Proper eye protection.
   You must always wear goggles to protect your eyes while you are working in the workshop.

iii. Remove tie and jewelry.
   Ties, watches, rings and other jewelers increase the chance of getting caught by moving machinery. You must remove them before entering the workshop.

iv. Cut or secure long hair. Long hair is also dangerous as it may be caught by the machine and pulls you into it.

v. Proper shoes. You must not wear sandals or soft shoe inside the workshop as they will not protect your feet from falling objects. A safety shoes (steel-toe shoes) will protect your feet if you accidentally drop something.

vi. The way you dress in the workshop is very important for your safety, always be sure to wear properly and encourage your friends to do the same.

General workshop safety

It's essential to be aware of and able to foresee the dangers which exist in the workshop and are likely to affect your health and safety.

You should make sure that your workspace is as safe as possible so that few dangers arise.

i) Use the appropriate protective clothing and equipment to minimize the risk of accident

ii) Act in a safe manner at all times.

General Safety Precautions while Working in a Workshop

i. One should not leave the machine ON even after the power is OFF and until it has stopped running completely. Someone else may not notice that the machine is still in motion and be injured.
ii. Operator should not talk to other industrial persons when he is operating a machine.
iii. One should not oil, clean, adjust or repair any machine while it is running. Stop the machine and lock the power switch in the OFF position.
iv. One should not operate any machine unless authorized to do so by the authorize person in the shop.
v. Always check that work and cutting tools on any machine are clamped securely before starting.
vi. The floor should be kept clean and clear of metal chips or curls and waste pieces. Put them in the container provided for such things. Scraps and chips or curls may cut through a shoe and injure the foot.
vii. Defective guards must be replaced or repaired immediately.
viii. One should not operate any machinery when the supervisor or instructor is not in the shop.
ix. All set screws should be of flush or recessed type. Projecting set screws are very dangerous because they catch on sleeves or clothing.
x. One should not try to stop the machine with hands or body.
xi. Only trained operator should operate machine or switches as far as possible.
xii. Always take help for handling long or heavy pieces of material.
xiii. Always follow safe lifting practices
xiv. No one should run in the shop at work time.
xv. Always keep your body and clothes away from moving machine parts. Get first aid immediately for any injury.
xvi. Never talk to anyone while operating the machine, nor allow anyone to come near you or the machine.
xvii. Stop the machine before making measurements or adjustments.
xviii. Operator should concentrate on the work and must not talk unnecessarily while operating the machines.
xix. Never wear necktie, loose sweater, wristwatch, bangles, rings, and loose-fitting clothing while working in workshop.
xx. Always wear overcoat or apron.
xxi. Stop machines before attempting to clean it.
xxii. Make sure that all guards are in their place before starting to operate a machine.
xxiii. Do not attempt to operate a machine until you have received operating instructions.
xxiv. Be thoroughly familiar with the ‘stop’ button and any emergency stop buttons provided on the machines.
xxv. Remove burrs, chips and other unwanted materials as soon as possible. They can cause serious cuts.

xxvi. Do not leave loose rags on machines.
xxvii. Wash your hands thoroughly after working to remove oils, abrasive particles, cutting fluid, etc.
xxviii. Report all injuries to the foreman, howsoever small. Cuts and burns should be treated immediately.
xxix. Keep the work area clean.
xxx. Keep your mind on the job, be alert, and be ready for any emergency.
xxxi. Always work in proper lighting.
xxxii. On should not lean against the machines.

Concept of accident

It is very difficult to give a definition of the word 'Accident'. However, a generally accepted conception that an accident is a mishap, a disaster that results in some sort of injury, to men, machines or tools and equipment and in general loss to the organization. The said injury or loss may be of minor or major nature and the accident is termed as non-reportable or reportable. For example, a small cut on the body will be reportable accident in a training workshop. It can be treated by first aid and does not involve any appreciable loss of time, and will not be considered a reportable accident in a production unit.

Causes of accidents

The 98% accidents could be easily avoided provided due precautions are taken well in time. A very familiar slogan goes on to say that accidents do not just happen but are caused due to the failure of one element or the other, and the most unfortunate factor is that the human element is the most pronounced of all which fail.
The common causes which lead to accidents are the following:

1. Unsafe working position.
2. Improper or defective tools or their improper use.
3. Improper acts- which result in violation of safety rules and non-observance of safety precautions.

Causes of accidents

1. **Causes due to human beings**

a) **Carelessness**

This is due to overconfidence, loss of interest, fatigue (continuous work without rest), monotony, unnecessary emotion which diverts concentration on the work being done hence resulting to accidents.

b) **Ignorance**

An operator must understand the users and the function of his machine equipment.

c) **Unsuitable PPEs in working areas**

Personnel should wear clothing which will provide protection against dangers in areas where they work. That is:

i. **Safety Shoes/boots.** They should be a type which provides protection against slippery conditions.
They should be strong enough in the feet to prevent injury from hurting objects e.g. safety boots.

ii. **Gloves-** They should be worn where there are risks when harming sharp objects whether inside or outside buildings.

iii. **Safety glass**

Safety glasses or goggles should be worn where there's likely of danger to the eyes, such as using drills, grinding machines etc.

d) **Untidiness**

i. Keep all passage ways clear and clean.
ii. Circular rods if stepped upon can cause nasty falls.
iii. Keep the workshop floor free from grease and oils.

2. **Contributing causes**

a) Unsatisfactory hand tools like being worn out without handles

i. Hammers with loose handles or crippled faces should never be used.
ii. Chisels with burred heads are dangerous as broken pieces from the edges may fly off and cause injury.
iii. Files should have tight handles to prevent accidents to the hands.
iv. Spanners which fit incorrectly will slip and can result I n damaging fingers.
v. When drilling always ensure that the work is securely held in a vice or otherwise securely clamped.

b) **Unsatisfactory machines**

i. That is being insufficiently spaced, unguarded, broken, improperly adjusted, insufficiently lubricated and being too small or weak for the job being undertaken.
ii. All machines are properly guarded, all abrasive wheels are kept in good condition and run at safe speeds.
iii. Don't attempt to adjust or remove by hand a belt on a rotating shaft.
iv. don' t allows idle belt to rest on rotating shaft and don' t attempt to oil overhead shafting while it' s in motion.

c) **Should never be overloaded.**

Physical condition of personnel while working like before lifting equipment ensure that the weight is within your capability to handle. A base that anything used for lifting is serviceable and in good working condition chains, hooks etc.

Common sources of accidents

The large number of machines in use and an even larger number of parts. This can be regarded as sources of danger and require guarding for protection against accidents.

Some common sources of accident are as listed below:

Projecting nips between sets of revolving parts, viz, gears, rolls and friction wheels, etc.

i. Projecting fasteners on revolving parts.
ii. Revolving cutting tools, circular saw blades.
iii. Revolving drums, crushers, spiked cylinder and armed mixers, etc.
iv. Revolving shafts, spindles, bars and tools like drills, reamers, boring bars and chucks, etc.
v. Projecting sharp edges or nips of belt and chain drives viz., belt, pulleys, chains, sprockets and belt fasteners.
vi. Reciprocating tools and dies of power presses, drop hammers, and revolving presses, etc.
vii. Grinding wheels and stones.
viii. Reciprocating knives and saw blades such as cutting and trimming machines and power hack-saws, etc.
ix. Revolving drums and cylinders without casing, such as concrete and other mixers.
x. Intermittent feed mechanisms.
xi. Projecting nips between various links and mechanisms, like cranks connecting rods, piston rods, rotating wheels and discs, etc.

Common Methods of Protection

The common methods of protection against accidents are the following:

i. Safety by position.
ii. Safety by construction.
iii. Safety by using interlock guards.gg
iv. Safety by using fixed guards.
v. Safety by using automatic guards.
vi. Safety by using distance guards.

Safety by construction

When a new machine is designed, it should be ensured that all its dangerous parts are either enclosed in suitable housings or provided with suitable safety guards. For example, the belt drive and motor in a lathe or milling machine are enclosed; the back gears in a lathe are either enclosed or provided with cast iron guards or covers. Lubricating points are provided on the outer surfaces so that the interior parts are not required to be opened every time.

Safety by position
The machine design is in such a way that the dangerous parts are located such that they are always beyond the reach of the operator. The dangerous parts of all the machines should invariably be guarded and undertaking should be made to make them enclosed in the body or housing of the machines.

Safety by using interlock guards
It is a very efficient and sound method of guarding in that the guard cannot be removed and dangerous parts exposed until and unless the machine is totally stopped. Similarly, the machine cannot be started to work unless the guard returns in position and protects the dangerous parts. An interlocking guard may be mechanical, electrical or some sort of a combination of these. It is essential that it should:

i. Prevent the starting and operation of the machine in case the interlocking device fails.
ii. Always acquire its position to guard the dangerous part before the machine can be started.
iii. Remain closed in position until the dangerous part is completely at rest.

Safety by using fixed guards
These guards either for man integral part of the machine or are tightly secured to them. They should be made to have rigid construction and should be so placed that any access to the dangerous parts of the machine is totally prevented in the running condition of the machines. Steel sheets can be advantageously used and they facilitate an easy fabrication of guards and are lighter in weight.

In some cases, the fixed guards are made adjustable in order to accommodate different kinds of works or sets of tools. In some cases, the fixed guards are provided at a distance from the danger point.

Safety by using distance guards
The principle of a distance guards is that a fencing, enough high, is made of bars, at a suitable distance from the machine such that even if the operative, by chance, extends his hands over it, his fingers, clothes or any part of the body does not reach within the area of dangerous parts. An additional measure of safety, some sort of tripping device is also usually incorporated to stop the machine quickly in case of an accident.

Safety by using automatic guards
The principle of an automatic guard is that its operation is actuated by some moving part of the machine.

It may link that the part will automatically bring the guard in protecting position before the operation of the machine starts. The design of the guard is such that it automatically forces the operative away from the dangerous area of work before the operation starts and does not permit

his access to the area again until and unless the machine stops. It may be noted that due to enough time being required for their operation, this type of guards are not suitable for quick-acting and fast-running machines. Their use is largely favored for heavy and slow acting machines like heavy power presses.

Industrial safety

The factory act 1961 states that:

i. Floors steps stairs passages and gang ways must be soundly constructed properly maintained and kept free from obstruction and any substance likely to cause a person to slip.
ii. Hand rails must be provided for stairs.
iii. All ladders must be soundly constructed and properly maintained.
iv. Opening in floors shall, wherever practicable be securely fenced.

Special regulations

The following precautions should be observed

i. Always work never runs
ii. Never throw rubbish on the floor
iii. Keep gang ways and work areas free of metal bars, components, etc.
iv. Keep to gangways when moving about never takes short cuts.
v. If oil water or grease is spilled wipe it up immediately
vi. Wear safety shoes- shoes are available with until slip soles and with metal toe caps to protect the feet from falling objects.
vii. Always check ladders for damage before use.
viii. Always position ladders on firm base at the correct angle.

Aims and objectives

The major objectives of the factory act are;

i. To provide protection to the workers employed in factories against industrial hazards and to ensure safe and better working conditions.
ii. It regulates and maintains properly various safety health and welfare activities in the factories.
iii. It regulates & maintains working hours of workers, employment of children and adolescents, employment of women, annual leave with wages etc.

The salient features of this act regarding safety are as follows;

i. Fencing of machinery
   Every prime mover like engine or motor, moving part of the machinery is fenced properly.
ii. Work on or near the machinery in motion.
   Only specially trained workers wearing tight fitting clothes should carry out inspection of any part of the machinery in motion.

iii. Employment of young persons on dangerous machines.
iv. No young person should be allowed to work on dangerous machine unless he is properly trained and carefully supervised
v. Hoist and lifts.
vi. Every hoist and lifts should be of god mechanical construction, adequate strength and must be protected by enclosure and fitted with gates.
Every hoist and lift should be adequately maintained and periodically examined
vii. Listing machinery, chains, ropes and lifting tackles
Lifting machines such as cranes, crab, etc should be of good construction, adequate strength should be maintained.
viii. Revolving machinery
It should always be ensured that safe working peripheral speed is not exceeded for every revolving machinery.
ix. Pressure plants.
The pressure plant should not be operated at a pressure higher than the specified safe working pressure.
x. Floors stairs and means of access to different places
All floors, steps, stairs, passages should of sound construction and free from obstructions
xi. Pits sumps, opening in floor etc.
Every pit, sumps, opening in floor, fixed vessels, tanks etc should be securely covered or fenced.
xii. Excessive weights
No person should be asked to lift carry or move any load so heavily that's likely to cause him injury. Protection of eyes.

Accident reports

Every accident must be reported to an employer and the details of the accident and treatment given are suitably documented. A first aid Log book or accident book containing first aid treatment record sheets could be used to effectively document accidents which occur in the workplace and the treatment given. Failure to do so may influence the payment of compensation at a later date if an injury leads to permanent disability.

To comply with the Data Protection Regulations, from the all First Aid Treatment Log books or Accident Report books must contain perforated sheets which can be removed after completion and filed away for personal security.

Environment Management and Coordination Act (EMCA)

General principles

Entitlement to a clean and healthy environment

Protection and conservation of the environment

No person shall, without the prior written approval of the Director-General given after an environmental impact assessment, in relation to a river, lake or wetland in Kenya, carry out any of the following activities—

i. Erect, reconstruct, place, alter, extend, remove or demolish any structure or part of any structure in, or under the river, lake or wetland;
ii. Excavate, drill, tunnel or disturb the river, lake or wetland;
iii. Introduce any animal, whether alien or indigenous, dead or alive, in any river, lake or wetland;
iv. Introduce or plant any part of a plant specimen, whether alien or indigenous, dead or alive, in any river, lake or wetland;
v. Exposit any substance in a lake, river or wetland or in, on or under its bed, if that substance would or is likely to have adverse environmental effects on the river, lake or wetland;
vi. Direct or block any river, lake or wetland from its natural and normal course; or
vii. Drain any lake, river or wetland.

Occupational risks

There are many jobs in industries which are highly prone to accidents. Coal-mining, marine transport, quarry and construction, chemical factories etc., are more dangerous as compared to communication, banking or IT industries.

Slipping, Tripping or Falling on the Floor:

People fall when they slip. Highly polished surfaces, accumulation of water, soap or oil, on the floor, torn or loose coverings causes the floor to be slippery.

Collision and Obstruction:

This takes place when there are inadequate lighting arrangements, furniture and equipments are placed improperly, sharp edges of machines etc.

Equipments and Machines:

Heavy mechanical machines are not handled properly or maintenance is low. Defective equipment, improperly guarded equipment, overloading of machines, wiring of suitable is not proper. Safety devices have been removed, adjusted or disconnected.

Types of hazards

Electric shock

Passage of current through the body of such magnitude as to have significant harmful effect.

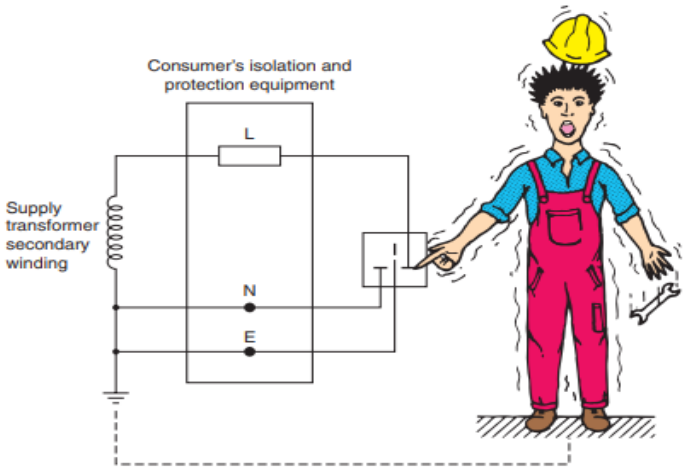

Figure 2: Demonstration of Electrical Shock

Touching live and earth or live and neutral makes a person part of the electrical circuit and can lead to an electric shock.

i. Electric shock occurs when a person becomes part of the electrical circuit.
ii. One gets electric shock when he or she is in contact with two objects that are at different potentials.
iii. The person completes the circuit to earth and the current flows through him/or her.

Electrical safety

i. Electrical cannot be seen we only see the effect due to it.
ii. Because of this care must be taken when using electricity. There are two main causes of accidents due to electricity.

These are:

i. Carelessness: this arises because of laxity. When electricians have worked for long period, they tend to assume the high standards of safety required and start to maintain equipment when it' s live and as a result an accident can easily occur.
ii. Ignorance and inexperience. Most of the electrical tasks appear very simple when carried out by well-trained electricians. When unqualified personnel attempt to do the same they are usually unable and they leave the tasks uncompleted. This is dangerous to the others. The safety precaution in any electrical installation is to:
    a) Prevent electric shock
    b) Prevent the occurrence of fire due to electrical fires.

The damage done to the human body will depend on the following factors:

i. Voltage between the two points
ii. The amount of current flowing

iii. The time taken for the current to flow

Also, the level or intensity of the shock will depend upon factors, such as age, fitness and the circumstances in which the shock is received. The lethal level is approximately 50 mA, above which muscles contract, the heart flutters and breathing stops. A shock above the 50-mA level is therefore fatal unless the person is quickly separated from the supply. Below 50 mA only an unpleasant tingling sensation may be experienced or you may be thrown across a room, roof or ladder, but the resulting fall may lead to serious injury.

Two ways in which one can be at risk of electric shock

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

Shock levels

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

Basic electrical protection against shock

i. Insulate any live parts.
ii. Ensure that any uninsulated live parts are housed in suitable enclosures and/or are behind barriers.
iii. Place obstacles in the way. (This method would only be used in areas where skilled and/or authorized persons were involved.)
iv. Placing live parts out of reach. (Once again, only used in special circumstances, e.g., live rails of overhead travelling cranes.)
v. 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 40ms 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 backup to the other methods. They must not be used as the sole means of protection.

The methods used to prevent electric shock are;

i. Earthing the metallic and any equipment within the installation
ii. Using all the insulated wiring systems

Treatment of electric shock

If somebody get electric shock, the immediate action should be:

i. Switch off the supply
ii. If necessary, start artificial respiration
iii. Seek medical assistance
iv. Treat the burns or injuries.
v. Keep the victim warm.

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? The most common method is by protective earthing, protective equipotential bonding and automatic disconnection in case of a fault.

Use of class II equipment

Double-insulated equipment, this is typical of modern appliances where there is no provision for the connection of a cpc. 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

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

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.

Use of enclosures

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.

Fire hazards:

Non-existence of fire escapes and exits can cause serious injuries, especially factories manufacturing inflammable objects like crackers, papers, chemical etc. Fire protection equipment and fire extinguishers have nor properly fitted or available in the factory.

Types of fires and fire fighting

Types of fires

Fire can cause loss of lives, jobs equipment, materials and buildings.

For all practical purposes there are three main classes of fires; A B &C

Class A fires.

Fires in ordinary combustible materials such as wood, paper & cloth.

The majorities of fires are in this class and can be most effectively extinguished by cooling with **water.**

Class-B fires

Fires from flammable liquids such as paraffin, petrol, paint, varnishes, oil and from greases and fats. These are effectively extinguished by smattering foam or other agents which exclude oxygen.

Class-C fires

Fires involving live electrical equipment and wiring. The safest method of extinguishing is to displace the oxygen by projecting a gas or dry powder into the vicinity of the fire.

In the event of a fire:

The following precautions should be observed at all times.

i. Know the correct fire drill and the positions of fire alarms, firefighting equipment and emergency exits.

ii. Know the correct appliance to use for a particular type of fire and know how to use it.
iii. Don't bock fire exit.
iv. Don't use fire appliances for any purpose other than intended.
v. Never smoke in no smoking areas
vi. Always ensure that matches and cigarettes are put out before throwing them away
vii. Avoid spillage of flammable liquids.

Extinguishers and fighting procedures

Water type

These are usually operated by striking a plunger to release a gas which pressures the water and forces it out of the nozzle. They are stable only for class-A fires.
The jet should be directed at the base of the fire and be kept moving across the area of the fire.

Chemical foam type

i. These may be operated by inverting the extinguisher or by releasing a plunger allowing two solutions to mix and produce foam.
ii. They are used on class B fires involving flammable liquids.
iii. The jet is directed with a gentle sweeping movement, allowing the foam to drop down and lie on the Surface of the liquid.
iv. This smothers the fire by excluding oxygen.

Carbon-dioxide (Co_2) type

These are operated by squeezing the discharge lever which allows the liquid co2 to be discharged as a gas. They are used on class c fires where after the current has been switched off the discharge horn is directed straight at the fire.

Dry powder pressure type.

This type contains a pressurized as and a dry chemical agent. After the release lever has been operated discharge is controlled by a nozzle at the end of the nose.
These are used on class c fires in the same way as the Co_2 type.

Use of fire extinguishers

Class of fire		Type of fire extinguisher			
		Water	Foam	Co_2	Dry powder
A	Ordinary fires: wood, paper, cloth	Yes	Yes	No	No
B	Flammable liquids: petrol, paraffin	No	Yes	Yes	Yes
C	Electrical equipment	No	No	Yes	Yes

Table 1: Use of Fire Extinguishers

Fire precautions

Fire is a great danger in a workshop and care must be taken not to start a fire. The main causes of fire are:

i. Careless storage of flammable materials.
ii. Careless electrical maintenance.
iii. People throwing away cigarettes.

First aid

First aid is the initial assistance or treatment given to a casualty for any injury or sudden illness before the arrival of an ambulance, doctor or other medically qualified person.
A first aider is someone who has undergone a training course to administer first aid at work and holds a current first aid certificate.

An appointed person is someone who is nominated to take charge when someone is injured or becomes ill, including calling an ambulance if required. The appointed person will also look after the first aid equipment, including re-stocking the first aid box.

Despite all the safety precautions taken on construction sites to prevent injury to the workforce, accidents do happen and you may be the only other person able to take action to assist a workmate. If you are not a qualified first aider limit your help to obvious common-sense assistance and call for help, but do remember that if a workmate's heart or breathing has stopped as a result of an accident, he has only 4 minutes to live unless you act quickly.

The Health and Safety (First Aid) Regulations 1981 and relevant approved codes of practice and guidance notes place a duty of care on all employers to provide adequate first aid facilities appropriate to the type of work being undertaken.

The regulations state that:
Employers are under a duty to provide such numbers of suitable persons as is adequate and appropriate in the circumstances for rendering first aid to his employees if they are injured or become ill at work.

For this purpose, a person shall not be suitable unless he or she has undergone such training and has such qualifications as the Health and Safety Executive may approve.
This is typical of the way in which the health and safety regulations are written. The regulations and codes of practice do not specify numbers, but set out guidelines in respect of the number of first aiders needed, dependent upon the type of company, the hazards present and the number of people employed.

First aid is the treatment of minor injuries which would otherwise receive no treatment or do not need treatment by a doctor or nurse or in cases where a person will require help from a doctor or nurse, first aid is treatment for the purpose of preserving life and minimizing the consequences of an injury or illness until such help is obtained. A more generally accepted definition of first aid might be as follows: first aid is the initial assistance or treatment given to a casualty for any injury or sudden illness before the arrival of an ambulance, doctor or other medically qualified person.

A first aider is someone who has undergone a training course to administer first aid at work and holds a current first aid certificate. The training course and certification must be approved by the HSE.

i. The aims of a first aider are to preserve life, to limit the worsening of the injury or illness and to promote recovery.
ii. A first aider may also undertake the duties of an appointed person. An appointed person is someone who is nominated to take charge when someone is injured or becomes ill, including calling an ambulance if required.
iii. The appointed person will also look after the first aid equipment, including re-stocking the first aid box.
iv. Appointed persons should not attempt to give first aid for which they have not been trained, but should limit their help to obvious common-sense assistance and summon professional assistance as required.
v. First aid personnel must be available at all times when people are at work, taking into account shift working patterns and providing cover for sickness absences.

Bleeding

If the wound is dirty, rinse it under clean running water. Clean the skin around the wound and apply a plaster, pulling the skin together.

If the bleeding is severe apply direct pressure to reduce the bleeding and raise the limb if possible. Apply a sterile dressing or pad and bandage firmly before obtaining professional advice.

To avoid possible contact with hepatitis or the AIDS virus, when dealing with open wounds, first aiders should avoid contact with fresh blood by wearing plastic or rubber protective gloves, or by allowing the casualty to apply pressure to the bleeding wound.

Burns

Remove heat from the burn to relieve the pain by placing the injured part under clean cold water. Do not remove burnt clothing sticking to the skin. Do not apply lotions or ointments. Do

not break blisters or attempt to remove loose skin. Cover the injured area with a clean dry dressing.

Broken bones

Make the casualty as comfortable as possible by supporting the broken limb either by hand or with padding. Do not move the casualty unless by remaining in that position he is likely to suffer further injury. Obtain professional help as soon as possible.

Contact with chemicals

Wash the affected area very thoroughly with clean cold water. Remove any contaminated clothing. Cover the affected area with a clean sterile dressing and seek expert advice. It is a wise precaution to treat all chemical substances as possibly harmful; even commonly used substances can be dangerous if contamination is from concentrated solutions. When handling dangerous substances, it is also good practice to have a neutralizing agent to hand.

Disposal of dangerous substances must not be into the main drains since this can give rise to an environmental hazard, but should be undertaken in accordance with local authority regulations.

Exposure to toxic fumes

Get the casualty into fresh air quickly and encourage deep breathing if conscious. Resuscitate if breathing has stopped. Obtain expert medical advice as fumes may cause irritation of the lungs.

Sprains and bruising

A cold compress can help to relieve swelling and pain. Soak a towel or cloth in cold water, squeeze it out and place it on the injured part. Renew the compress every few minutes.

Breathing stopped

i. Remove any restrictions from the face and any vomit, loose or false teeth from the mouth. Loosen tight clothing around the neck, chest and waist.
ii. To ensure a good airway, lay the casualty on his back and support the shoulders on some padding.
iii. Tilt the head backwards and open the mouth.
iv. If the casualty is faintly breathing, lifting the tongue, clearing of the airway may be all that is necessary to restore normal breathing.
v. However, if the casualty does not begin to breathe, open your mouth wide and take a deep breath, close the casualty's nose by pinching with your fingers, and, sealing your lips around his mouth, blow into his lungs until the chest rises.
vi. Remove your mouth and watch the casualty's chest fall.
vii. Continue this procedure at your natural breathing rate.
viii. If the mouth is damaged or you have difficulty making a seal around the casualty's mouth, close his mouth and inflate the lungs through his nostrils.

ix. Give artificial respiration until natural breathing is restored or until professional help arrives.

Heart stopped beating

i. This sometimes happens following a severe electric shock. If the casualty's lips are blue, the pupils of his eyes widely dilated and the pulse in his neck cannot be felt, then he may have gone into cardiac arrest.
ii. Act quickly and lay the casualty on his back.
iii. Kneel down beside him and place the heel of one hand in the Centre of his chest.
iv. Cover this hand with your other hand and interlace the fingers.
v. Straighten your arms and press down on his chest sharply with the heel of your hands and then release the pressure.
vi. Continue to do this 15 times at the rate of one push per second.
vii. Check the casualty's pulse. If none is felt, give two breaths of artificial respiration and then a further 15 chest compressions.
viii. Continue this procedure until the heartbeat is restored and the artificial respiration until normal breathing returns. Pay close attention to the condition of the casualty while giving heart massage.
ix. When a pulse is restored the blueness around the mouth will quickly go away and you should stop the heart massage. Look carefully at the rate of breathing. When this is also normal, stop giving artificial respiration.
x. Treat the casualty for shock; place him in the recovery position and obtain professional help.

Shock

Everyone suffers from shock following an accident. The severity of the shock depends upon the nature and extent of the injury. In cases of severe shock, the casualty will become pale and his skin become clammy from sweating. He may feel faint, have blurred vision, feel sick and complain of thirst. Reassure the casualty that everything that needs to be done is being done. Loosen tight clothing and keep him warm and dry until help arrives.
Do not move him unnecessarily or give him anything to drink.

Some of the items that are found in a First-Aid Box

i. Pair of scissors
ii. Large size sterilized dressings
iii. Medium size sterilized dressings
iv. Small sized sterilized dressings
v. Large size burn dressings
vi. Packets of sterilized cotton wool

vii. Rolled bandages 10 cm wide
viii. Rolled bandages 5 cm wide
ix. Bottle (4 oz) of salvolative having the doze and made 1 of administration indicated on label
x. Safety pins
xi. Eye drops
xii. Adhesive plaster
xiii. 4 bottles containing KMnO4 crystals, etc.
xiv. 4 bottles containing a 2% alcoholic solution
xv. Betadine ointment (50mg)
xvi. Slaframine ointment (50mg)
xvii. Dettol

Methods of resuscitation

If the person is in contact with the live conductors then the first thing is to break the contact. care must be taken in order not electrocute yourself.

Try to switch off the supply or to unplug the equipment incase it's a portable tool e.g., a drill. Under no circumstances should you attempt to touch the person. It may be possible to detach the person by pulling or pushing him/her by using insulated object e.g. an insulated cable looped rounded the victims arm or body using a dry wooden pole.

After the victim is removed from the live contacts provide artificial respiration by using any of the following methods

i. Mouth to mouth
ii. Holger-Nelson

Mouth -mouth

In this method, the patient must be on his back and his mouth should be inspected for any obstructions e.g., false teeth.

i. The patient head should be extended by placing one hand on his crown and the other immediately beneath his chin.
ii. Gently bend his head backwards and then using his both hands, lift his jaw forward.
iii. Place your lips over the patients' mouth and make a good seal with the thumb and one fore finger of one hand gently close the patient nostrils.
iv. Take a deep breath and exhale into the patient using little force.
v. Watch and feel the patient's chest rise. Remove your lips and let the lungs deflate.
vi. The above procedure should be repeated twelve times per minute remembering to turn away your head as you don't fill your own lungs with the patients expired air.

vii. Continue inflation and depletion of the lungs until spontaneous breathing is maintained.

Holger and Neilson.

i. The patient should be placed face downwards with the arm overhead, the elbows flexed so that one hand rests on the other in turn.
ii. Turn the patients head to one side so that the neck rests on his upper most hand. Kneel to one side of the patients head and put the foot of your other leg near his elbow.
iii. Place your hands on his back just below the shoulder blades and rock forwards with your elbow straight until your arms are approximately vertical, exerting- steady pressure on his chest.
iv. Grasp the patient's arms just above the elbow and rock backwards raising his arms until tension is felt at the patient's shoulder lower his arms.
v. The complete cycle should be repeated twelve times a minute.
vi. This method is practical only when there's no gross injury to the arms shoulder and the ribs.

Learning activities

i. Demonstrate dorning of the PPEs and allow the trainee to practice.
ii. Demonstrate firefighting techniques.
iii. Demonstrate the resuscitation techniques using dummies.

Field/Visit to an established electrical workshop

Visit Objective/Aim	**Indicators**	**Special Instruction**
To establish the use of PPEs in a workshop	• Technician fully in PPEs	Take notes

Table 2: Visit to an Electrical Workshop

Self-Assessment questions

1. What are classes of fire? (3 Marks)
2. How is Holger-Nelsons respiration method? (5Marks)
3. What items are found in the first aid box? (7Marks)

Tools, Equipment and Materials

❑ PPE including working gloves, overalls/dustcoats, safety shoes, helmets, goggles, safety harness.
❑ Assorted firefighting equipment
❑ Copies of regulations

REFERENCES

- ❑ Occupational Safety and Health Act
- ❑ Work Injury Benefits Act
- ❑ Environmental Management and Co-ordination Act
- ❑ Institute of Electrical Engineers regulations
- ❑ Electrical Installation by A.J Watkins . C. Kitcher
- ❑ Guidelines for Personal Protective Equipment (PPE)- University of Washington
- ❑ Basic First Aid Training and Procedures for emergency - Uncharted Supply Co.

1.

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Model answers to Self-Assessment Questions

1. **Classes of fire (3 Marks)**
   - i. Class A
   - ii. Class B
   - iii. Class C
   - iv. Class D
   - v. Class E
2. Holger-Nelson's respiration method (5Marks)
   - i. The patient should be placed face downwards with the arm overhead, the elbows flexed so that one hand rests on the other in turn.
   - ii. Turn the patients head to one side so that the neck rests on his upper most hand. Kneel to one side of the patients' head and put the foot of your other leg near his elbow.
   - iii. Place your hands on his back just below the shoulder blades and rock forwards with your elbow straight until your arms are approximately vertical, exerting- steady pressure on his chest.
   - iv. Grasp the patient's arms just above the elbow and rock backwards raising his arms until tension is felt at the patient's shoulder lower his arms.
   - v. The complete cycle should be repeated twelve times a minute.
   - vi. This method is practical only when there's no gross injury to the arms shoulder and the ribs.

3. **Items of a First-Aid Box (7Marks)**
   - i. Pair of scissors
   - ii. Large size sterilized dressings
   - iii. Medium size sterilized dressings
   - iv. Small sized sterilized dressings
   - v. Large size burn dressings

vi. Packets of sterilized cotton wool
vii. Packets of sterilized cotton wool
viii. Rolled bandages 10 cm wide
ix. Rolled bandages 5 cm wide
x. Bottle (4 oz) of salvolative having the doze and made 1 of administration indicated on label
xi. Safety pins
xii. Eye drops
xiii. Adhesive plaster
xiv. Dettol

1.1.Perform Basic Metal Works

Introduction

This learning outcome specifies the content of competencies required on metal working, forming processes, cutting processes, joining processes and associated processes of basic metal works.

Performance Standard

i. Use of safety harness and PPE
ii. Types of metals e.g., Mild steel, steel
iii. Purpose of the metals
iv. Application of metals

Information Sheet.

Metalworking

Is the process of working with metals to create individual parts, assemblies, or large-scale structures. Metalworking generally is divided into three categories:

i. Forming
ii. Cutting,
iii. Joining.

Most metal cutting is done by high-speed steel tools or carbide tools. Each of these categories contains various processes.

Prior to most operations, the metal must be marked out and/or measured, depending on the desired finished product.

Marking out (also known as layout) is the process of transferring a design or pattern to a work piece and is the first step in the handcraft of metalworking. It is performed in many industries or hobbies, although in industry, the repetition eliminates the need to mark out every individual piece. In the metal trades area, marking out consists of transferring the engineer's plan to the workpiece in preparation for the next step, machining or manufacture.

Figure 3: Combination Square used for transferring design

.

Calipers are hand tools designed to precisely measure the distance between two points. Most calipers have two sets of flat, parallel edges used for inner or outer diameter measurements. These calipers can be accurate to within one-thousandth of an inch (25.4 μm). Different types of calipers have different mechanisms for displaying the distance measured. Where larger objects need to be measured with less precision, a tape measure is often used.

Figure 4: A Caliper for Measuring Length

Compatibility chart of materials versus processes

	Material										
Process	Iron	Steel	Aluminium	Copper	Magnesium	Nickel	Refractory metals	Titanium	Zinc	Brass	Bronze
Sand casting	X	X	X	X	X	X			0	0	X
Permanent mold casting	X	0	X	0	X	0			0	0	X
Die casting			X	0	X				X		

Investment casting		X	X	X	0	0				0	X
Ablation casting		X	X	X	0	0					
Open-die forging		0	X	X	X	0	0	0			
Closed-die forging		X	0	0	0	0	0	0			
Extrusion		0	X	X	X	0	0	0			
Cold heading		X	X	X		0					
Stamping & deep drawing		X	X	X	0	X		0	0		
Screw machine	0	X	X	X	0	X	0	0	0	X	X
Powder metallurgy	X	X	0	X		0	X	0			
Key: X = Routinely performed, 0 = Performed with difficulty, caution, or some sacrifice, blank = Not recommended											

Table 3: Compatibility Chart of Material versus Processes

Metal casting

Casting achieves a specific form by pouring molten metal into a mold and allowing it to cool, with no mechanical force. Forms of casting include:

i. Investment casting (called lost wax casting in art)
ii. Centrifugal casting
iii. Die casting

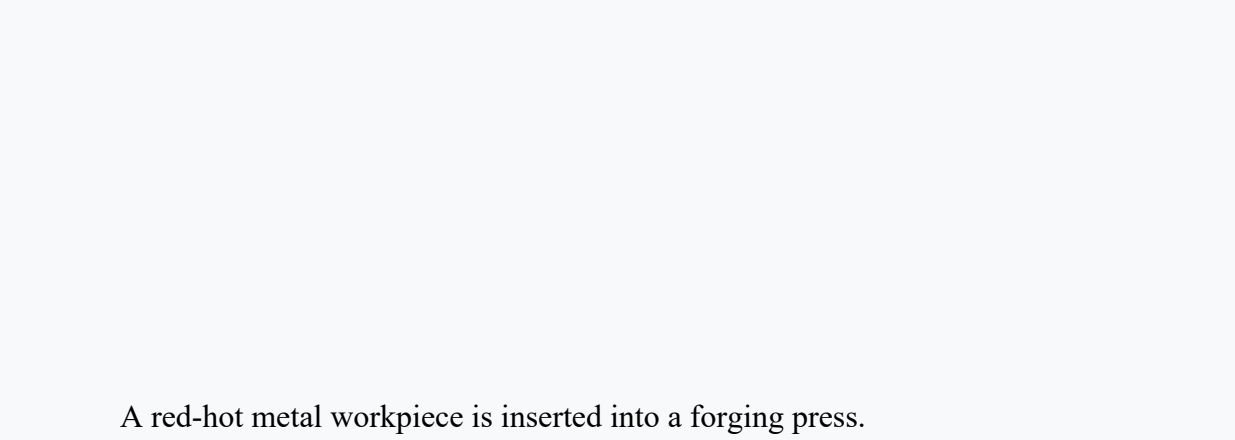
iv. Sand casting
v. Shell casting
vi. Spin casting

A Sand-casting mold

Figure 5: A Sand- Casting Mold

These forming processes modify metal or workpiece by deforming the object, that is, without removing any material. Forming is done with a system of mechanical forces and, especially for bulk metal forming, with heat

Bulk forming processes



A red-hot metal workpiece is inserted into a forging press.

Plastic deformation involves using heat or pressure to make a work piece more conductive to mechanical force. Historically, this and casting were done by blacksmiths, though today the process has been industrialized. In bulk metal forming, the work piece is generally heated up.

i. Cold sizing
ii. Extrusion
iii. Drawing
iv. Forging
v. Powder metallurgy
vi. Friction drilling
vii. Rolling
viii. Burnishing

Sheet metal

These types of forming process involve the application of mechanical force at room temperature. However, some recent developments involve the heating of dies and/or parts. Advancements in automated metalworking technology have made progressive die stamping possible which is a method that can encompass punching, coining, bending and several other ways below that modify metal at less cost while resulting in less scrap.

i. Bending
ii. Coining
iii. DE cambering
iv. Deep drawing (DD)
v. Flow forming
vi. Hydroforming (HF)

vii. Hot metal gas forming
viii. Hot press hardening
ix. Incremental forming (IF)
x. Spinning, Shear forming or Flow forming

Figure 6: A Metal Spun brass vase

xi. Raising
xii. Roll forming
xiii. Roll bending
xiv. Repoussé and chasing
xv. Rubber pad forming
xvi. Shearing
xvii. Stamping
xviii. Superplastic forming (SPF)
xix. Wheeling using an English wheel (wheeling machine)

Cutting Process

Figure 7: A CNC Plasma Cutting Machine

Cutting

Cutting is a collection of processes wherein material is brought to a specified geometry by removing excess material using various kinds of tooling to leave a finished part that meets specifications. The net result of cutting is two products, the waste or excess material, and the finished part. In woodworking, the waste would be sawdust and excess wood. In cutting metals, the waste is chips or swarf and excess metal.

Cutting processes fall into one of three major categories:

- ❑ Chip producing processes most commonly known as machining
- ❑ Burning, a set of processes wherein the metal is cut by oxidizing a kerf to separate pieces of metal
- ❑ Miscellaneous specialty process, not falling easily into either of the above categories

Drilling a hole in a metal part is the most common example of a chip producing process. Using an oxy-fuel cutting torch to separate a plate of steel into smaller pieces is an example of burning. Chemical milling is an example of a specialty process that removes excess material by the use of etching chemicals and masking chemicals.

There are many technologies available to cut metal, including:

i. Manual technologies: saw, chisel, shear or snips
ii. Machine technologies: turning, milling, drilling, grinding, sawing
iii. Welding/burning technologies: burning by laser, oxy-fuel burning, and plasma
iv. Erosion technologies: by water jet, electric discharge, or abrasive flow machining.
v. Chemical technologies: Photochemical machining

Cutting fluid or coolant is used where there is significant friction and heat at the cutting interface between a cutter such as a drill or an end mill and the workpiece. Coolant is generally introduced by a spray across the face of the tool and workpiece to decrease friction and temperature at the cutting tool/workpiece interface to prevent excessive tool wear. In practice there are many methods of delivering coolant.

Milling

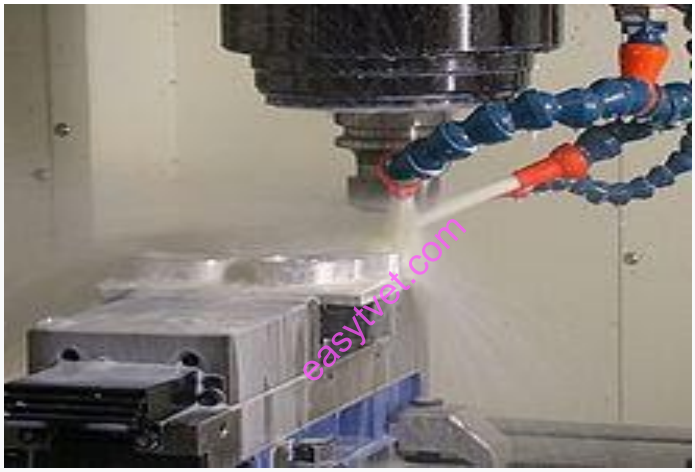


Figure 8: A Milling Machine in Operation, including Coolant Hoses

Milling (machining)

Milling is the complex shaping of metal or other materials by removing material to form the final shape. It is generally done on a milling machine, a power-driven machine that in its basic form consists of a milling cutter that rotates about the spindle axis (like a drill), and a worktable that can move in multiple directions (usually two dimensions [x and y axis] relative to the workpiece).

The spindle usually moves in the z axis. It is possible to raise the table (where the workpiece rests). Milling machines may be operated manually or under computer numerical control (CNC), and can perform a vast number of complex operations, such as slot

cutting, planning, drilling and threading, rabbeting, routing, etc. Two common types of mills are the horizontal mill and vertical mill.

The pieces produced are usually complex 3D objects that are converted into x, y, and z coordinates that are then fed into the CNC machine and allow it to complete the tasks required. The milling machine can produce most parts in 3D, but some require the objects to be rotated around the x, y, or z coordinate axis (depending on the need). Tolerances come in a variety of standards, depending on the locale. In countries still using the imperial system, this is usually in the thousandths of an inch (unit known as thou), depending on the specific machine. In many other European countries, standards following the ISO are used instead.

In order to keep the bit and material cool, a high temperature coolant is used. In most cases the coolant is sprayed from a hose directly onto the bit and material. This coolant can either be machine or user controlled, depending on the machine.

Materials that can be milled range from aluminum to stainless steel and almost everything in between. Each material requires a different speed on the milling tool and varies in the amount of material that can be removed in one pass of the tool. Harder materials are usually milled at slower speeds with small amounts of material removed. Softer materials vary, but usually are milled with a high bit speed.

The use of a milling machine adds costs that are factored into the manufacturing process. Each time the machine is used coolant is also used, which must be periodically added in order to prevent breaking bits. A milling bit must also be changed as needed in order to prevent damage to the material. Time is the biggest factor for costs. Complex parts can require hours to complete, while very simple parts take only minutes. This in turn varies the production time as well, as each part will require different amounts of time.

Safety is key with these machines. The bits are traveling at high speeds and removing pieces of usually scalding hot metal. The advantage of having a CNC milling machine is that it protects the machine operator.

Figure 9: A Lethe Cutting Material from a Workpiece

Turning

Turning is a metal cutting process for producing a cylindrical surface with a single point tool. The workpiece is rotated on a spindle and the cutting tool is fed into it radially, axially or both. Producing surfaces perpendicular to the workpiece axis is called facing. Producing surfaces using both radial and axial feeds is called profiling.

A lathe is a machine tool which spins a block or cylinder of material so that when abrasive, cutting, or deformation tools are applied to the workpiece, it can be shaped to produce an object which has rotational symmetry about an axis of rotation. Examples of objects that can be produced on a lathe include candlestick holders, crankshafts, camshafts, and bearing mounts.

Lathes have four main components: the bed, the headstock, the carriage, and the tailstock. The bed is a precise & very strong base which all of the other components rest upon for alignment. The headstock's spindle secures the workpiece with a chuck, whose jaws (usually three or four) are tightened around the piece. The spindle rotates at high speed, providing the energy to cut the material. While historically lathes were powered by belts from a line shaft, modern examples use electric motors.

The workpiece extends out of the spindle along the axis of rotation above the flat bed. The carriage is a platform that can be moved, precisely and independently parallel and perpendicular to the axis of rotation. A hardened cutting tool is held at the desired height (usually the middle of the workpiece) by the tool post. The carriage is then moved around the rotating workpiece, and the cutting tool gradually removes material from the workpiece. The tailstock can be slid along the axis of rotation and then locked in place as necessary. It may hold centers to further secure the workpiece, or cutting tools driven into the end of the workpiece.

Other operations that can be performed with a single point tool on a lathe are:

Chamfering : Cutting an angle on the corner of a cylinder.
Parting : The tool is fed radially into the workpiece to cut off the end of a part.
Threading : A tool is fed along and across the outside or inside surface of rotating parts to produce external or internal threads.
Boring : A single-point tool is fed linearly and parallel to the axis of rotation to create a round hole.
Drilling : Feeding the drill into the workpiece axially.
Knurling : Uses a tool to produce a rough surface texture on the work piece. Frequently used to allow grip by hand on a metal part.

Modern computer numerical control (CNC) lathes and (CNC) machining centres can do secondary operations like milling by using driven tools. When driven tools are used the work piece stops rotating and the driven tool executes the machining operation with a rotating cutting tool. The CNC machines use x, y, and z coordinates in order to control the turning tools and produce the product. Most modern-day CNC lathes are able to produce most turned objects in 3D.

Nearly all types of metal can be turned, although more time & specialist cutting tools are needed for harder workpieces.

Threading

Figure 10: Three Different Types and Sized of Taps

Threading (manufacturing)

There are many threading processes including:

i. Cutting threads with a tap or die,
ii. Thread milling,
iii. Single-point thread cutting,
iv. Thread rolling,
v. Cold root rolling and forming,
vi. thread grinding.

A tap is used to cut a female thread on the inside surface of a pre-drilled hole, while a die cuts a male thread on a preformed cylindrical rod

Grinding

Figure 11: Grinding

Grinding uses an abrasive process to remove material from the workpiece. A grinding machine is a machine tool used for producing very fine finishes, making very light cuts, or high precision forms using an abrasive wheel as the cutting device. This wheel can be made up of various sizes and types of stones, diamonds or inorganic materials.

The simplest grinder is a bench grinder or a hand-held angle grinder, for deburring parts or cutting metal with a zip-disc.

Grinders have increased in size and complexity with advances in time and technology. From the old days of a manual toolroom grinder sharpening endmills for a production shop, to today's 30000 RPM CNC auto-loading manufacturing cell producing jet turbines, grinding processes vary greatly.

Grinders need to be very rigid machines to produce the required finish. Some grinders are even used to produce glass scales for positioning CNC machine axis. The common rule is the machines used to produce scales be 10 times more accurate than the machines the parts are produced for.

In the past grinders were used for finishing operations only because of limitations of tooling. Modern grinding wheel materials and the use of industrial diamonds or other man-made coatings (cubic boron nitride) on wheel forms have allowed grinders to achieve excellent results in production environments instead of being relegated to the back of the shop.

Modern technology has advanced grinding operations to include CNC controls, high material removal rates with high precision, lending itself well to aerospace applications and high-volume production runs of precision components.

Filing

Filing (metalworking)

Figure 12: Filing

A file is an abrasive surface like this one that allows machinists to remove small, imprecise amounts of metal.

Filing is combination of grinding and saw tooth cutting using a file. Prior to the development of modern machining equipment, it provided a relatively accurate means for the production of small parts, especially those with flat surfaces. The skilled use of a file allowed a machinist to work to fine tolerances and was the hallmark of the craft. Files can vary in shape, coarseness, and whether the teeth or single cut or double cut depending on what application the file is to be used for. Today filing is rarely used as a production technique in industry, though it remains as a common method of deburring.

Joining process

Figure 13: Mig Welding

Welding

Welding is a fabrication process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the workpieces and adding a filler material to form a pool of molten material that cools to become a strong joint, but sometimes pressure is used in conjunction with heat, or by itself, to produce the weld.

Many different energy sources can be used for welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding can be done in many different environments, including open air, underwater and in space. Regardless of location, however, welding remains dangerous, and precautions must be taken to avoid burns, electric shock, poisonous fumes, and overexposure to ultraviolet light.

b) Brazing

Brazing is a joining process in which a filler metal is melted and drawn into a capillary formed by the assembly of two or more work pieces. The filler metal reacts metallurgically with the workpiece(s) and solidifies in the capillary, forming a strong joint. Unlike welding, the work piece is not melted. Brazing is similar to soldering, but occurs at temperatures in excess of 450 °C (842 °F).

Brazing has the advantage of producing fewer thermal stresses than welding, and brazed assemblies tend to be more ductile than weldments because alloying elements cannot segregate and precipitate.

Brazing techniques include, flame brazing, resistance brazing, furnace brazing, diffusion brazing, inductive brazing and vacuum brazing.

Soldering

Figure 14: Soldering a Printed Circuit Board

Soldering is a joining process that occurs at temperatures below 450 °C (842 °F). It is similar to brazing in the way that a filler is melted and drawn into a capillary to form a joint, although at a lower temperature. Because of this lower temperature and different alloys used as fillers, the metallurgical reaction between filler and work piece is minimal, resulting in a weaker joint.

Riveting

Riveting is one of the most ancient metalwork joining processes. It retains important uses in industry and construction, and in artisan crafts such as jewelry, medieval armouring and metal

couture . The earlier use of rivets is being superseded by improvements in welding and component fabrication techniques.

A rivet is essentially a two-headed and unthreaded bolt which holds two other pieces of metal together. Holes are drilled or punched through the two pieces of metal to be joined. The holes being aligned, a rivet is passed through the holes and permanent heads are formed onto the ends of the rivet utilizing hammers and forming dies (by either cold working or hotworking). Rivets are commonly purchased with one head already formed.

When it is necessary to remove rivets, one of the rivet's heads is sheared off with a cold chisel. The rivet is then driven out with a hammer and punch.

Associated processes

While these processes are not primary metalworking processes, they are often performed before or after metalworking processes.

Heat treatment

Metals can be heat treated to alter the properties of strength, ductility, toughness, hardness or resistance to corrosion. Common heat treatment processes include annealing, precipitation hardening, quenching, and tempering. The annealing process softens the metal by allowing recovery of cold work and grain growth. Quenching can be used to harden alloy steels, or in precipitation hardenable alloys, to trap dissolved solute atoms in solution. Tempering will cause the dissolved alloying elements to precipitate, or in the case of quenched steels, improve impact strength and ductile properties.

Often, mechanical and thermal treatments are combined in what is known as thermo-mechanical treatments for better properties and more efficient processing of materials. These processes are common to high alloy special steels, super alloys and titanium alloys.

Plating

Electroplating is a common surface-treatment technique. It involves bonding a thin layer of another metal such as gold, silver, chromium or zinc to the surface of the product by hydrolysis. It is used to reduce corrosion, create abrasion resistance and improve the product's aesthetic appearance. Plating can even change the properties of the original part including conductivity, heat dissipation or structural integrity. There are four main electroplating methods to ensure proper coating and cost effectiveness per product: mass plating, rack plating, continuous plating and line plating.

Thermal spraying

Thermal spraying techniques are another popular finishing option, and often have better high temperature properties than electroplated coatings due to the thicker coating. The four main

thermal spray processes include electric wire arc spray, flame (oxy acetylene combustion) spray, plasma spray and high velocity oxy fuel (HVOF) spray.

Learning Activities

A **corded drill** is the only real power tool that we will be using in this class. While cordless drills get all the fanfare, corded drills give you the most bang for your buck - particularly for metalworking. You don't need to be particularly portable in the shop, and corded drills never run low on power. They also have a lot of torque, which is useful for metalworking. While they typically don't have all the fancy settings you may find on a cordless drill, these drills basically do one thing and they do it very well.

For this course you will only need a **7/64" drill bit**. That said, you may as well invest in a **basic drill bit set**. This is just generally useful for metalworking. We will be discussing drill bits more in the drilling lesson.

Another thing you will need is a **6-32 tap**, and a **tap handle wrench**. This is used to thread drilled holes. We will be discussing this much more in the fastener lesson.

If it is solid, you can likely cut through it with a hacksaw**.** A hacksaw can cut through just about anything, it just may take a while. In this course, we will be cutting metal using a hacksaw. Aside from learning about how metal cuts in a hands-on manner, it should give you a healthy appreciation for power saws.

A **table vise** is a handy tool when holding parts by hand won't cut it. For this course, a small vise that clamps onto the table will do (pictured). If you get deeper into metalworking, you will want to get one more heavy duty (preferably with a built-in anvil**)** that bolts onto your workbench.

For more delicate shaping operations, a hand file set is much more useful than a hacksaw. Files come in a range of shapes, and sizes. They also have a range of cutting teeth arrangements to provide finer or rougher cuts in the metal. You may notice that my files here are all bastards. This does not mean they were forged out of wedlock, but have 30 teeth per inch (TPI). This is about an average tooth count, and good for general purpose use. There are countless configurations of files available for just about every imaginable purpose. Files are one of the most fundamental tools of metalworking, and are used in almost every aspect of metalworking for shaping and finishing parts. While filing metal may seem like a simple activity, it can take a lifetime to truly master.

When you saw and drill metal, you leave behind sharp raised uneven edges called burrs. The **deburring tool** is designed to remove them. By dragging along the edge of the cut surface,

the burr is simply scraped away. This leaves behind a nice smooth beveled edge in its place. We will go over this more in a bit.

When metalworking, you will want a hammer. If you have a standard **claw hammer** at home already, that will be fine for now. However, for metalworking you will eventually want to invest in a **ball peen hammer** and a **dead blow** (both pictured above). A ball peen hammer has a striking surface on one side, and a ball on the other for shaping metal. This is much more useful than a generic claw hammer, since you will unlikely have any nails that will need removing. In addition, a dead blow has a counterweight inside of the striking head that minimizes rebound and translates most of the force downwards onto the surface being struck. This is useful for shaping metal (amongst other things).

Center punches are used to mark the center of the hole you are trying to drill. When used correctly, they leave behind a small dimple that will keep your drill bit in place and prevent it from wandering. You shouldn't consider drilling metal without first center punching it.

A **scribe** is used to leave a really light scratch on the surface of a metal part. This is used for marking cut and drill lines. This is preferably to pencil or marker because a scratch line is thinner, more accurate, and does not wear off easily.

If you are going to making scribe lines on your metal, you are likely going to need to do some measuring. It is recommended you get **digital calipers** and a **metal ruler**. You have likely used a ruler before, but may have not use calipers. So, to explain, digital calipers have two jaws which slide back and forth upon a track. On the readout, it tells you the distance between the two jaws to a fraction of an inch. This is useful for making really precise measurements, which you often need to do for metal. Unlike softer materials such as wood or plastic, metal has no give. You need to be spot-on with your measurements.

For this course you will want to get wet/dry **sandpaper** in a variety of sizes from 220 up to 2000. This is a little different than normal dry sandpaper used for woodworking. The most important part, is that the paper is stronger and doesn't rip as easily. We will be discussing sanding much more in the finishing section.

The **buffing wheels** we will be using in this class are shank-mounted and designed to go into a drill bit. They are basically a bunch of thin layers of fabric sandwiched together. It is the edge of the sandwiched fabric disc that is used to buff metal. This is yet another thing we will discuss more later.

If you are using a buffing wheel, you will want to get some metal-appropriate **buffing compound**. There are many different types of buffing compounds. Essentially, they act upon the

surface of the metal much in the same way a fine sandpaper does. This is a finishing touch used to create a smooth, shiny, surface upon metal.

Self-Assessment

1. Which is not a safety practices in metal works?
   A. Any person handling sheet metal fabrication tools should be equipped with safety gear.
   B. They should wear hard hats, goggles, gloves, and safety shoes at all times.
   C. Make sure that when working or handling any product, your back and neck are supported adequately.
   D. Eating in the workshop.
2. Which metal is not used for metal work?
   A. Copper
   B. Iron,
   C. wood
   D. Bronze
3. What are the processes in metal works technology?
   A. Forming
   B. Cutting
   C. Joining.
   D. Casting
4. What is the easiest metal to work with?
   A. Welding metals
   B. Low carbon steel
   C. Cast iron.
   D. Silicon

Tools, Equipment and Materials

i. Hacksaw
ii. Table vise
iii. Hand file set
iv. Deburring tool
v. Corded drill
vi. 36 and 6-32 drill and tap set
vii. Center punch set
viii. 16 oz. ball peen hammer
ix. Steel ruler
x. Calipers
xi. Scribe
xii. Adjustable tap handle
xiii. Assorted sandpaper pack

xiv. 4" buffing wheels
xv. Surface Scratch Remover Buffing Compound

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Model answers for Self -Assessment

1. D
2. C
3. D
4. A

1.2.Install PVC Sheathed cable

Introduction

In this context, by the end of the lesson the learner should learn about PVC cables, PPEs, learn about meaning of PVC sheathed cables, types and wiring methods.

Performance standard

i. Meaning of PVC sheathed cables
ii. Types of sheathed cables
iii. PVC sheathed cables wiring methods
iv. Applications of sheathed cables

Information Sheet

PVC sheathed cable

PVC is considered one of the most versatile among the thermoplastic materials. Used as a base material to cover the surface of electric cables, it is particularly suitable for the construction of electrical energy systems made up of rigid cables, long lasting and resistant to any type of

temperature. The cables with PVC covering are therefore ideal for outdoor use and are specially designed to give the installer the opportunity to realize both the installation and the raceways.

A thermoplastic-sheathed cable (TPS) consists of a toughened outer sheath of polyvinyl chloride (PVC) thermoplastic, covering one or more individual annealed copper conductors, themselves insulated with PVC. This type of wiring is commonly used for residential and light commercial construction in many countries.

Cables with PVC covers or insulation are:

Flame retardants resistant to various chemicals, including oils, acids and alkalis.

Given their lightness, PVC covers must be used with full knowledge and located in areas not subject to excessive impact or pressure. Furthermore, since the PVC coverings do not guarantee a great resistance to heat, it is advisable not to use them in areas exposed to high temperatures.

When to use PVC cables

One of the main problems that may arise while using electric wires is the short circuit, responsible for fires and propagation of free flames very dangerous for the general safety.

Given the composition of the protections, the cables in PPE or PE are particularly resistant to fire and indicated to ensure therefore higher levels of protection against possible propagation of flames and fire in the event of a short circuit.

In order to be able to use PPE cables in the most congenial way, it is necessary to keep in mind the European legislation, in order to create an adequate compromise on the use of practical, functional and at the same time safe power cables.

For this reason, the main European legislation systems have immediately issued laws designed to guarantee users and installers the maximum degree of safety in the construction of power plants.

The objective of the regulations is to verify, through practical tests, that:

i. During the arrangement the cables cannot harm the installer;
ii. The cables resist heat and do not feed any flames;

iii. In the event of a short circuit, do not cause flames;
iv. Possible splashes of water do not trigger a short circuit;
v. The quality of the cable guarantees an optimal yield.

The IEC 60331-11 standard

There are some main protocols, issued specifically to verify the resistance of electric cables at particularly high temperatures. One of these is the international IEC 60331-11 protocol, which provides for the exposure of cables (of standard length) to a flame having a temperature of up to 750 degrees Celsius, for at least an hour and a half.

Other tests are carried out in a similar manner and are dedicated to safeguarding the safety of the installer and the end user, who is primarily responsible for the use of the power plant.

Types of Sheathed Cables

Cable types may be grouped according to:

i. **Conductor used**: - according to the conducting material used i.e., cables made of copper, aluminum etc.
ii. **According to the number of cores**: bases on the number of cores a cable consists of, the cables may be divided into classes known as single core cables; twin core cables; three core cables.
iii. **According to the voltage grading,** the cables may be divided into (I) 250/440-volt cables and (II) 650/1,100-volt cables.
iv. **According to the type of insulation used**: these types of cables may be categorized as;
    a) Vulcanized Indian – Rubber (VIR) insulated cables.
    b) Tough rubber sheathed (TRS) or cab tyre sheathed (CTS) cables.
    c) Polyvinyl Chloride cables (PVC)
    d) Lead sheath cables
    e) Weather proof cables
    f) Flexible cords and cable

Advantages & Disadvantages of Different Sheathed cables

i. **Plastic insulated cables.** It has the advantage of good insulation performance, the manufacturing process is simple, the price is low, regardless of the application or pipe can replace the rubber insulation, thus saving a lot of rubber and cotton yarn.

The disadvantage is poor performance to adapt to the climate, low temperature when the hard brittle, high temperature or sunlight under the plasticizer is easy to volatilize insulation aging accelerated. Therefore, in the absence of effective insulation measures in the high temperature environment, daylight exposure or cold places should choose the appropriate special type of plastic cable.

ii. **Neoprene insulated cable.** Increasing weight, 35mm2 below the ordinary rubber line has been replaced by chloroprene rubber insulated cable trend. It is characterized by good oil resistance, not easy mold, no flame, to adapt to climate performance, light aging process is slow, aging time is about two times the ordinary rubber insulated cable, so suitable for outdoor laying. Since the mechanical strength of the insulating layer is weaker than that of ordinary rubber, it is not recommended for pipe laying.

iii. **Overhead insulated cable**, the use of increasingly wide, it is better resistance to light aging performance, mainly for high groundwater level, excellent place to deal with corrosion of liquid overflow, two plant outside the cable number of small and inconvenient buried underground, the Cable is suitable for urban distribution cable reconstruction.

iv. **viscous impregnated low insulation power cable,** its advantages allow high operating temperature, low dielectric loss, high voltage strength, long life, the shortcomings of poor insulation properties of insulating materials cannot be laid at low temperatures, or easy to damage insulation.

v. **PVC insulated and sheathed power cable** (referred to as plastic cable), 1KV and 6KV poles, the main advantage is the manufacturing process is simple, no laying height difference, light weight, bending performance, Simple, resistant to acid and alkali corrosion, no flame, with internal armor structure, so that steel or steel wire from corrosion, cheap.

vi. **Rubber insulated power cable**. Its bending performance is better, can be laid in the cold climate, especially for the laying of line height difference and vertical laying occasions. It is not only suitable for fixed laying lines, but also for fixed movement of fixed laying lines. Mobile electrical equipment, power supply circuit should be used rubber insulated rubber sheathed flexible cable (referred to as rubber flexible cable)

vii. **Metal sheathed mineral insulated cables**. High temperature, high temperature, 1000 ℃) and the following high temperature, high humidity, high temperature, high temperature, high temperature, high temperature, high temperature, high temperature, , Flammable, explosive environment. Its long-term working environment temperature up to 250ºC ~ 400ºC, is the ideal high temperature cable.

PILC Solid Type Copper

Single or Three Conductors

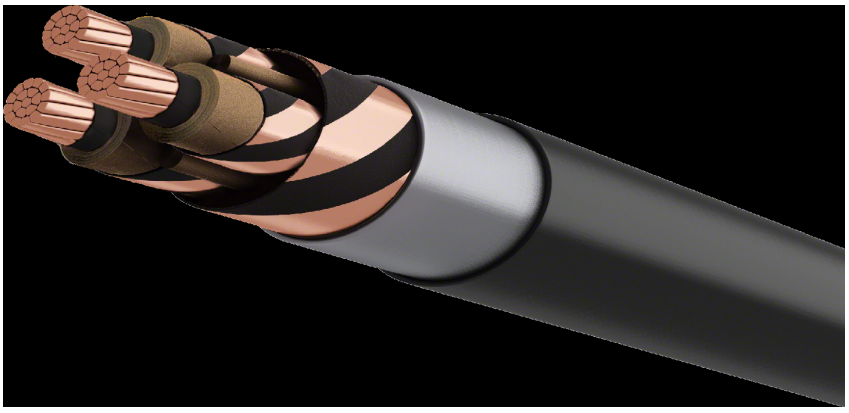


Figure 15: Parts of PILC Cables

i. **Copper Conductor**: Annealed bare copper conductor, normal, compact round, or compact sectoral stranded, per ASTM B3, B8, B496.

ii. **Conductor Shield**: Carbon black impregnated semiconducting paper tapes adjacent to and in contact with the conductor.

iii. **Insulation**: Paper, 100% high quality sulphate – processed wood pulp paper tapes helically and uniformly applied around the conductor.

iv. **Insulation Shielding**: For 10 kV rated cables and up, semiconducting carbon black paper tapes over the insulation in single conductor cable. In shielded multiple conductor cable, copper tapes intercalated with carbon black semi-conducting paper tapes over individual insulation. Belted multi-conductor shielded cables shall have a shielding consisting of carbon black semiconducting paper tapes.

Assembly (Multi-conductor cables): Individual insulated conductors are cabled with paper fillers in interstices to give around core, and a binder paper tape.

v. **Binder**: For shielded multi-conductor cables an optional binder of semi-conducting tapes (20 mil maximum), paper tapes (20 mil maximum) or copper tapes intercalated with paper tapes. Impregnate: High viscosity impregnating oil, applied after an appropriate vacuum drying process.

vi. **Sheath**: Commercially pure lead sheath. Some other lead alloys available on request.

vii. **Jacket**: Extruded thermoplastic polyethylene. Optional polyvinyl chloride (PVC) jacket.

Advantages:
PILC cables are hermetically sealed with a lead sheath, which protect the cables against humidity, gasoline and most chemical agents.
Outer jacket provides additional protection against corrosion and galvanic action.

Application
PILC cables are used in power distribution and other industrial circuits, where it is necessary to splice into existing PILC cable system.

Reasons Why PVC Cables Are Widely Used for Internal Wiring

i. PVC insulation provides better flexibility for the cables
ii. PVC insulation has better insulating qualities
iii. PVC insulation is not highly affected by chemicals
iv. PVC insulation has thin layer which will give smaller diameter of cables which makes it possible to accommodate more wires in the conduit of a given size unlike VIR or CTS wires

Flexible cables

Flexible cables are cables containing one or more cores each formed of a group of wires, the diameter of cores and of the wires being very small in order to give it flexibility.

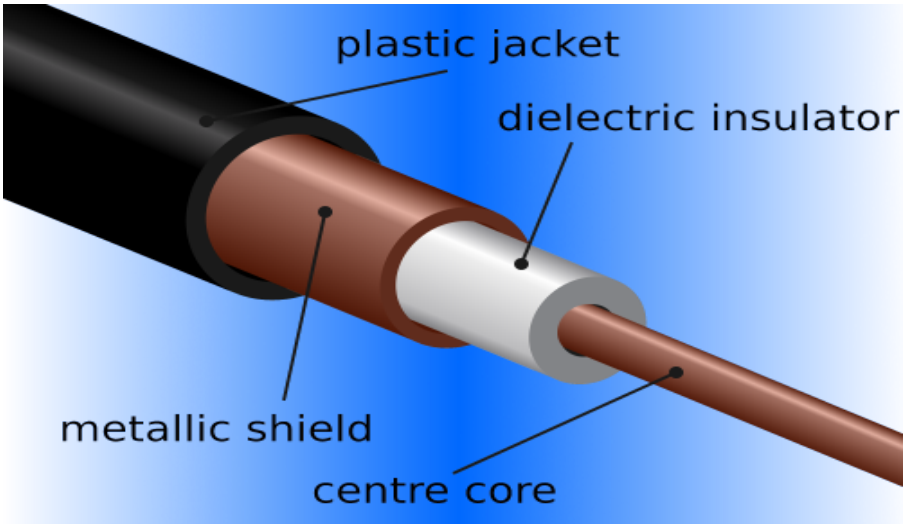


Figure 16: Flexible Cable

These cables are used as connecting wires for portable apparatus such as radios, fans and lamp holders etc. The flexibility of the cable prevents it from easy breakage.

PVC sheathed cables wiring methods

Electrical wiring system (methods)

It is a network of wires connecting various accessories for distribution of electrical energy from the supplier meter board to devices that consumes the energy such as televisions, refrigerators, fans, lamps etc.

Choice of Wiring Systems

Before wiring start, right choice of wiring should be made basing on technical and economic factors.

Factors to be considered when making choice for a particular system of wiring;

i. Cost of wiring: - The initial cost of the wiring system to be chosen or selected should be economical.
ii. Durability: - wiring type should be durable (long lasting) and should also be of proper specifications and in accordance with assessed life and type of building to be wired.

iii. Permanency: The wiring should not deteriorate by the action of weather, fumes, dampness etc. the cables should be resistant to harsh weather and chemical attacks.
iv. Accessibility: Facilities used in the wiring should be available (within range) and accessible when the need for alteration, extension or renewal arises.
v. Appearance: The wiring should provide a good look after its installation.
vi. Mechanical Protection: The wiring should be protected from mechanical damage during its use.
vii. Safety: When it comes to wiring, safety is paramount factors to be considered because electrocution is one thing you won't have the time to give it a second thought. Where there is possibility of fire hazard, conduit wiring should be used.
viii. Maintenance Cost: Wiring system employed should have low maintenance cost.
ix. Load: The types of loads consuming the electrical energy in a building will determine the kinds of cables to be used. You cannot use a cable with small diameter for heavy loads (high current) as cables will be damaged. Voltage to be employed and fire hazard and insurance standards should also be kept in mind in case of large factories

Types of Electrical Wiring Systems and installation used in Internal Wiring

PVC sheath Wiring (CTS or TRS)

Is in form of single core or double core or three core circular oval shape cables.
TRS cables are chemical, water, steam proof, but are slightly affected by lubricating oil.
They are run on wood batten with at least a thickness of 10mm.
They are held on the wooden batten by means of tinned brass link clips (buckle clip) already fixed on the batten with brass pins and spaced 10cm horizontal and 15cm for vertical runs.

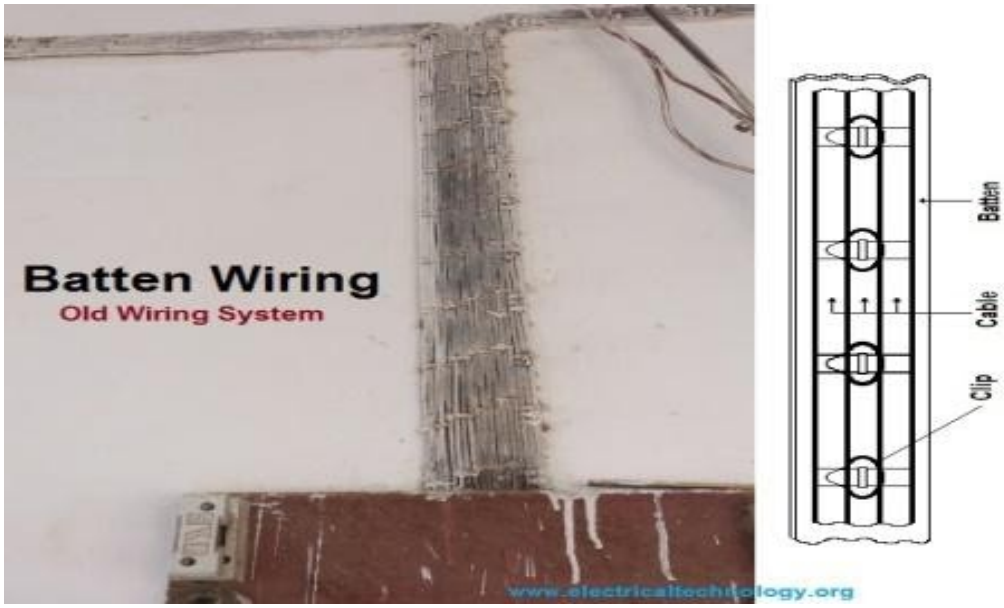


Figure 17: House Service Overhead System

Figure 18: House Service Overhead System

i. In electric power distribution, a service drop is an overhead electrical line running from a utility pole, to a customer's building or other premises. It is the point where electric utilities provide power to their customers.
ii. The customer connection to an underground distribution system is usually called a "service lateral". Conductors of a service drop or lateral are usually owned and maintained by the utility company, but some industrial drops are installed and owned by the customer.
iii. At the customer's premises, the wires usually enter the building through a weatherhead that protects against entry of rain and snow, and drop down through conduit to an electric meter which measures and records the power used for billing purposes, then enters the main service panel.
iv. The utility's portion of the system ends, and the customer's wiring begins, at the output socket of the electric meter.
v. The service panel will contain a "main" fuse or circuit breaker, which controls all of the electric current entering the building at once, and a number of smaller fuses/breakers, which protect individual branch circuits.
vi. There is always provision for all power to be cut off by operating either a single switch or small number of switches (maximum of six in the United States, for example); when circuit breakers are used this is provided by the main circuit breaker.

Advantages of PVC sheath Wiring

i. Wiring installation is simple and easy

ii. cheap as compared to other electrical wiring systems
iii. Paraphrase is good and beautiful
iv. Repairing is easy
v. Customization can be easily done in this wiring system.
vi. less chance of leakage current in batten wiring system

Disadvantages of PVC sheath Wiring

i. Cannot be installed in the humidity, Chemical effects, open and outdoor areas.
ii. High risk of fires.
iii. Not safe from external wear & tear and weather effects (because, the wires are openly visible to heat, dust, steam and smoke.
iv. Heavy wires can't be used in batten wiring system.
v. Only suitable below 250V.
vi. Need more cables and wires.

Lead Sheathed wiring (mineral insulated metal sheath)

The type of wiring employs conductors that are insulated with VIR and covered with an outer sheath of lead aluminium alloy containing about 95% of lead. The metal sheath gives protection to cables from mechanical damage, moisture and atmospheric corrosion.
The whole lead covering is made electrically continuous and is connected to earth at the point of entry to protect against electrolytic action due to leaking current and to provide safety in case the sheath becomes alive. The cables are run on wooden batten and fixed by means of link clips just as in TRS wiring.

Applications and benefits of mineral insulated cable (MIC)
MI cable is a specialized type of cable used in high temperatures or harsh environmental conditions because it has low flammability, even when operating at high temperatures. It resists oxidation and enables precise measurement.

Mineral insulated cable consists of copper or thermocouple wires inside a copper, stainless steel, or Inconel® sheath, insulated by packed minerals such as magnesium oxide (MgO). Magnesium oxide makes an excellent electrical insulation material because it resists oxidation and ionizing radiation, and it is both chemically and physically stable at high temperatures. After the cable has been packed with MgO insulation, it may be rolled under pressure to achieve the desired diameter. The outer sheath protects the internal thermocouple wire from heat, chemical or other environmental damage. The metal sheath may be covered with an additional colored plastic

sheath to add in identification and to add an additional layer of protection from corrosion.

An MI cable may contain any number of wires, but the most common configurations include 1, 2 or 3 pairs of conductors. Specialized MI cables may include additional thermocouples in customized configurations. MI cable is available in a variety of diameters and lengths, depending on the specific requirements. Many MI cables are calibrated using sensitive, fast and highly accurate dry block probe calibrators.

RTD and thermocouple sensors manufactured from MI cable are used extensively in heat treating metals, solid waste incinerators, sintering powdered metals, firing ceramic materials, gas or oil-fired furnaces, fuel fired heat exchangers, box furnaces, and nuclear or hydrocarbon-based energy plants.

Advantages of MI Cable

Figure 19: A Diagram on Advantaged of MI Cable

Molten Metal Oil Rig The metal sheath that clads MI cable helps to protect the thermocouple wires from oxidation when used in chemically active or wet environments.
Corrosion resistance makes MI cable ideal for use in areas where failure and replacement could be dangerous or even impossible. For example, MI cable is used in nuclear plants to monitor core temperatures. It would be extremely dangerous if the temperature controllers were not receiving accurate readings, and it would be difficult to repair or replace cables in that environment.

The mineral fillings in MI cables provide excellent non-reactive insulation, preventing the thermocouple wires from contact with each other or with caustic substances such as oils, solvents or water. This helps to ensure that the thermocouple probes remain accurate, critical in applications such as heat treating or sintering where the quality of the product could be adversely affected by temperature fluctuations.

The insulation in MI cables does not burn, which makes it ideal for applications where fire could be catastrophic. Medical devices, power plants, and oil rigs are examples of places where installation of MI cables makes operations safer.

Since the thermocouple probes are protected from contact with other electrically active wires by the insulation, they are not readily subject to malfunction or inaccurate temperature measurements. Carefully calibrated to meet international standards, MI cables provide accurate and precise temperature measurement over long duty cycles with little or no loss of accuracy.

Because of the mineral insulation, MI cables can operate in high-temperature conditions with no loss of accuracy. This makes them ideal in kilns, firing ceramics or heat-treating metals or in any high-temperature process. MI cables retain their accuracy even during and after exposure to high temperatures, so they are ideal as a thermocouple probe in these operations. In addition, for industries such as medical devices or aerospace where safety standards are strictly enforced, process deviations could result in life-threatening quality issues. MI cables are carefully calibrated and verified using NIST standards at Omega against known temperatures or certified thermometers. NIST traceable calibration ensures temperature accuracy under actual operating conditions and provides documentation of their original accuracy. To remain NIST certified, the chain of verification must be intact and the thermocouples must be recalibrated as part of a well-documented and executed quality management system.

Properties and Advantages of Mineral Insulated Cables

At room temperature and up to the more common application temperatures mineral powder insulates so well that the sheath can be considered to be entirely separated from the inner conductor. Consequently, there are no adverse effects if the conductor touches other metal parts of the equipment or is connected to them.

Long Life

The construction of the cable guarantees a long conductor life and thus the function of the conductor because the sheath and the insulating powder protect the conductors (cores) against environmental conditions such as corrosion or scaling.

Easy Installation

The cables are pliable, easy to handle and can be installed easily in a limited space or in locations where access is difficult. No additional insulation is required.

Mechanical Strength

The compact construction with densely packed mineral powder and the robust metal sheath ensures the position of the conductors in the compound and thus the function of the cable even when exposed to mechanical stresses such as bending, twisting or flattening. The cable can also be used in pressure or vacuum equipment.

Safety

Since the insulation is attained exclusively from powders on a mineral base the cables are fire-proof and can thus be exposed to considerably higher temperatures than cables with synthetic sheaths (e.g., PVC, teflon or textile fibres etc.).

Rapid Response

The high density of the mineral powder effects rapid transmission of heat between conductor and sheath: This factor makes the cable highly suitable for temperature measurement and control techniques.

Dielectric Strength

Despite its small size the compact construction allows an amazingly high dielectric strength conductor/conductor or conductor/sheath, respectively, which means the cables can be used in power supply systems at 220 V and above.

Radiation Resistance

The correct choice of component ensures radiation resistance making possible the use of these cables in primary circuits as well as in the incore area, i.e. inside the actual reactor core.

Corrosion and Scaling Resistance

The vast array of materials included in our standard programme and the possibility to make materials to specification has put us in a position to supply suitable sheath materials even for unfavorable environmental conditions in a corrosive atmosphere and at high temperatures. Depending on the choice of component the maximum application temperatures are between 500ºC and 1000ºC.

Long Lengths

Long lengths of cable can be obtained due to the initial measurements before drawing and the production method.

Small Cable Diameter

The relatively small diameter (compared with conventional cables) which is a result of the construction has many advantages for both customer and construction engineer.

Learning Activities

i. Identification of various types of cables and their areas of applications
ii. Justification for the choice of different types of wring system.

Self-Assessment

1. What are the disadvantages of Polyvinyl Chloride?
2. What are hazards of PVC material?
3. What happens to PVC material as its ages?
4. Why is PVC used for cables?

Tools, Equipment and Materials

i. PPE including working gloves, overalls/dustcoats, safety shoes, helmets, goggles, safety harness.
ii. Distribution boards
iii. Consumer control units (complete with circuit breakers)
iv. Utility boxes
v. Screws
vi. Accessories/fittings
vii. Fasteners/clipper

viii. Junction boxes

References

i. https://www.prysmiancable.com.au/construction/pvc-cables-recommended-installation-practices/
ii. https://www.electricveda.com/building-services/wiring-materials-and-installation-methods-in-electrical-construction-works

Model Answers to Self-Assessment

1. Disadvantages of Polyvinyl Chloride
   i. Polyvinyl Chloride has very poor heat stability. For this reason, additives which stabilize the material at higher temperatures are typically added to the material during production.
   ii. Polyvinyl Chloride emits toxic fumes when melted and/or subject to a fire.

2. Hazards of PVC material
   PVC contains dangerous chemical additives including phthalates, lead, cadmium, and/or organotins, which can be toxic to your child's health. These toxic additives can leach out or evaporate into the air over time, posing unnecessary dangers to children.

3. Effects of aging to PVC material
   PVC get brittle with age, even in the ground, I can tell you that. PVC becomes increasingly brittle as the temperature drops. When exposed to freezing temperatures for prolonged periods of time, it can become brittle enough to crack quite easily.

4. Advantages of PVC used for cables
   i. PVC insulation is frequently used owing to its good insulating properties but low corona resistance, and is best suited for low and medium voltage cables and low frequency insulation requirements.
   ii. The benefits of PVC as cable insulation and sheathing material include its chemical stability, robustness and durability

1.3.Install electrical metallic/non- metallic (PVC) conduits

Introduction

In this context, describes on how to install PVC conduits, learn on-site communications and electrical symbols for drawings that help in interpretation of electrical drawings and plans and finally on maintenance and storage of tools and equipment

Performance Standard

i. Interpretation of electrical drawings and plans
ii. Identification and use
iii. Storage of tools and equipment
iv. Maintenance and storage of tools and equipment
v. Materials specification
vi. Use of materials

Information Sheet
Interpretation of electrical drawings and plans

On-site communications
Good communication is about transferring information from one person to another.
Electricians and other professionals in the construction trades communicate with each other and the general public by means of drawings, sketches and symbols, in addition to what we say and do. drawings and diagrams Many different types of electrical drawing and diagram can be identified: layout, schematic, block, wiring and diagrams.

The type of diagram to be used in any particular application is the one which most clearly communicates the desired information.

Layout drawings -These are scale drawings based upon the architect's site plan of the building and show the positions 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.

Electrical symbol for drawing
For electrical drawing, commonly used by contractor for electrical industry is the British Standard EN 60617 for Graphical Symbols for Electrical Power, Telecommunications and Electronic Diagrams.

This electrical symbol is easy to understand without complex shape or symbol to avoid confusing and it effected the work installation progress.

Below are some of the electrical symbols that are commonly used for electrical drawing.
We can used from others symbol that suitable with our application and country code. The main purpose is to easier identified the electrical drawing for works installation.

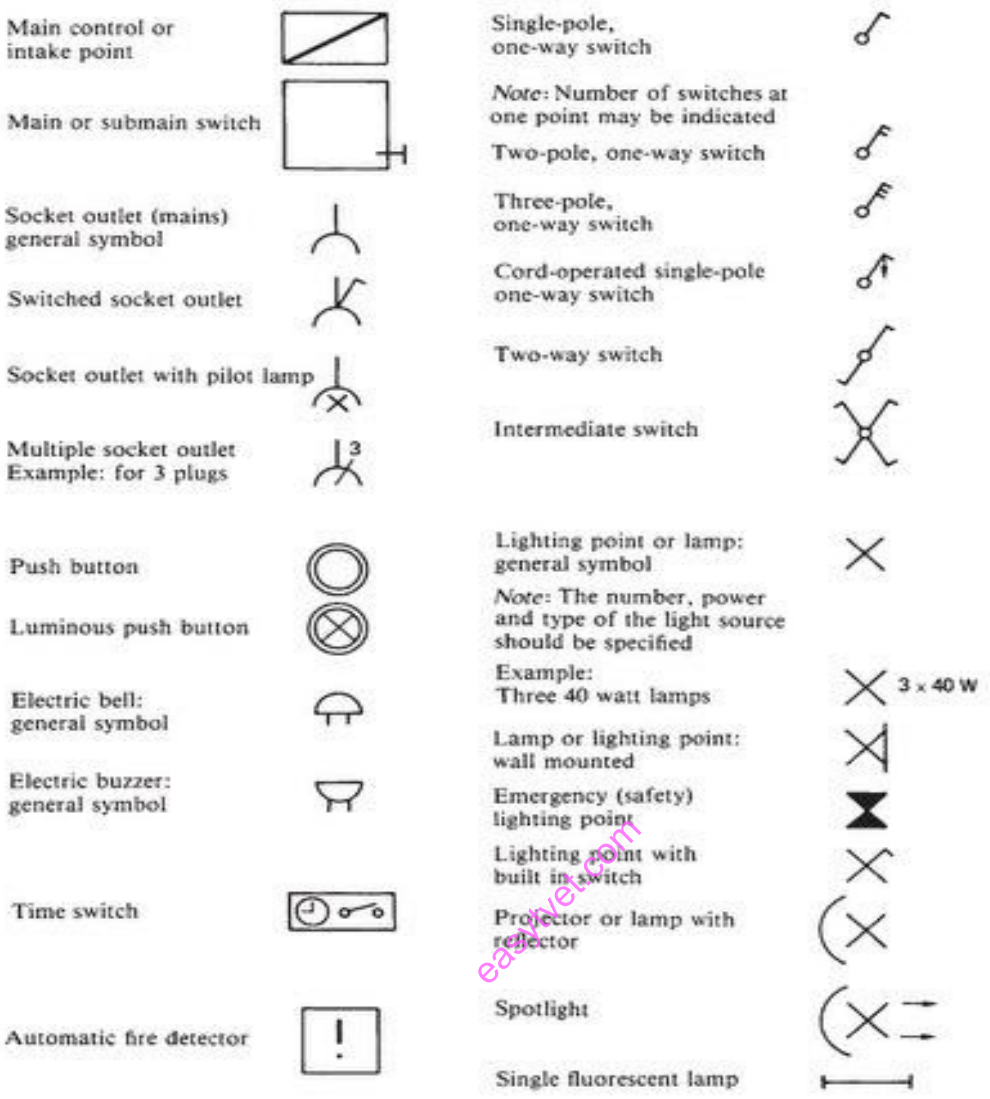


Figure 20: Electrical Symbols

This electrical symbol is different depend on country standard code and application. It not the big matter because the important thing is, we can do our electrical installation works in proper manner and completed it with successful.

Here is an example of electrical wiring diagram

This is called by layout drawing. From these we easier can do our jobs with actual location for all equipment installation and electrical wiring purpose.

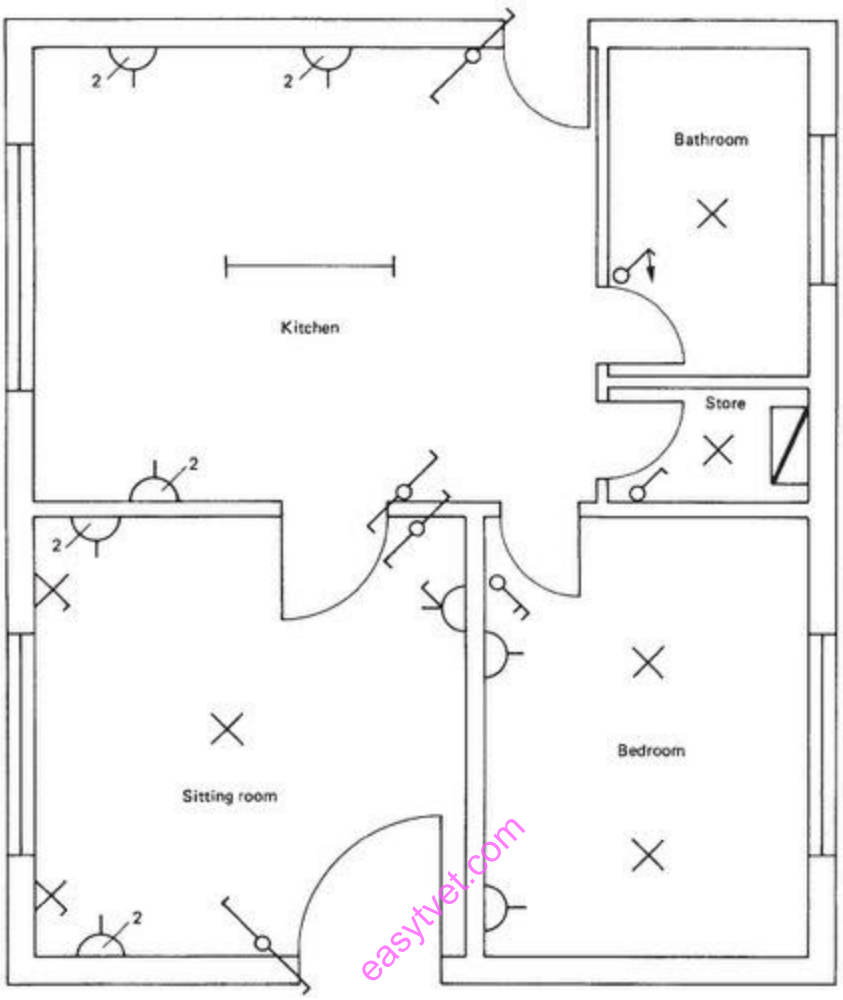


Figure 21: Layout drawing for electrical installation

i. A layout drawing of a small domestic extension is shown in figure above.
ii. It can be seen that the mains intake position, probably a consumer's unit, is situated in the store-room which also contains one light controlled by a switch at the door.
iii. The bathroom contains one lighting point controlled by a one-way switch at the door.
iv. The kitchen has two doors and a switch is installed at each door to control the fluorescent luminaire.
v. There are also three double sockets situated around the kitchen.
vi. The sitting room has a two-way switch at each door controlling the centre lighting point.
vii. Two wall lights with built-in switches are to be wired, one at each side of the window. Two double sockets and one switched socket are also to be installed in the sitting room. The bedroom has two lighting points controlled independently by two one-way switches at the door.

The basic maintenance of electrical tools and equipment

i. Wipe the cords down to keep them from becoming damaged from oil and grease.
ii. The prongs on the cords should be examined as well.
iii. Make sure that the casing is intact and the prongs are not loose. The electric tools in your toolbox that have a cutting surface should be lightly oiled to prevent rust.

Installation of Conduits

Types of Conduits

i. 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.
ii. 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.

Examples of types of conduit used in electrical installation work are as follows :

i. Steel
ii. PVC
iii. Flexible
iv. Stainless Steel

Steel Conduit System

Types and Sizes of Steel Conduit

i. Steel conduits are manufactured to specifications defined by the British Standards Institute (BS).
ii. Class 4 conduit has a hot dip galvanized finish. It is of heavy gauge with a welded seam. This conduit is suitable for use in external or damp installations.This is the conduit most widely used in this country.
iii. Note:The galvanized finish on conduit is to prevent the steel from corroding in normal use.
iv. Also manufactured is a solid drawn seamless conduit which is more expensive and only used for special gas tight, explosion proof or flame proof installations.
v. Conduit is normally supplied in 3 or 3.75 metre lengths and typical conduit external diameters are 16, 20, 25 and 32mm.

Eddy Currents in Steel Conduit

Metal conduits in which a.c. circuit wiring is installed MUST contain all the current carrying conductors of each circuit in the same conduit, to eliminate the possibility of induced eddy currents. Eddy currents could result in the metal conduit and cables becoming hot.

Advantages of Steel Conduit

i. Affords cables good mechanical protection
ii. Permits easy rewiring
iii. Minimises fire risks.
iv. Can be utilized as the Circuit Protective Conductor. (CPC)

Disadvantages of Steel Conduit

i. Under certain conditions moisture is liable to form on the inside wall of the conduit.
ii. Expensive compared with some other wiring systems.
iii. Liable to corrosion where subject to acids, alkalis and corrosive fumes.

Cable Capacity of Steel Conduit (Space Factor)

i. Having determined the correct number and cross-sectional area of cables for a given load it is necessary to select the size of conduit that will accomodate them.
ii. If a greater number of cables are installed in the conduit, over-heating, insulation damage and fire may result. As a general rule the number of cables drawn into a conduit should not be such as to cause damage to either the cables or the conduit during the installation.
iii. The maximum number of cables which may be drawn into a conduit can be calculated by using the factor system described in the ETCI Rules.

Cutting Steel Conduit

Conduit should be cut with a hacksaw, using a blade having 32 teeth / inch.
The cut should be made at right angles to avoid difficulty in threading the conduit.

i. Hold conduit to be cut securely in a pipe vice. Avoid damage to the galvanised coating.
ii. Stand square to the job and make sure your movement is unobstructed.
iii. Grip the hacksaw lightly and apply light pressure on the forward cutting stroke. Use the full length of the blade.

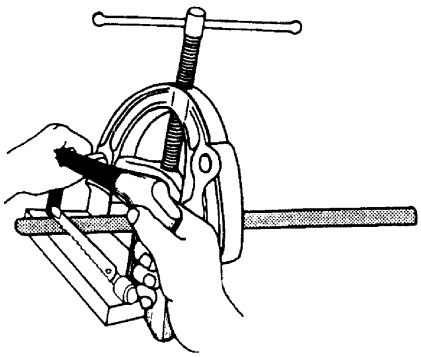


Figure 22: Threading Steel Conduit

It is necessary to cut threads on the conduit ends in order to screw them into conduit couplings and accessory boxes. The conduit ends are threaded using stocks and dies. After threading the ends, all internal burrs must be removed to ensure that cables are not damaged as they are being drawn into the conduits.
All threaded ends must be screwed up tightly into accessories to ensure earth continuity.

i. Hold the conduit securely in a pipe vice (ensure that pipe vice jaw bolts are tight).
ii. While threading keep the die well lubricated preferably with a manufacturer's paste or tallow.
iii. Thread to required length and remove any burrs with a file or reamer, this will prevent sharp edges causing damage to cables while being drawn into the conduit.
iv. To ensure a clean, unbroken thread the die should be rotated counter-clockwise frequently and finally run up and down the threads to remove any swarf (metal fragments).

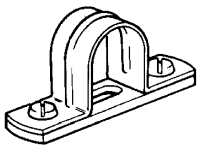
Fitting and Fixing Steel Conduit

Conduit must be securely fixed and where it is liable to mechanical damage, it should be suitably protected.
Drainage outlets must be provided at points where condensation is likely to collect.
Spacing of Supports for Conduits
The table below shows a suggested spacing of supports for steel conduits up to 25mm in diameter. Supports should be positioned within 300mm of bends and fittings. The table assumes that the conduit is not subject to other external mechanical stresses.

Conduit Size	Horizontal Runs	Vertical Runs
Not exceeding 16mm	750mm	1000mm
20-25mm	1750mm	2000mm

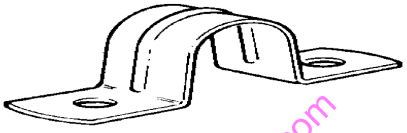
Saddle Spacing of Supports for Conduits

A range of clips and saddles are available for conduit installations. The spacer bar saddle, is the device most commonly used for fixing conduit, see Figure 2. They provide a very secure method of fixing and generally should be spaced as per the table on the previous page.



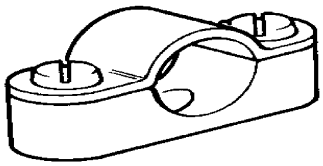
Spacer bar saddles incorporate a spacing plate. These spacing plates are approximately 5mm thick. This spacing plate tends to align the conduit with the knockouts in switch and socket outlet boxes. On vertical runs ensure that saddles are fitted the correct way round. An important function of the spacer bar saddle is to keep the conduit out of contact with plaster and cement surfaces. Contact between conduit and these surfaces could result in corrosion of the conduit and discolourment of the surfaces.

When a conduit is fixed to concrete, much installation time is spent in plugging the concrete for fixings. Spacer bar saddles have the advantage of a central, single-hole fixing. The additional cost of spacer bar saddles over the plain saddle can be offset against the saving in time and effort required in fixing.



Distance Saddles

Distance saddles are designed to space the conduit approximately 10mm from the wall or ceiling. These saddles are generally made of malleable cast iron. They are much more substantial than spacer bar saddles and the additional spacing provides greater protection against corrosion. The use of distance saddles eliminates the possibility of dust and dirt collecting behind the conduit. By adequate spacing it is possible to keep the conduits free of dust and it is for this reason distance saddles and hospital saddles are generally specified.



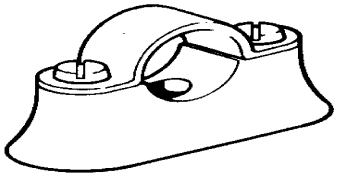


Figure 23: Distance Saddles

Multiple Saddles

Where two or more conduits follow the same route, it is generally an advantage to use multiple saddles. Proper spacing of the conduits ensures that there is no need to set the conduits where they enter conduit accessories

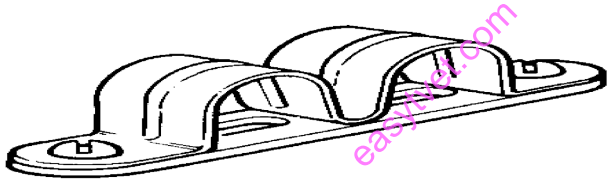


Figure 24: Multiple Saddles

Termination of Steel Conduit to Enclosures

Two methods of terminating steel conduit are commonly used.

a) The coupling and male bush method
b) The locknut and female bush method

Coupling and Male bush Method

The coupling and male bush method is slightly more expensive than the locknut and female bush method but it allows more wiring space and is a stronger form of termination. Using this method a coupling is screwed securely on to a standard threaded conduit end and then butted against the accessory box. A male bush is passed through the box entry and screwed tightly into the coupling using an open-ended spanner or a bushing spanner.

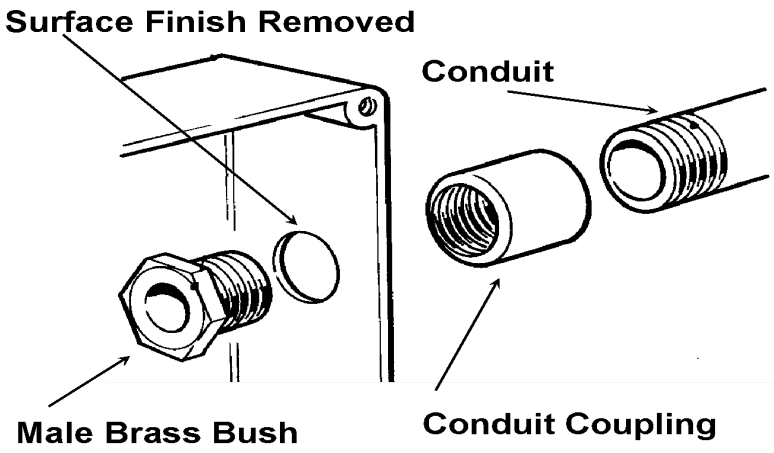


Figure 25: Coupling and Mable Bush Method

Locknut and Female Brass Bush Method

Using this method a locknut is screwed tightly onto a standard threaded conduit end and the thread passed through the hole in the accessory box. A second locknut is screwed onto the conduit effectively sandwiching the wall of the box. To prevent damage to cables, from the exposed end of the conduit, a female bush is then screwed onto the conduit thread. One disadvantage in using this method of terminating a conduit to a switch or socket box is that the conduit protrudes into the box and may inhibit the fixing of the switch or socket.

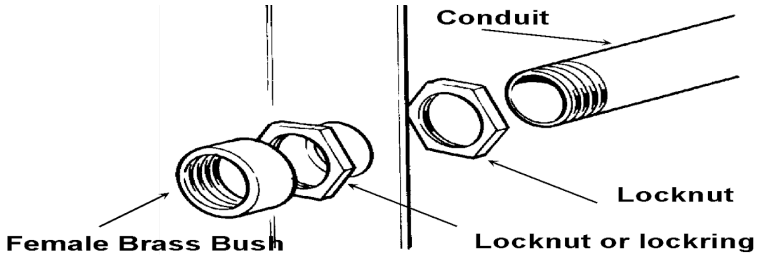


Figure 26: Locknut and Female Brass Bush Method

Note: - These are earth terminations

Galvanized Steel Conduit Accessories

Illustrates a range of galvanised steel conduit boxes, reducers and adaptors.

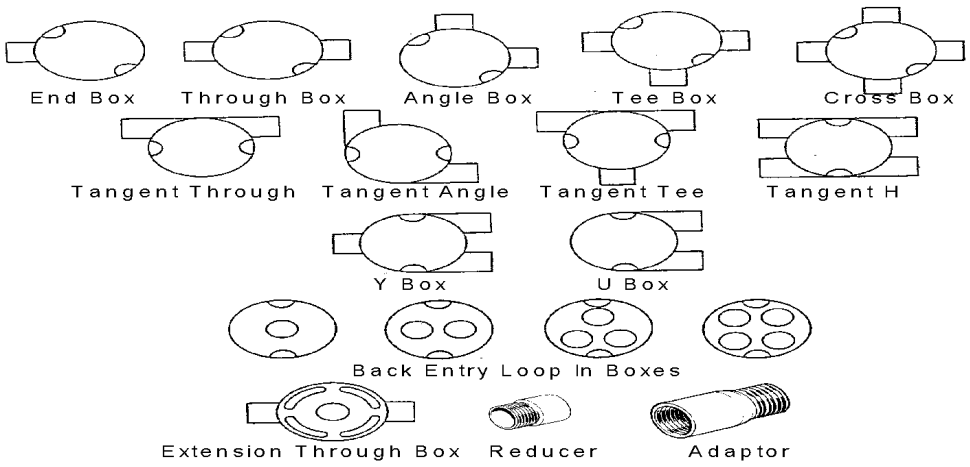


Figure 27: Galvanized Steel Conduit Accessories

Jointing Steel Conduit

Where two lengths of conduit are to be joined a plain coupling is used. To ensure good electrical continuity and maximum mechanical strength the tube ends must tighten inside the coupling (Max gap 2 mm). Care must be exercised to do this without leaving threads outside the coupling.

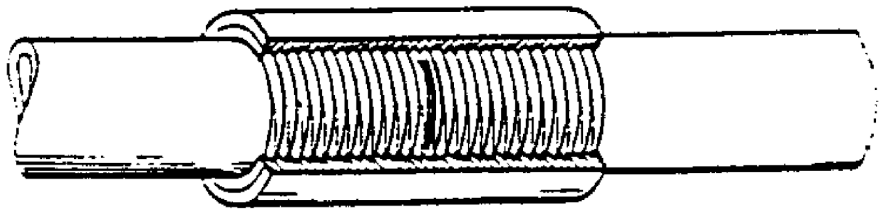
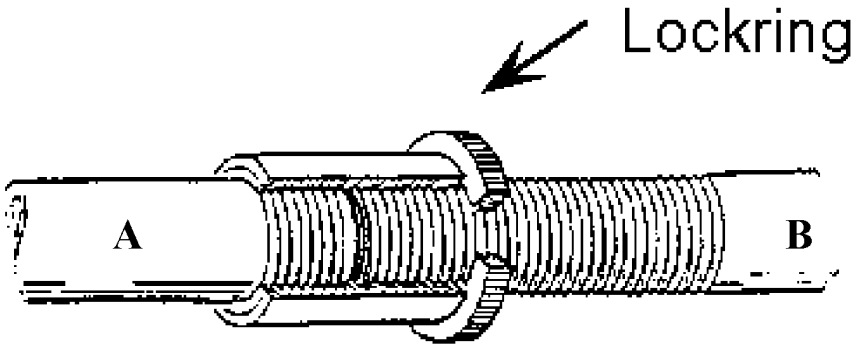


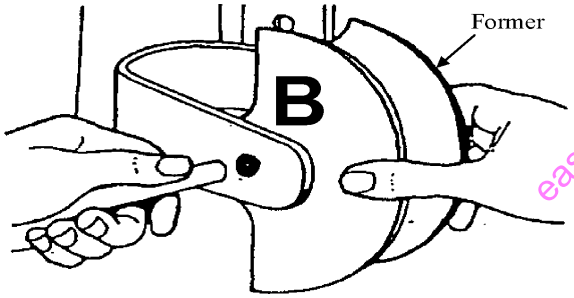
Figure 28: Jointing Steel Conduit

Where neither tube can be turned it is necessary to resort to the technique known as the "running coupling" .After tightening up the lockring the exposed thread must be painted to prevent corrosion.

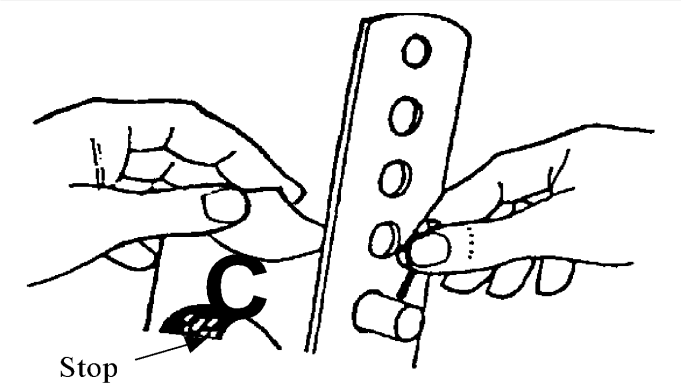


Setting up Sequence of a Bending Machine

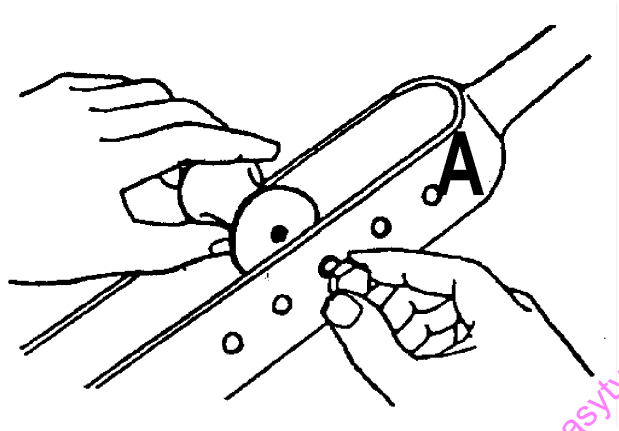
Place the semi-circular former 'B' (to suit the size of conduit to be bent) in position and secure the centre-pin.



Position the stop 'C' in the correct position for size of conduit.



Insert the grooved roller in the correct position for size of conduit.



Bending Steel Conduit

The most common method of bending steel conduit is to use a bending machine. However, for bending 32mm diameter or larger conduits it is recommended to use a portable ratchet bender. The following are the main steps to be taken when using a bending machine.

i. Insert the conduit under the stop and into the groove in the former.
ii. Pull down the handle, allowing the roller to bend the conduit around the former.
iii. Use a template to compare the angle of the bend formed with the desired angle.

Bends should be formed to an internal radius of not less than 2.5 times the conduit diameter
Making a 90º Bend in Steel Conduit
Illustration of a right-angle bend in steel conduit, which must be formed to a dimension of 200mm.

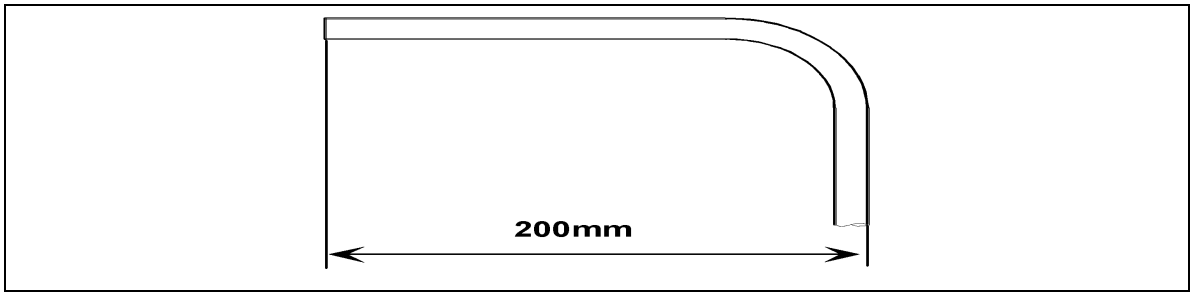
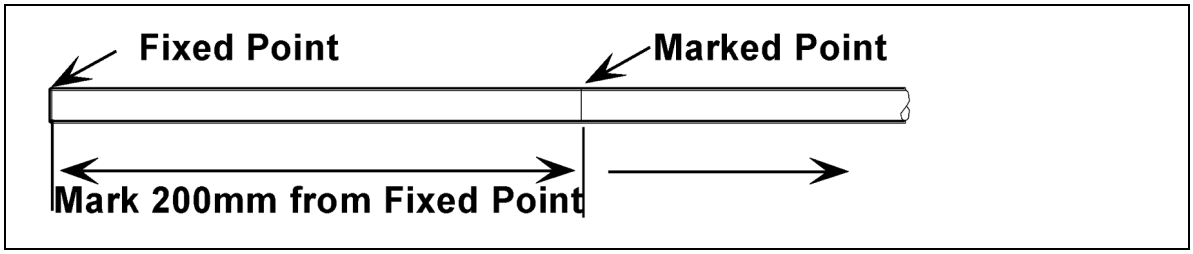
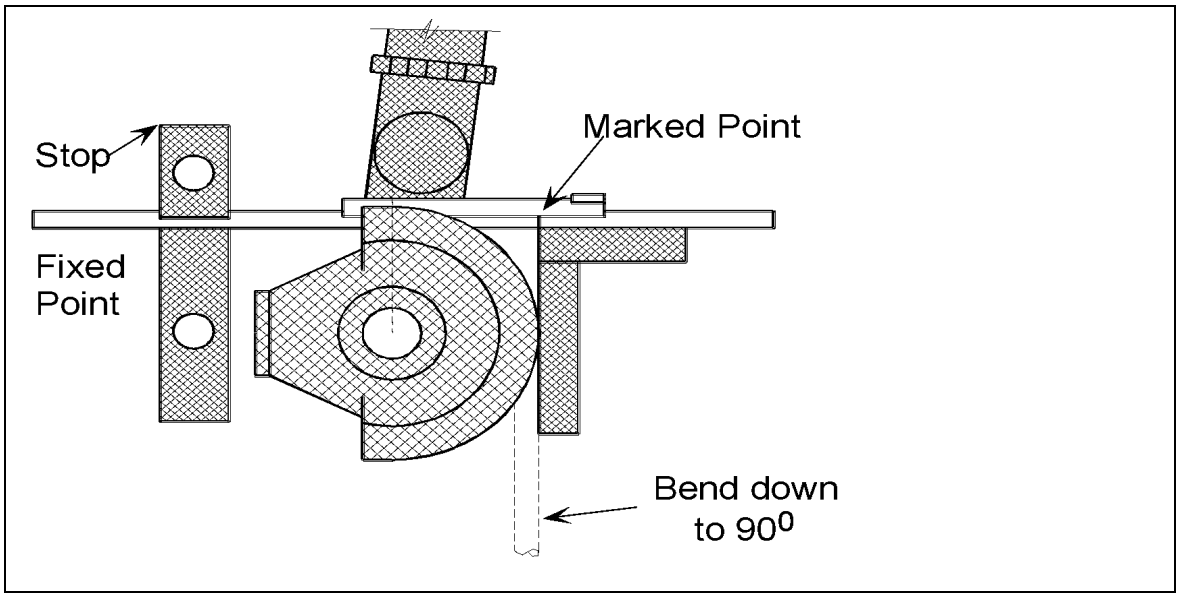


Figure 29: Bending Steel Conduit

The first step is to mark off 200mm from the end of the conduit as illustrated in Figure 12.



The next step is to place the conduit in the former with the mark to the rear. Position the conduit so that a try-square, held against the mark touches and forms a tangent to the edge of the former as illustrated below.



Next pull the lever down until the 90° angle, is achieved.

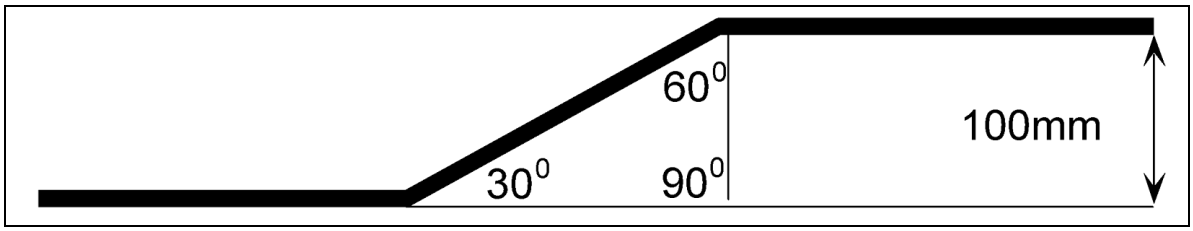
Making a Double Set or Offset in Steel Conduit

Normally offsets should be formed at either 30° or 45°.
A 30° offset is preferred for two reasons:

i. Ease of measurement.
ii. Ease of drawing-in cables.

Forming of a 30° Offset

Figure 14 illustrates a 30° offset to be formed in steel conduit. From the illustration it can be seen that the 30° angle is one of three angles forming a right angled triangle.



A rule of thumb for a right-angle triangle (30°, 60°, 90°) states that the relationship between the three sides is in the ratio of 1:2:√3, see Figure 1.67.

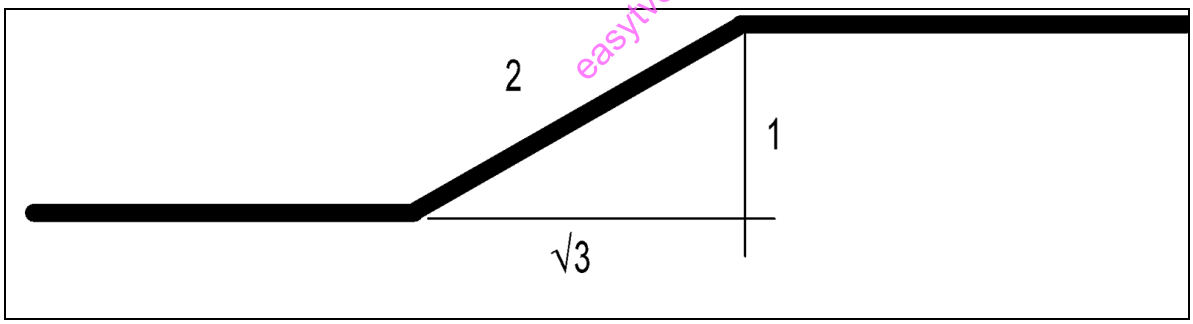
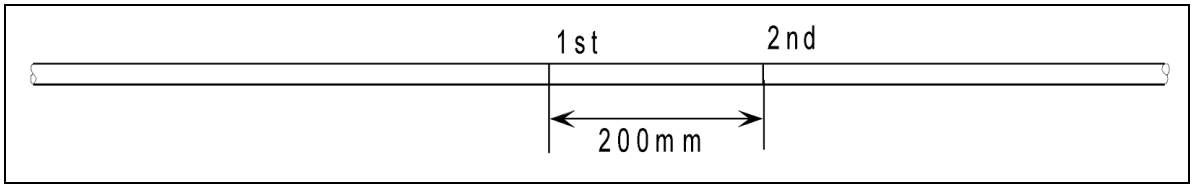
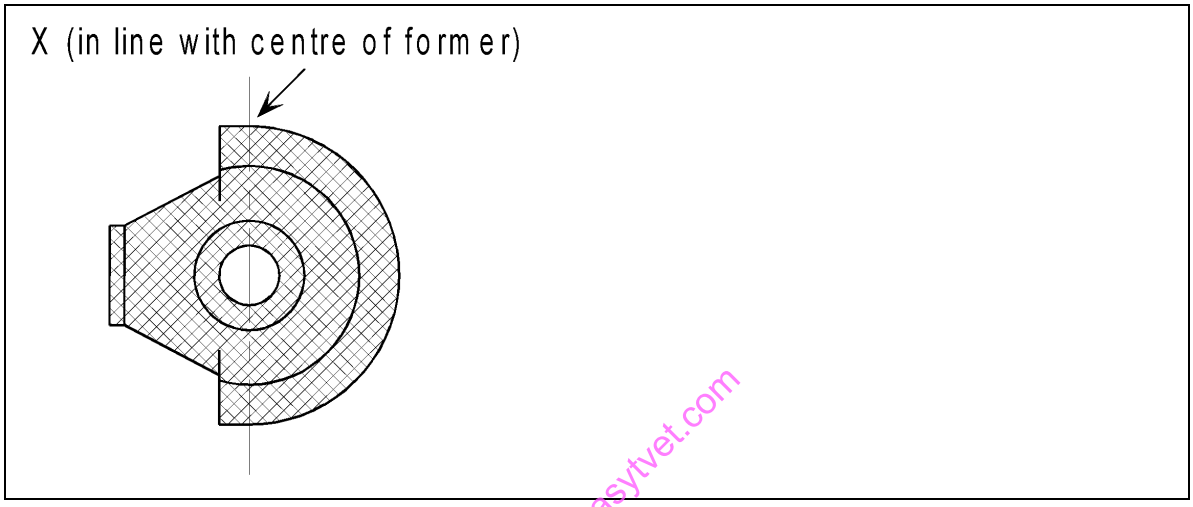


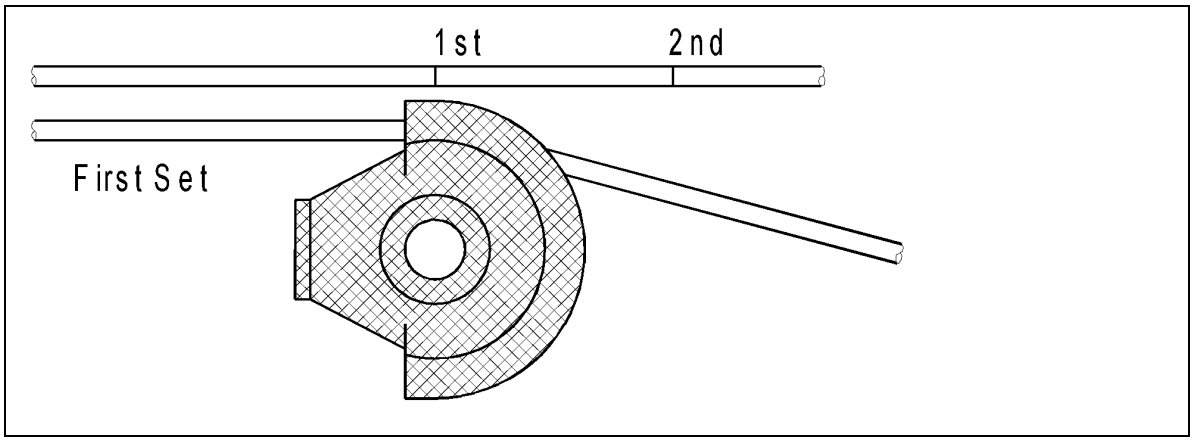
Figure 30: Forming of a 30 Degrees Offset

With this information, once we know the dimension of the offset (100mm in this case) we can now calculate and mark off the distance between the two bends. At this point take the straight piece of conduit and mark on it where you want the first bend to start from, then measure 200mm from that point to where the second bend starts.

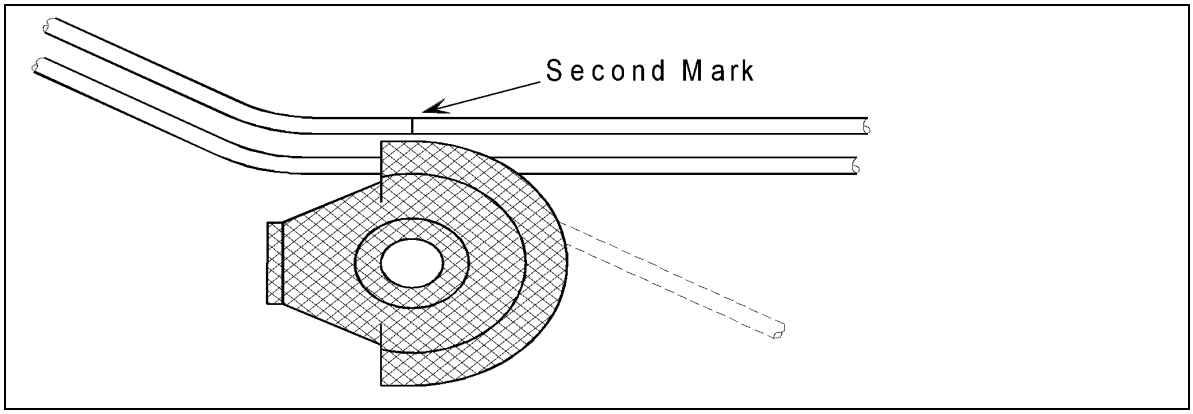


Now go to the bending machine. Mark a point on the former as shown in Figure 17. Place the conduit in the former matching the first mark on the conduit with the mark on the former and bend to 30° as shown in Figure 18. Now remove the conduit and check the offset angle against a 30° template.



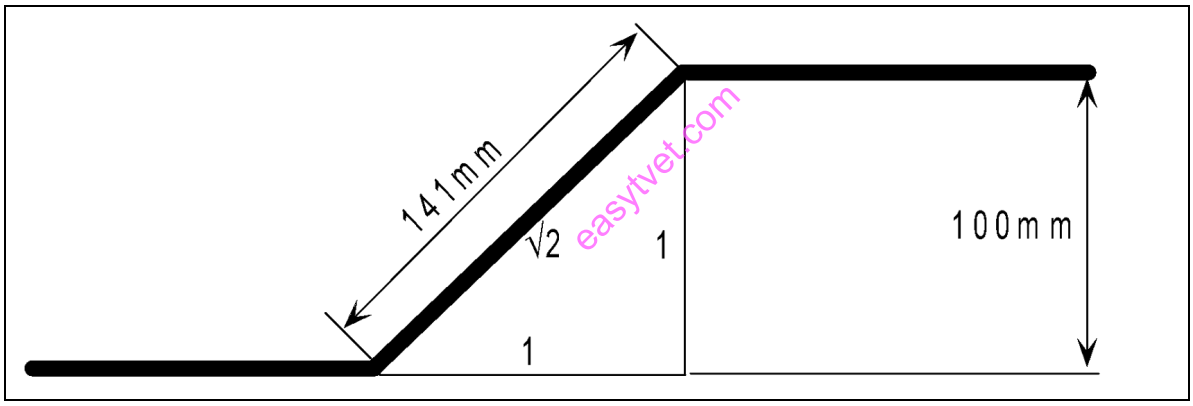


Place the conduit back in the machine pointing in the same direction as before but inverted and match the second mark on the conduit with the mark on the former, see Figure 19. The second offset is now formed until it is in parallel with the first offset.



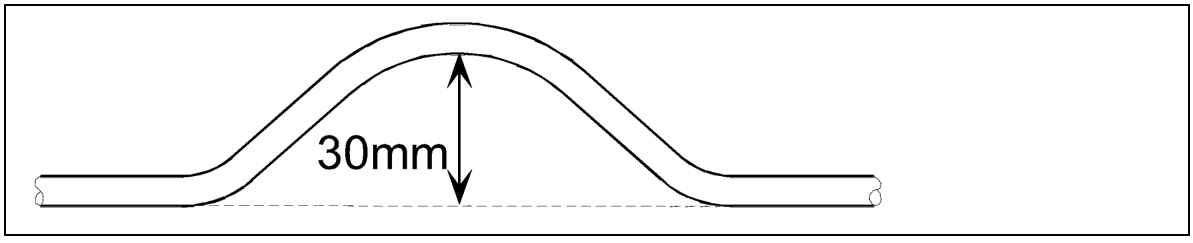
Forming a 45° Offset

A 45° degree offset is formed in exactly the same manner as the 30° version except that the measurements between the first and second bends are calculated using the following formula 1:1:√2. Figure 20 illustrates the use of this formula, in this case √2 =141mm or 100 x √2 = 141mm.



Making a Saddle Set (Jump) in Steel Conduit

Assume you are required to form a saddle set with a clearance of 30mm as illustrated below.



The first step is to bend the conduit to an angle of 45° as shown below.

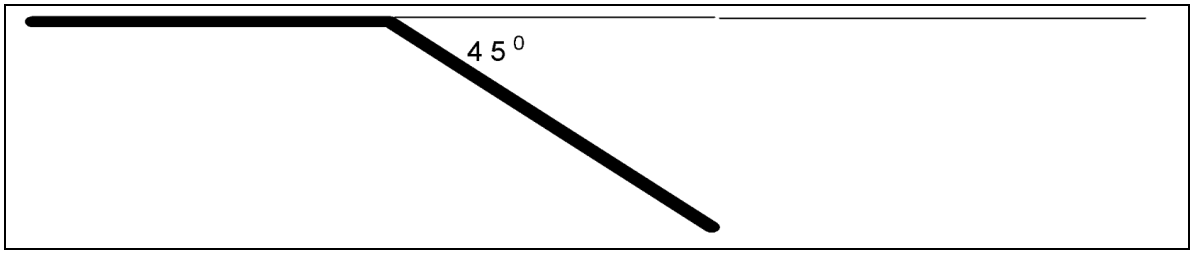
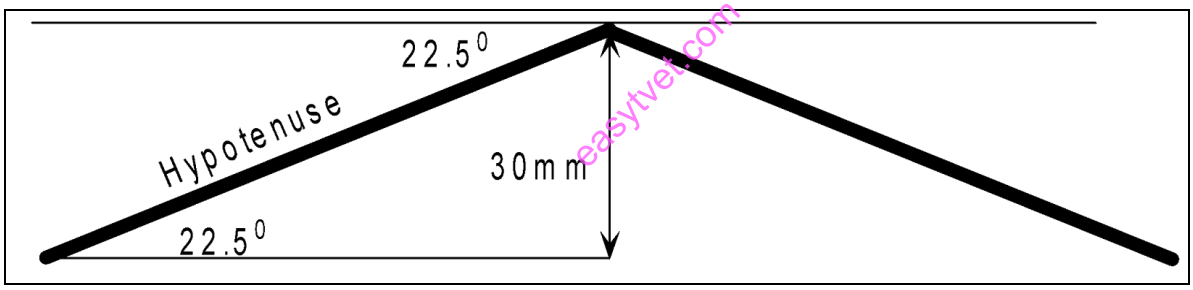


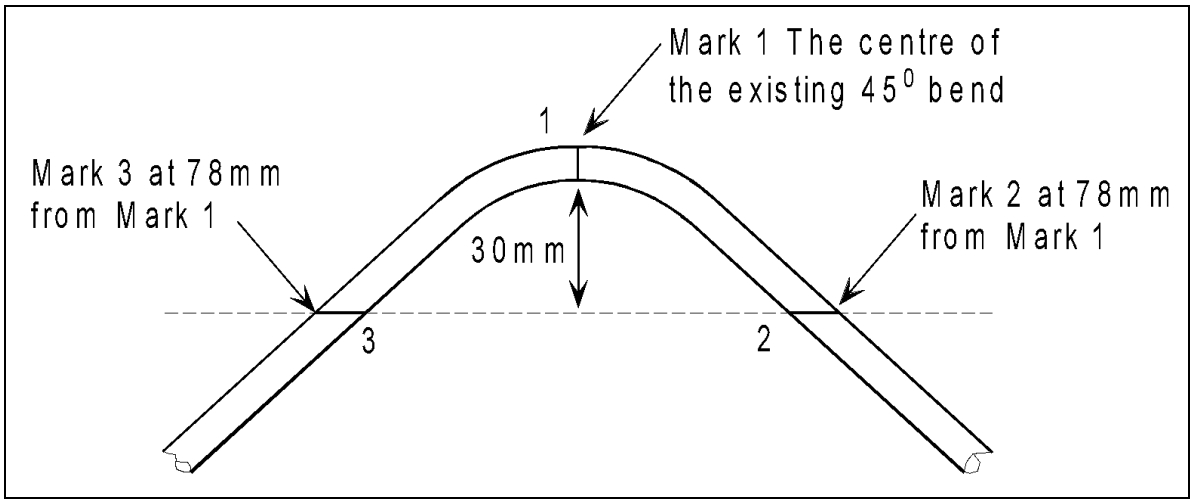
Figure 31: Forming a 45 Degrees Offset

The following formula will help you calculate the position of the next two bends which must be formed in order to achieve the 30mm clearance required.

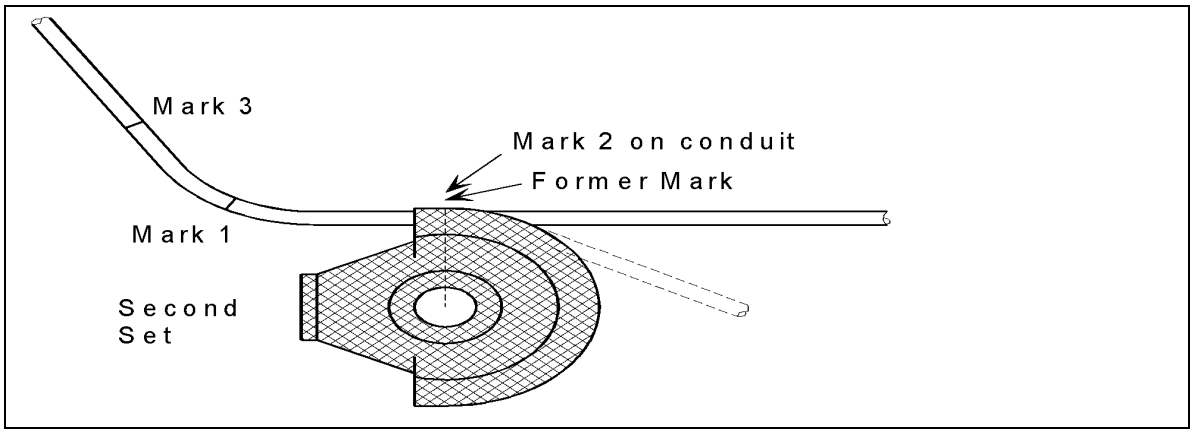
Sine of the Angle = Opposite/Hypotenuse
Sine 22.5 = 30/Hypothenuse
Hypothenuse = 30/Sine 22.5
Hypothenuse = 30/.3827 mm
Hypothenuse = 78mm.
Illustration of the application of the formula.



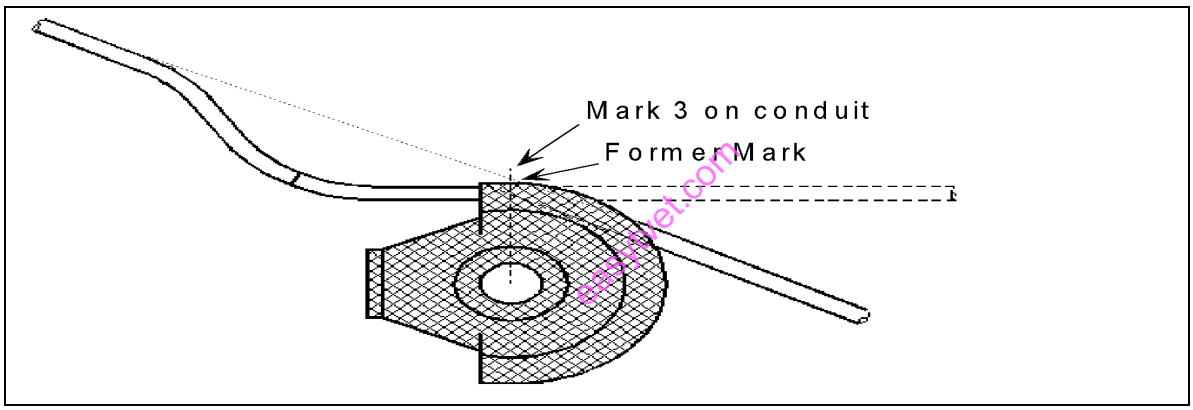
Mark the conduit as shown in Figure 1.76.



Marks 2 and 3 may also be located using a straight edge or other method.
Place the conduit in the machine so that mark 2 is opposite the existing mark on the former, and bend downwards as shown in Figure 1.77



Reverse the conduit in the former and match mark 3 with the existing former mark. Bend down until the edges of the conduit are in line, see Figure 1.78



Making a Double 90º Bend in Steel Conduit

Measurements for a double 90° bend in steel conduit can be taken using any of the three methods shown in Figure 1.79

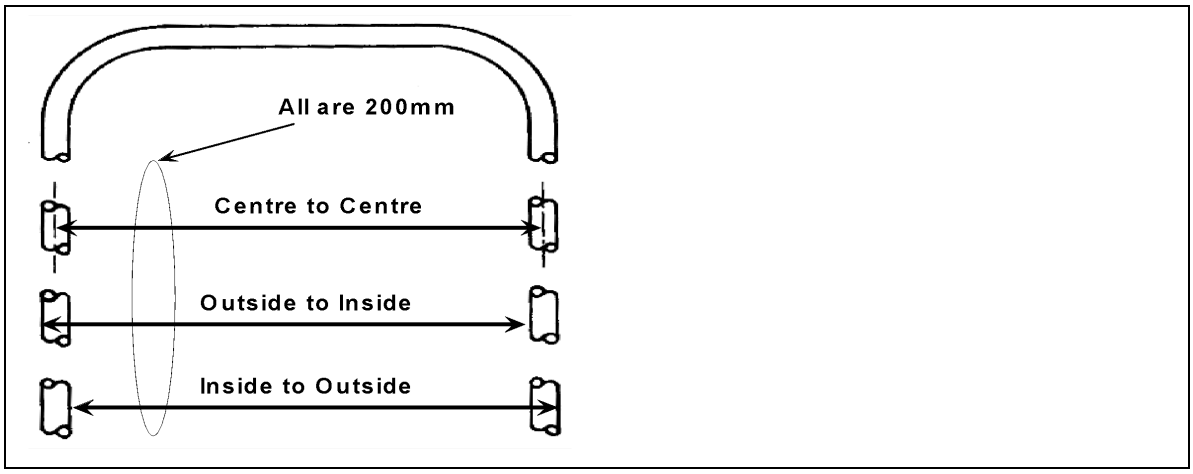
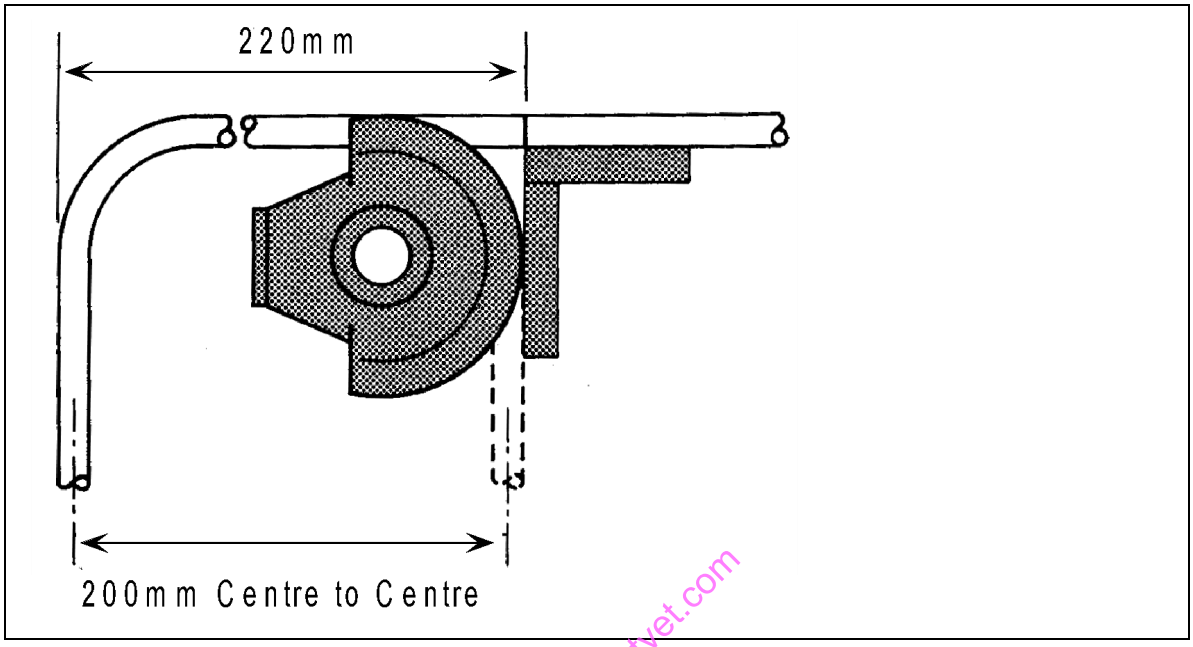


Figure 32: Making a Double 90 Degrees Bend on a Steel Conduit

If you add the outside diameter of the conduit (20mm) to the centre to centre measurments (200mm) we can now mark the position of the second bend (220mm), see Figure 28. Bend down until the 90^0 angle is achieved.



Note: - The above methods may require adjustments due to manufacturer's tolerances and wear in different bending machines

Steps in Preparing Steel Conduit Installation

Step 1: Anchor Boxes. Anchor metal boxes to the wall with screws.
Step 2: Measure Conduit. Once the boxes are installed, measure the conduit for cutting.
Step 3: Cut Conduit. Cut the conduit to fit with a hacksaw.
Step 4: Slide in Conduit.
Step 5: Anchor Conduit.

Step 1: Anchor Boxes

Figure 33: Step 1, Anchor Boxes

Anchor metal boxes to the wall with screws. For exposed wiring use handy boxes, which have rounded edges and metal covers. An offset fitting allows the conduit to run tight up against the wall.

Step 2: Measure Conduit

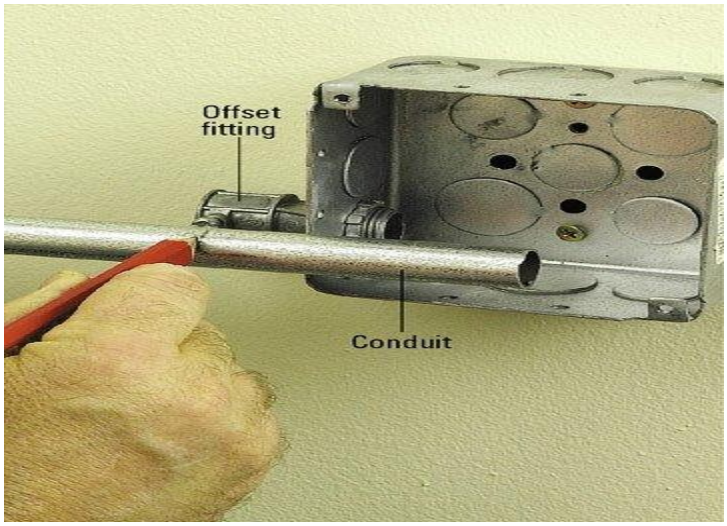


Figure 34: Step 2, Measure Conduit

Once the boxes are installed, measure the conduit for cutting. The surest method is to hold a piece in place and mark it, rather than using a tape measure. Remember that the conduit slides about an inch into each fitting.

Step 3: Cut Conduit

Figure 35: Step 3, Cut Conduit

Cut the conduit to fit with a hacksaw. Do not use a tubing cutter, which creates sharp edges inside the conduit that could damage wire insulation. Remove the burrs inside and out with a conduit-reaming attachment on a screwdriver.

Step 4: Slide in Conduit

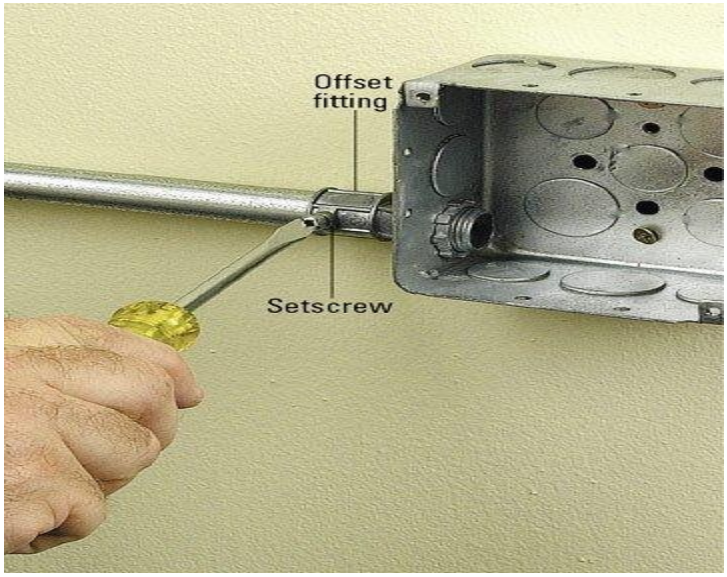


Figure 36: Step 4 Slide in Conduit

Slide the conduit all the way into a fitting and tighten the setscrew. Test to make sure the connection is tight. (If you are not installing a ground wire, these connections are critical for grounding.)

Make sure the wires have ample room inside the conduit to slide through easily. Codes have detailed rules regarding conduit size, but generally 1/2-inch conduit is large enough for five or fewer wires; 3/4-inch conduit is used for more than five wires. When in doubt or if you might run more wire in the future, buy the larger size—it doesn't cost much more.

Step 5: Anchor Conduit

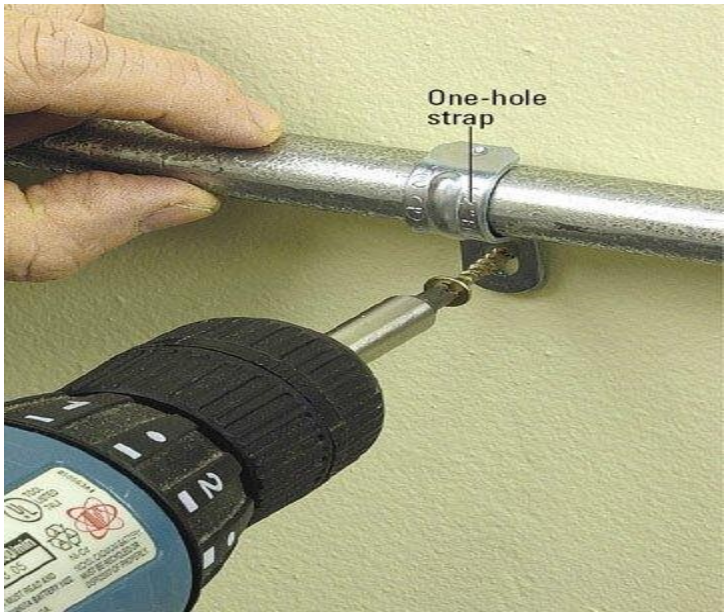


Figure 37: Step 5 Anchor Conduit

Anchor the conduit with a one-or two-hole strap at least every 6 feet and within 2 feet of each box. The larger the conduit, the closer the straps need to be. Check with local codes. Screws should be driven into joists or studs, not just drywall.

Additional step to Install a Pulling Elbow

Figure 38: Additional Step to Install a Pulling Elbow

With every turn it gets harder for the wires to slide through a conduit. If the conduit makes more than three turns before entering a box, install a pulling elbow. Never make a splice here; just use it as an access point when pulling wires.

Installation of PVC conduit

Electrical conduit fittings form the outer covering for most electrical wiring from one point to the next. They shield the wires from the external environment so as to make the wire last longer and also to keep humans and pets safe from electric shocks or other such vulnerabilities. Electrical conduits are predominantly made of insulating and sturdy material for optimum functionality.

Composition of PVC Conduit

The basic material is poly-vinyl-chloride (PVC) which is produced in both flexible and rigid forms. It is impervious to acids, alkalis, oil, aggressive soils, fungi and bacteria and is unaffected by sea, and air. It withstands all pests and does not attract rodents.

PVC conduit may be buried in lime, concrete or plaster without harmful effects.

Choice of PVC Conduit

The choice is dependant on the type of work being undertaken and the job specification.

i. Heavy gauge round conduit is normally used in surface work and for forming on-site.
ii. Light gauge round conduit is suitable for concealed work.
iii. Oval conduit is normally chosen for use in plaster walls and can be used for drops in surface work.

Typical electrical installations use a heavy guage standard impact tube manufactured to BS 4607. The conduit sizes and range of fittings are the same as those available for metal conduit.

Jointing PVC Conduit

PVC conduit is most often jointed by placing the end of the conduit into the appropriate fitting. Joints into accessories can be easily made dry or by the use of silicone grease or a permanent solvent, dependant on the installation conditions. The silicone grease should be used for expansion couplings and where an installation may be subject to future alteration.

Precautions When Using Adhesives

Care should be taken when using adhesives, which are pro-chemical based, and as such are quite flammable and volatile.

i. Replace the lid on the tin immediately after use.
ii. Use in a ventilated area away from naked flame.
iii. If adhesive should get into your eyes, seek first-aid immediately.

Expansion of PVC Conduit

Expansion couplings should be used for surface installations at a recommended maximum of 4 metre intervals.

Where frequent variations in ambient temperature are likely to occur this distance must be greatly reduced.

Note: PVC conduit is not suitable for installations subject to temperatures below -5oC or above 65oC

Fitting and Fixing of PVC Conduit

A range of fixings for PVC conduit is available as shown below.

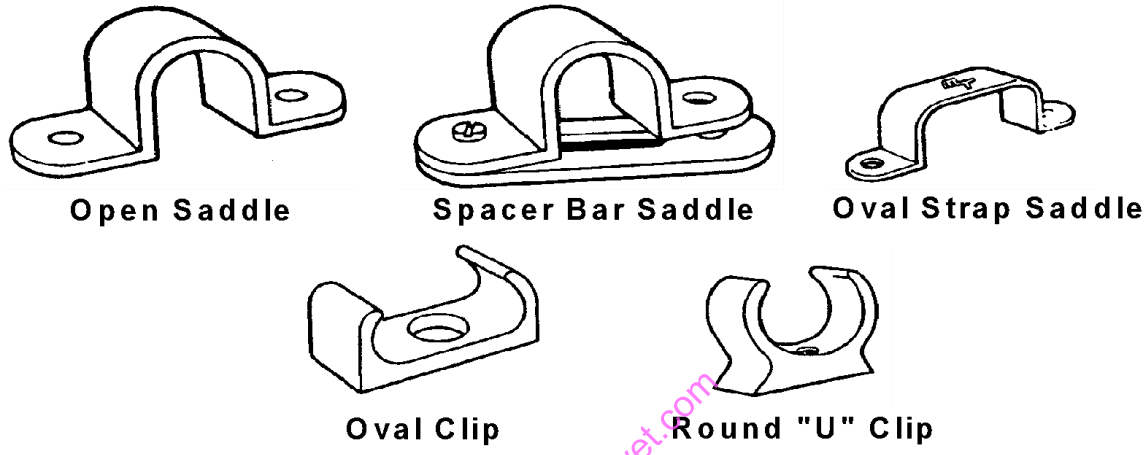


Figure 39: Fitting and Fixing of PVC Conduit

PVC conduit is fixed in the same way as metal conduit. All horizontal runs should be saddled at not more than 900 mm intervals unless high ambient temperatures or rapid changes in temperature are likely to be encountered, when the intervals should be reduced.

Vertical runs should be saddled at not more than 1200 mm intervals except where directional changes are made. Saddles should be installed approximately 150 mm either side of a bend. Conduit should be able to move freely in the saddle.

Advantages of PVC Conduit

i. Lightweight and easy to handle
ii. Easy to cut and deburr
iii. Simple to form and bend
iv. Does not require painting
v. Minimal condensation due to low thermal conductivity in wall of conduit.
vi. Speed of installation
vii. Excellent electrical and fire resistant properties

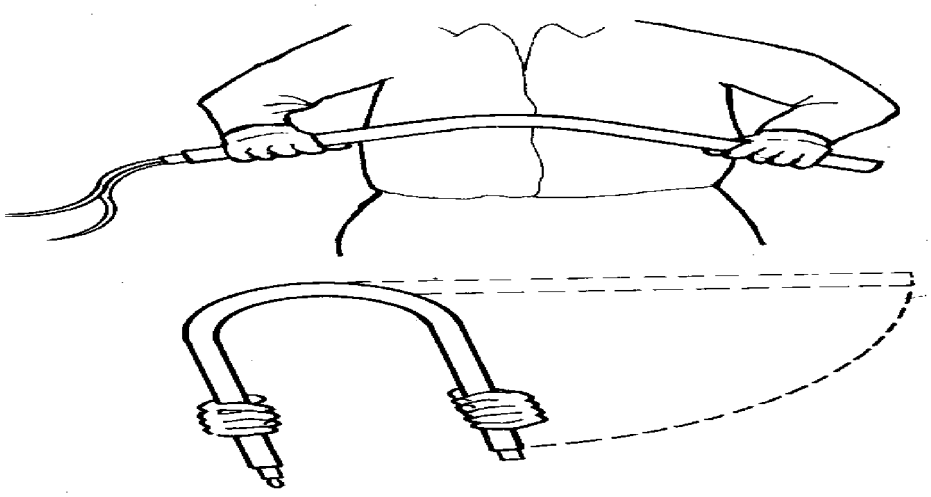
Disadvantages of PVC Conduit

i. Care must be taken when glueing joints to avoid forming a barrier across the inside of the conduit.
ii. If insufficent adhesive is used the joints may not be waterproof.
iii. PVC expands about 5 times as much as steel and this expansion must be allowed for.
iv. PVC does not offer the same level of mechanical protection as steel.
v. A separate Circuit Protective Conductor must be run inside the conduit.

Working with PVC Conduit

i. PVC conduit is easily cut using a junior hack saw. Any roughness of cut and burrs should be removed with the aid of knife blade or simply by wiping with a cloth. There are proprietary tools available for cutting PVC conduit.
ii. Cold bending of PVC conduit may be carried out on conduit sizes up to 25mm diameter using a bending spring, see Figure 30. It is essential to use the correct size bending spring and it should be noted that springs for heavy guage conduit are colour coded green and those for light gauge conduit are colour coded white. They are not interchangable.
iii. It is important that the spring is not damaged or kinked. A faulty spring can cause the conduit to kink and fracture. The spring can also jam inside the bend.
iv. The radius of the bends should be as near as possible to that of a similar bend formed in steel conduit of a similar size.

Having inserted the spring into the conduit, grip the conduit on either side of the proposed bend and bend the conduit slowly, as illustrated below.



v. The conduit should be bent to a more acute angle than the angle finally desired because of the tendency of PVC to "recover" after bending. This tendency lessens as the temperature decreases.

vi. In very cold weather it is recommended that the conduit is warmed slightly by rubbing with a cloth held in the hand. If the conduit is bent too quickly there is a risk of kinking and / or fracturing of the conduit and possible damage to the bending spring.

vii. If the conduit is intended for surface work it should be saddled and fixed as soon as possible after bending. Once a bend has been formed it should not be forced backwards as this can damage both the conduit and the spring.

viii. To remove the spring, twist it in an anti-clockwise direction. This will reduce the diameter of the spring and make it possible to pull the conduit and spring apart. If the spring jams during this operation do not pull hard on it, otherwise the spring will be damaged.

Hot Bending of PVC Conduit

i. Hot bending of conduit should be carried out on sizes over 25mm diameter. A bending spring of the correct size should be used. Apply a gentle heat preferrably with a hot air torch, electric heating element or hot water. Bend the conduit in accordance with above instructions.

ii. Care should be taken to avoid the direct application of flame to the conduit. When the conduit is in a pliable state it should be slowly bent around a suitable former and held in position for about one minute until set. After setting, the bending spring may be twisted anti-clockwise and removed.

Steps in Preparing a Pvc Conduit Installation

i. Choose the right material for installing electrical conduit fittings

ii. Chalk out a wiring plan

iii. Measure the amount of conduit that you would need

iv. Make the necessary bends
v. Attach fittings to the wall

Step 1: Choose the right material for installing electrical conduit fittings

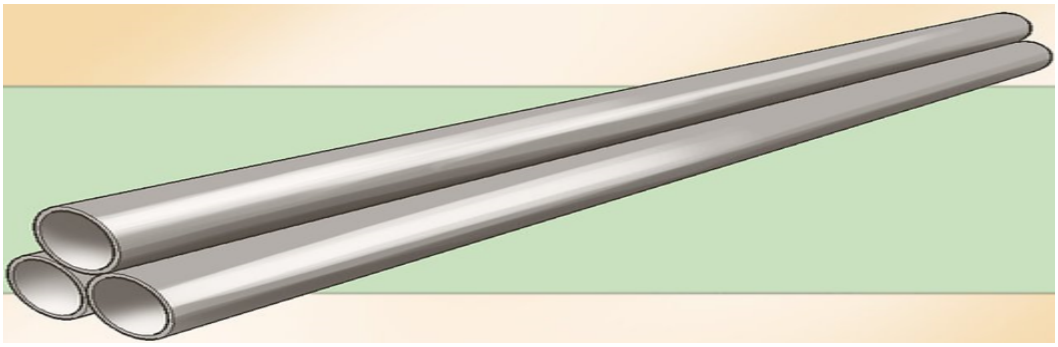


Figure 40: Choosing the Right Material for Installing Electrical Conduit Fittings

The most preferred material is known as EMT (Electrical Metallic Tubing). EMT is very easy to install as you can effortlessly bend it and assemble it as per your needs. Also, you can conveniently take it off in case your wiring goes wrong somewhere. If you do not have it in your house, you can buy EMT from any of the electrical surplus stores for pretty cheap.

Step 2: Chalk out a wiring plan

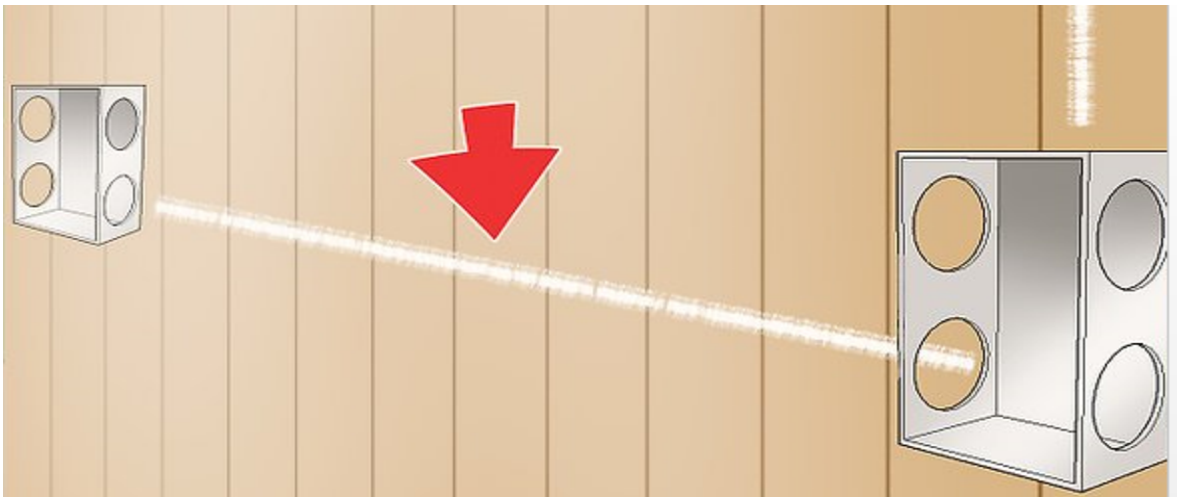


Figure 41: Chalk out a wiring plan

Find out the location of the electrical boxes on your wall to trace the route of the conduit. Draw the path from the main power source to the electrical box.

Step3: Measure the amount of conduit that you would need

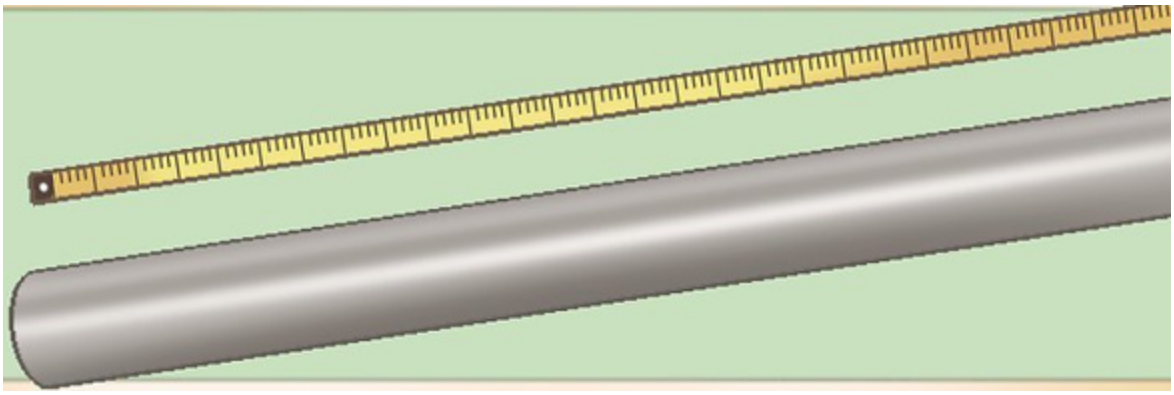


Figure 42: Measure the amount of conduit that you would need

Make appropriate marks in pencil wherever you think the bends should be, and measure the total length of the conduit that would be needed to finish the entire electrical conduit fittings. Now cut the length that you just measured with a tool called hacksaw. The cut ends are likely to have burrs which can be removed using a deburring tool or with pliers

Step 4: Make the necessary bends

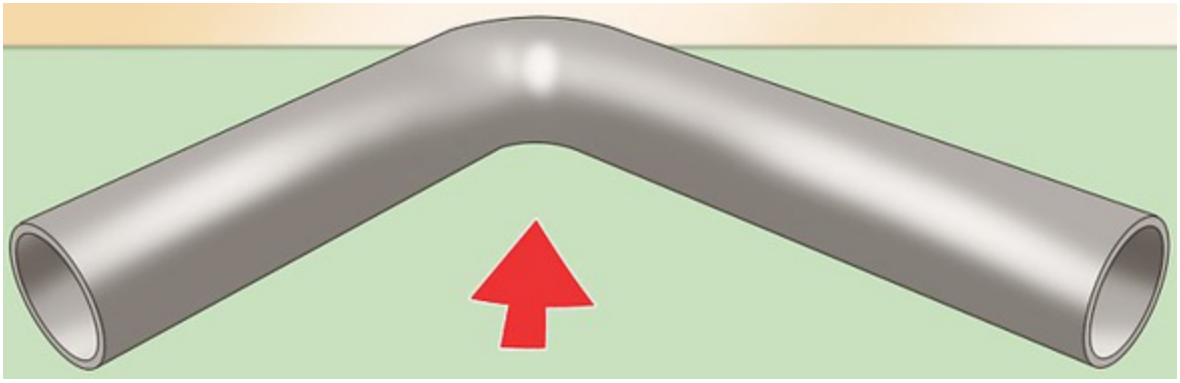


Figure 43: Step 4, Make the necessary bends

It is now time to make bends that you had marked on the pipe in the previous step. Owing to the easy flexibility of EMT, this should not be very difficult. Conduit benders come in handy for doing this bending.

Step 5: Attach fittings to the wall

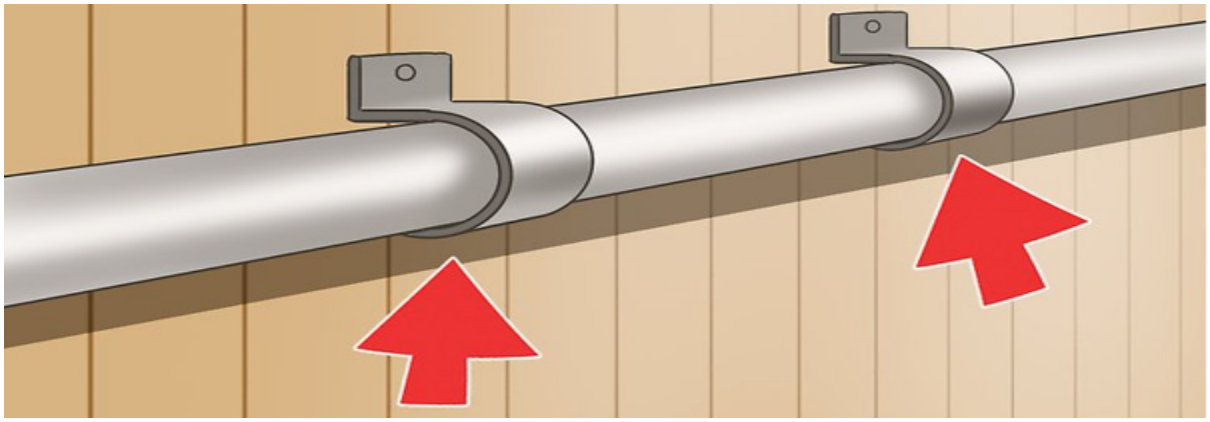


Figure 44: Step 5, Attach fittings to the Wall

You can use screws and straps with either single or double holes, available at electrical surplus shops, to attach electrical conduit fittings to the wall.

Step6: Tape the ends and put the wires in place

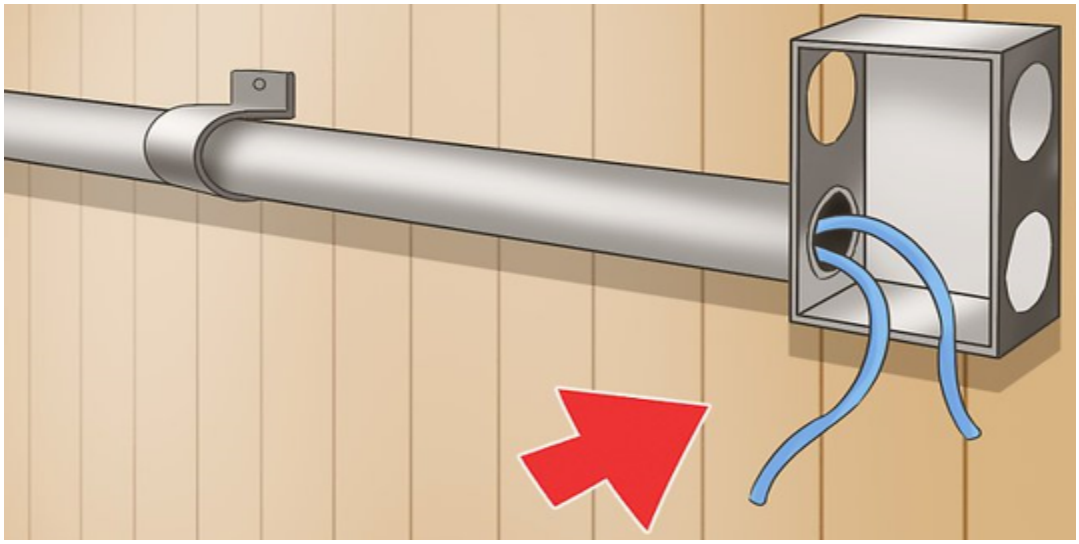


Figure 45: Step 6, Tape the end and put the wires in place

Use a widely available fish tape and run it through the entire route of the conduit fittings you just installed. Fix together the ends along with the electrical wires with the same fish tape. Give a finishing touch by pulling all the wire in the pipe in their right place.

Installation of PVC mini trunk

i. Install PVC boxes, then measure and mark the conduit for a cut. Cut with a backsaw and miter box, a hacksaw, or a circular saw equipped with a plywood blade.
ii. Use alignment marks to ensure that the pieces face in the correct direction. Apply PVC primer (if needed) and cement to the outside of the conduit and to the inside of the fitting.
iii. Immediately push the conduit into the fitting, twisting slightly to align the marks. Hold the pieces together for about 10 seconds; wipe away excess cement.

Step 1: Install Raceway Starter Box

Figure 46: Step, Install Raceway Starter Box

Turn off the power and test to make sure it is off. Take the cover off an outlet and pull out the receptacle. Screw a raceway starter box, which has a large opening in the back, over the box in the wall.

Step 2: Align and Measure Channel

Position a flat elbow onto the end of the raceway channel and hold it over a stud. Have someone help you hold the channel in place, and level it. Mark where to cut the channel — when installed the channel extends into the box by about 3/8 inch. Cut the channel with a hacksaw.

Step 3: Attach Channel Clips

Position the channel temporarily in place. Level it and trace along it. Find the studs with a stud finder and drill pilot holes into them for screws that hold the channel clips in place. Attach the clips.

Step 4: Install Channel to Elbow

Reposition the flat elbow. Tap the channel gently with a rubber mallet to snap it into place. Screw the elbow to the wall.

Step 5: Attach Second Channel

Cut a second length of channel, attach it with clips, and tap it into place with a rubber mallet.

Step 6: Fixture Box

Attach a fixture box.

Step 7: Thread Wires

Fish wires through the channel and attach the covers over the elbow.

Step 8: Hang Fixture

Hang the fixture and connect it to the outlet. Connect the wiring at the original receptacle.

Storage of tools and equipment

i. Have a designated place for each kind of tools.
ii. Label the storage cabinet or place correctly for immediate finding.
iii. Store them near the point of use.
iv. Wash and dry properly before storing.
v. Store knives properly when not in use with sharp edge down.

Learning Activities

1. Draw the wiring diagram and install the circuit using PVC conduits

Self-Assessment

1. A scale drawing showing the position of equipment by graphical symbols' is a description of a:
   A. Block diagram
   B. Layout diagram
   C. Wiring diagram
   D. Circuit diagram.
2. The recommended voltage for portable hand tools on construction sites is:
   A. 50 V
   B. 110 V

C. 230 V
D. 400 V

Tools, Equipment and Materials

i. Drill
ii. Screwdriver
iii. Spirit Level
iv. Rubber mallet
v. Strippers
vi. Side cutters
vii. Hacksaw
viii. Lineman's pliers
ix. Raceway components
x. Wire nuts
xi. Electrician's tape
xii. Screw

References

www.doityourself.com › stry › taking-care-of-electric-tools

Model Answers to Self-Assessment questions

1. **D**
2. **C**

1.4. Install Wire Ways, Trunking and Cable Trays

Introduction

In this context the learner should be able to explain and install different types of trunking and cable trays, also explain the procedures for installing of wire ways, trunkings and cable trays.

Performance Standard

i. Steel Trunking
ii. Types and Sizes of Steel Trunking
iii. Types of Support

Information Sheet

Steel Trunking

i. A trunking is an enclosure that provides for the protection of cables. It is normally square or rectangular in cross section, and has a removable lid.
ii. A trunking system offers great flexibility when used in conjunction with conduit systems. Trunking forms the backbone or framework of an installation. Conduits run from the trunking to accessory outlet boxes.
iii. When an alteration or extension is required to an installation it is easy to drill a hole in the side of the trunking and run a conduit to the new accessory point. New wiring can then be drawn through the new conduit and the existing trunking to the supply point.

Types and Sizes of Steel Trunking

There are a number of types of steel trunking such as: -

i. Lighting Trunking
ii. Cable trunking
iii. Multi-Compartment trunking
iv. Bus-bar Trunking

Typical surface finishes.

i. Hot dipped galvanized coating
ii. Grey enamel on zinc coating
iii. Silver enamel on zinc coating
iv. Stainless steel

Standard Sizes of Trunking

i.	50mm x 50mm	150mm x 75mm
ii.	75mm x 50mm	150mm x 100mm
iii.	75mm x 75mm	150mm x 150mm
iv.	100mm x 50mm	200mm x 100mm
v.	100mm x 75mm	225mm x 150mm
vi.	100mm x 50mm	250mm x 150mm
vii.	100mm x 100mm	300mm x 250mm

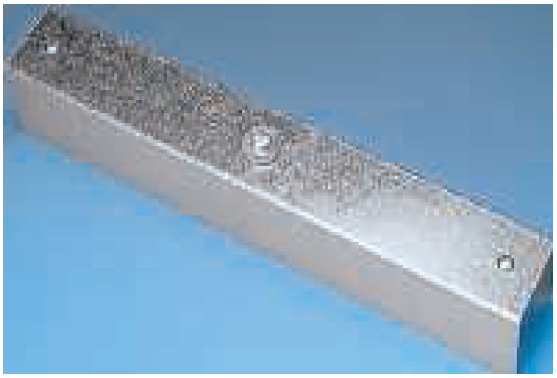
Trunking is generally supplied in 3 metre lengths. Lighting trunking is often supplied in 5 metre lengths. Other lengths are available on request.

Lighting Trunking

Steel trunking may be used to install luminaires. This type has quick fit drive-in couplings, which allow for fast, easy installation of long runs. The trunking is installed with the opening downwards as shown in Figure 1.

.

Trunking



Drive-in coupling

Figure 47: Light Trunking

A range of fittings is available to accommodate changes in direction, tees and intersections. These are bolted in position using at least two bolts depending on trunking size.

Flat Bend

Tee

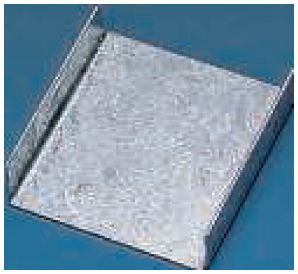
Cable retainers are used to prevent the cables falling out of the trunking. Special attachments are used to fix the luminaires to the trunking and also to allow the cables enter for connection.

Cable Retainer

Attachment

Suspension brackets are used to suspend the trunking at the required height below the ceiling. End caps and either steel or plastic lids are installed to complete the enclosure. The lid is simply clipped into position.

Suspension Bracket



End Cap

Cable Trunking

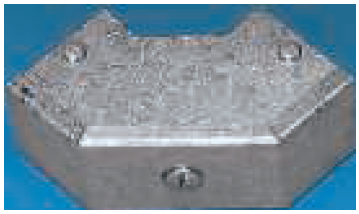
Standard cable trunking is similar in design to lighting trunking. The lid in this case is held in place with turnbuckles. A quarter turn of a large flat screwdriver will either fasten or loosen the turnbuckle.

Figure 48: Cable Trunking

A range of fittings is available to accommodate changes in direction, tees, intersections and to couple lengths together. These are bolted in position using at least two bolts depending on trunking size.

Flat Bend

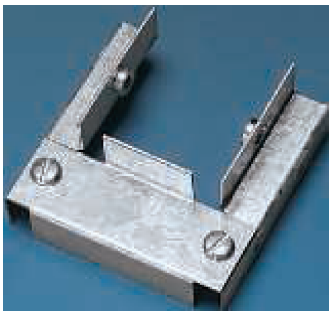
Internal Bend

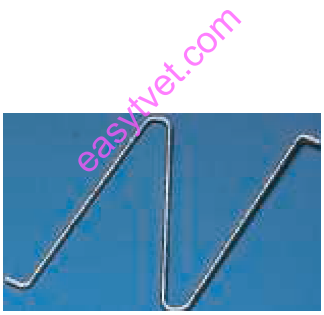


External Bend

Tee 45° Bend Coupling

Changes in trunking size are simply made by using reducers. Cables are easily kept in place in the trunking with cable retainers. End caps are used to complete the enclosure.





Reducer Cable Retainer End Cap

Multi-Compartment trunking

The increasing use of electronics and differing voltage levels in industrial installations has necessitated the use of multi-compartment trunking, which is designed to segregate (separate) the various voltages and services.

Segregation of this nature is a requirement of the ETCI Rules. For example, it prevents an extra low voltage system, coming into contact with a low voltage system even in the event of a fault. It shows a typical section of multi-compartment trunking.

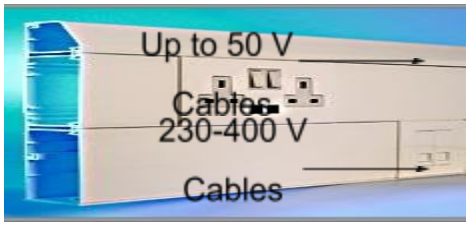


Figure 49: Multi-Compartment trunking

Areas of Application

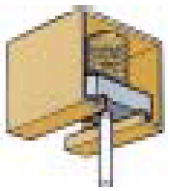
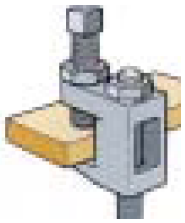
i. Steel trunking systems are used in commercial and industrial premises.
ii. Lighting trunking is generally used to supply and support fluorescent fittings, which illuminate large floor areas.
iii. Cable trunking is installed at a suitable height around the walls of the building. Conduit drops are then used to supply outlet points.
iv. Multi-compartment trunking is used where different electrical services are required in close proximity to each other. It is ideal in large offices and classrooms. Here it may be used to accommodate cables for supplying equipment at 230 Volts, plus data cables for computers, printers etc. These supplies must be segregated from each other**.**

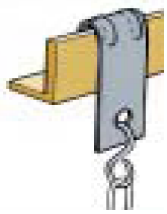
Types of Support

i. Trunking should be secured by round-headed screws or bolts. This prevents damage to cables during installations.
ii. In industrial installations, trunking may be run overhead, supported at intervals by the lower members of the roof trusses. It may be suspended from or fastened directly to right angle brackets. It may also be fixed directly to a wall surface.

A number of fixings, which may be used to support trunking.


Beam Clamp



Vertical Flange Hangers


Channel Spring Nut

A run of trunking supported by suspension brackets. The threaded rod also allows for final height adjustment.

Spacing of Supports

There are so many variables such as: - size of trunking, size and number of cables to be installed, type and strength of support available. However, the following table lists the maximum distances between supports for steel trunking.

Maximum Support Spacing for Steel Trunking		
Trunking Size	Horizontal	Vertical
50 x 50	1.75	2.0
75 x 50	3.0	3.0
Larger Sizes	3.0	3.0

Table 4:The Maximum distance between supports for steel trunking

Cable Capacity and Space Factor

i. Trunking is primarily intended for the installation of PVC insulated cables.

ii. The maximum number of cables that can be installed in a trunking system is based on only 45% of the available space being occupied. This does not mean that the trunking should appear to be less than half full of cable. Remember that all the unoccupied space in between the cables is included in the calculation.

iii. The main reason for limiting the number of cables to this level is to eliminate problems associated with an excessive buildup of heat inside the trunking. If too many cables are installed the cable insulation will suffer damage due to overheating. There is also the possibility of fire risk.

iv. The ETCI Rules provides a handy guide to aid the calculation of the cable capacity of trunking. It allows for a mixture of all the common cable sizes up to 10 mm^2. Other cable

sizes have to be accounted for on an individual basis. Remember that the overall cable CSA must be used in the calculation (not the CSA of the conductor alone).

v. If multi-core cables are to be installed in trunking the 45% space factor still applies, except in the case of one multi-core cable only.

Fabrication and Installation of Tees and Bends

Tee and bends may be fabricated where required in lengths of trunking.

This may be necessary or simply more convenient, particularly if the required bend or set is non-standard.

It takes more time to fabricate tees or bends than to bolt on manufactured accessories.

Note-: It is recommended that a 32 TPI hacksaw blade be used for cutting steel trunking.

Forming a Tee Joint

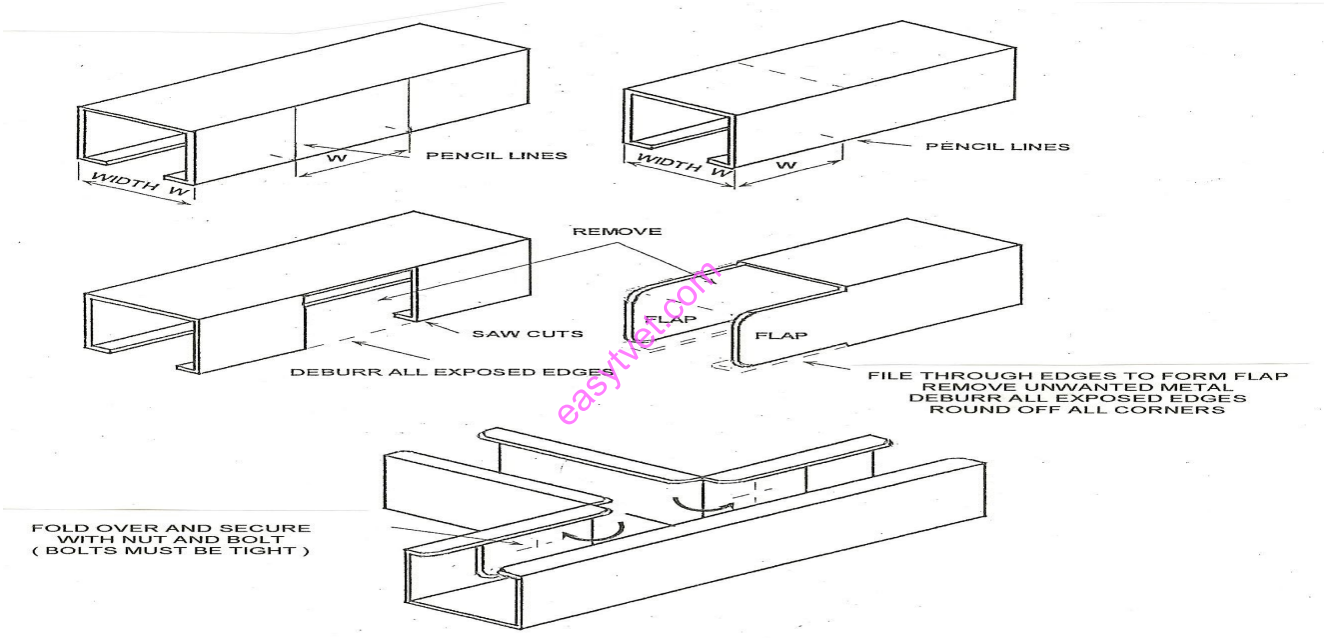


Figure 50: Forming a T-Joint

Forming an Internal Bend

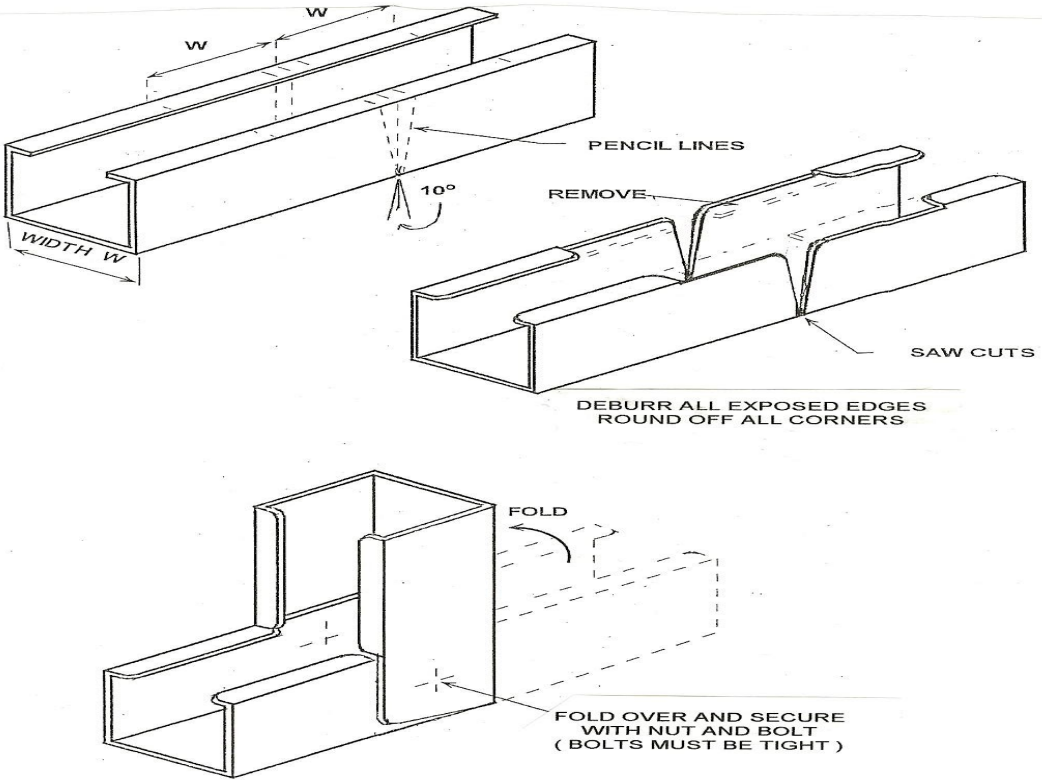
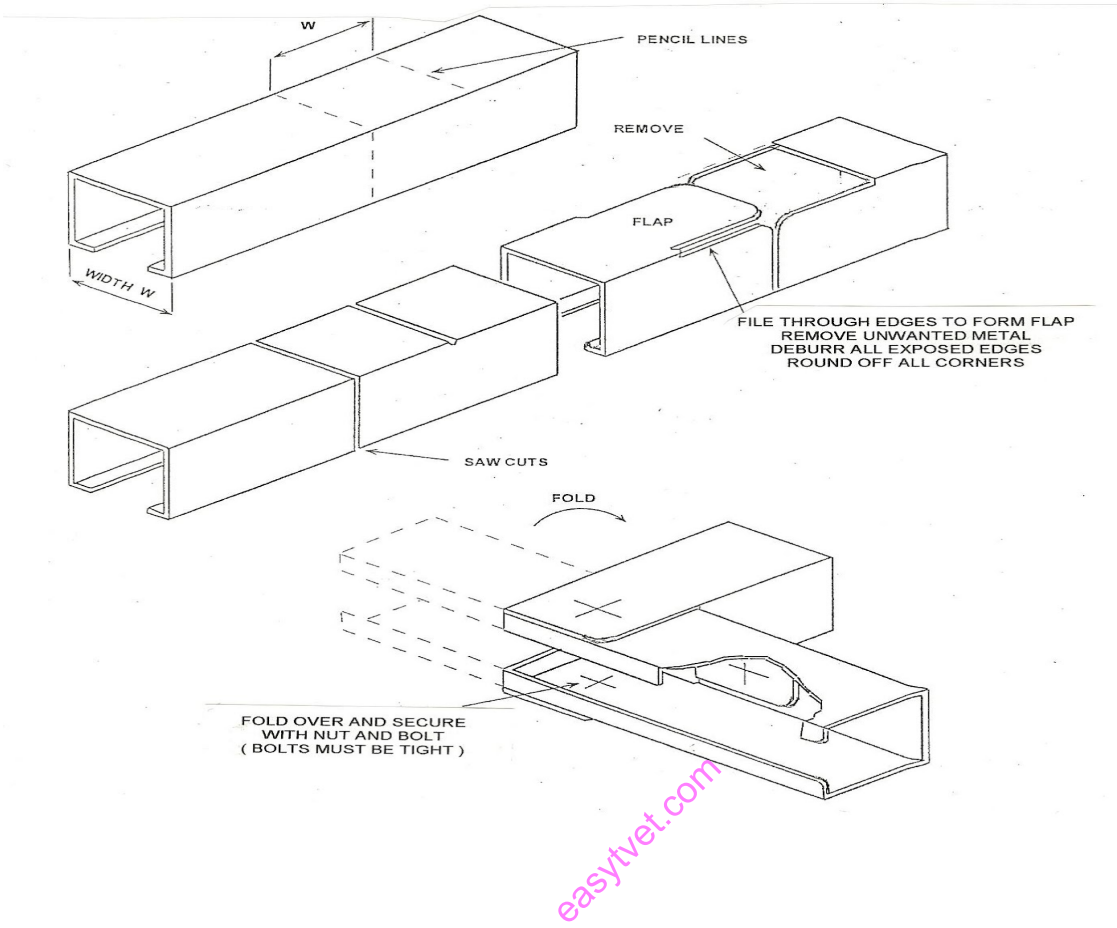
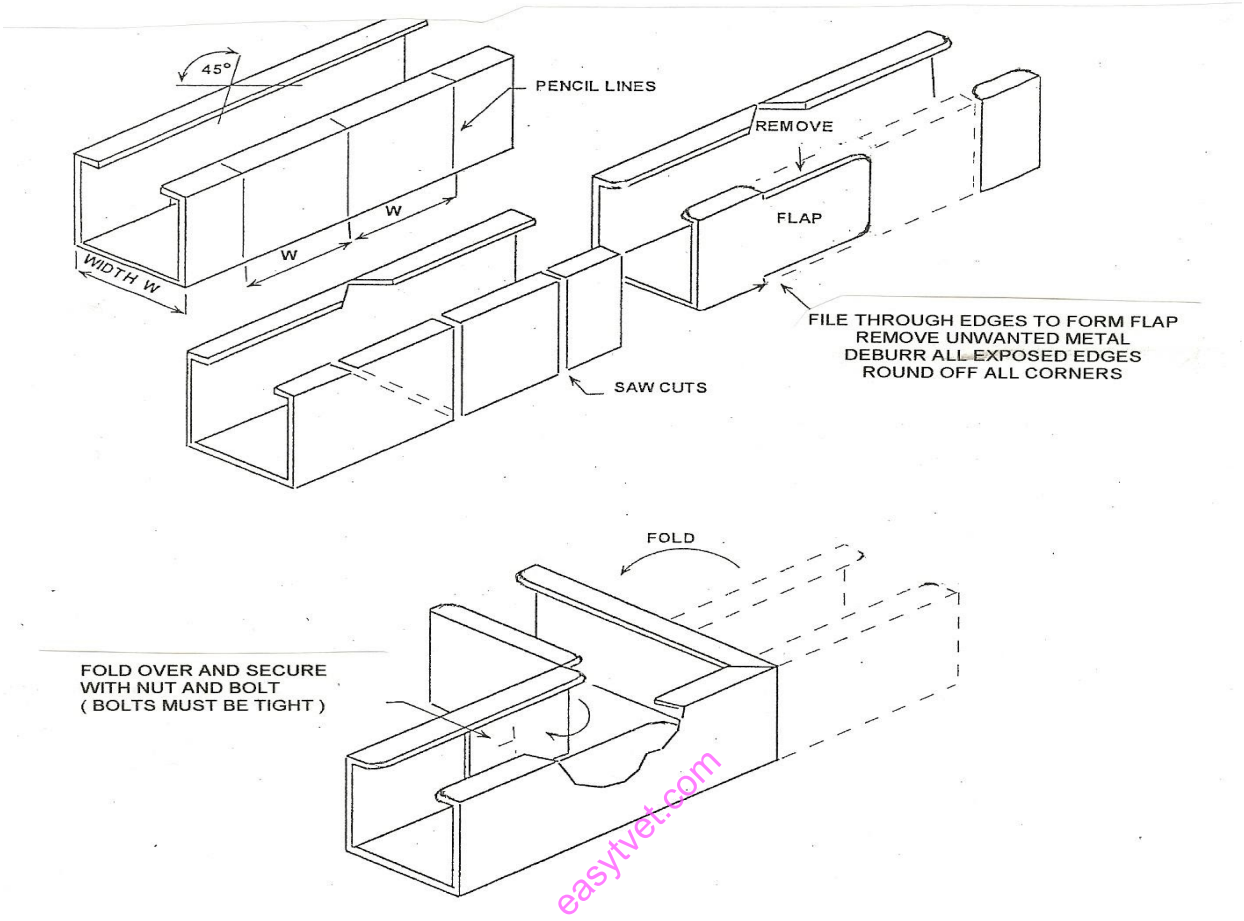


Figure 51: Forming an Internal Bend

Forming an External Bend



Forming a Flat Bend



Earthing of Steel Trunking

A trunking installation must be earthed. Earth continuity is ensured by the proper tightening of all bolts used throughout the system. Some manufactures recommend that earth continuity be completed by fixing a copper or aluminium strap across all joints. It is more important that all the bolts involved in the system are tightened. It is not unusual to find that copper or aluminium straps are used, but are left loose, resulting in poor earth continuity.

Copper Earth Strap

Learning Activities

1. Discussion on how to make a hot bending of PVC conduit
2. Using PVC conduit make the following off sets
   i. 45◦
   ii. 30◦
   iii. 90◦ bend using steel conduit.

Self-Assessment

1. What are the Advantages of PVC Conduit? (6marks)
2. What are the types of conduit used in electrical installation work? (4marks)

Tools, Equipment and Materials

i. Drill
ii. Screwdriver
iii. Level
iv. Rubber mallet
v. Strippers
vi. Side cutters
vii. Hacksaw
viii. Lineman's pliers
ix. Raceway components
x. Wire nuts
xi. Electrician's tape
xii. Screws

References

https://www.electricveda.com/building-services/method-statement-for-installation-of-cable-tray-o

Model Answers to Self-Assessment

1. Advantages of PVC Conduit? (6marks)

   i. Lightweight and easy to handle
   ii. Easy to cut and deburr
   iii. Simple to form and bend
   iv. Does not require painting
   v. Minimal condensation due to low thermal conductivity in wall of conduit.
   vi. Speed of installation

2. Types of conduit used in electrical installation work? (4marks)
   i. PVC
   ii. Steel
   iii. Flexible
   iv. Stainless Steel

1.5.Install distribution board frames and auxiliary components

Introduction

In this section the learner should learn on how to earth distribution board, conduct final checks for work manship, conformity with instructions with job requirements.

Performance Standard

i. Distribution Boards
ii. Method of earthing to main distribution board
iii. Method of earthing to sub-distribution boards
iv. Method of earthing to lighting and power outlet wiring
v. Method of earthing to final ring sub-circuits
vi. Method of earthing to electric loads and end units
vii. Earthing System

Information Sheet

Distribution Boards

Distribution boards (generally only one in residential premises) usually include the meter(s) and in some cases (notably where the supply utilities impose a TT earthing system and/or tariff conditions which limit the maximum permitted current consumption) an incoming supply differential circuit-breaker which includes an overcurrent trip. This circuit-breaker is freely accessible to the consumer.

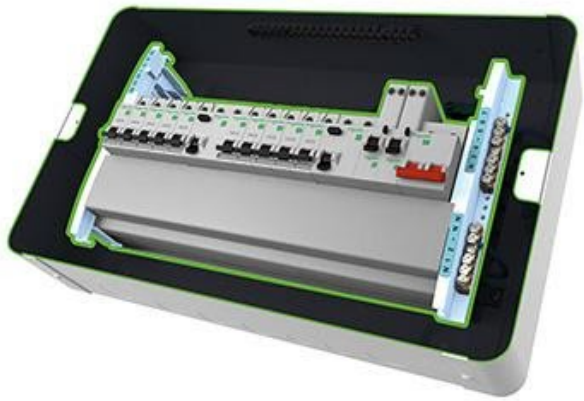
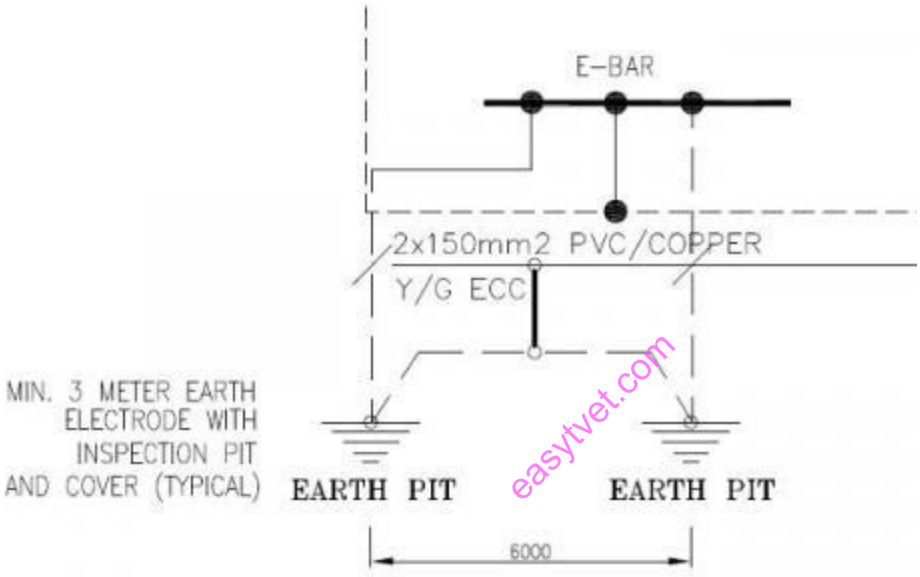


Figure 52: Residential DB

Method of earthing to main distribution board

Main earthing bar is to be provided in main distribution room and connected to earth electrode by 2 insulated conductors (minimum 150 mm2) via testing joints.

Earthing bars of main distribution boards are to be connected, by insulated earthing conductor, directly to main earthing bar at main distribution room.



Method of earthing to sub-distribution boards

Distribution, lighting and power panels are to be connected by protective conductors run together with incoming feeder cable, connecting, and earth terminals in panel boards with respective main distribution board earthing bar.

Method of earthing to lighting and power outlet wiring

Socket outlets are to be earthed by protective conductor looped around with the branch circuit and connected to earth terminal within socket outlet box and to which socket outlet is to be connected

Method of earthing to final ring sub-circuits

Protective conductor of every final ring sub –circuit is to be in form of a ring having both ends connected to earth terminal at origin in panel board

Method of earthing to electric loads and end units

Lighting fixtures and other exposed conductive parts of electrical installations, such as, switches, heaters, air conditioning units etc. are to be connected by protective earth conductors to earthing terminals of respective panel boards

Earthing System

i. An earthing system or grounding system connects specific parts of an electric power system with the ground, typically the Earth's conductive surface, for safety and functional purposes.

ii. The choice of earthing system can affect the safety and electromagnetic compatibility of the installation.

iii. In addition to electric power systems, other systems may require grounding for safety or function. Tall structures may have lightning rods as part of a system to protect them from lightning strikes.

iv. Telegraph lines may use the Earth as one conductor of a circuit, saving the cost of installation of a return wire over a long circuit. Radio antennas may require particular grounding for operation, as well as to control static electricity and provide lightning protection.

IEC terminology

International standard IEC 60364 distinguishes three families of earthing arrangements, using the two-letter codes TN, TT, and IT.

The first letter indicates the connection between earth and the power-supply equipment (generator or transformer):

"T" — Direct connection of a point with earth.

"I" — No point is connected with earth except perhaps via a high impedance.

The second letter indicates the connection between earth or network and the electrical device being supplied:

"T" — Earth connection is by a local direct connection to earth, usually via a ground rod.

"N" — the earth connection is supplied by the electricity supply network, either separately to the neutral conductor (TN-S), combined with the neutral conductor (TN-C), or both (TN-C-S). These are discussed below.

Types of TN networks

i. In a TN earthing system, one of the points in the generator or transformer is connected with earth, usually the star point in a three-phase system. The body of the electrical device is connected with earth via this earth connection at the transformer. This arrangement is a current standard for residential and industrial electric systems.

ii. The conductor that connects the exposed metallic parts of the consumer's electrical installation is called protective earth. The conductor that connects to the star point in a three-phase system, or that carries the return current in a single-phase system, is called neutral (N).

iii. Three variants of TN systems are distinguished:

TN−S

PE and N are separate conductors that are connected together only near the power source.

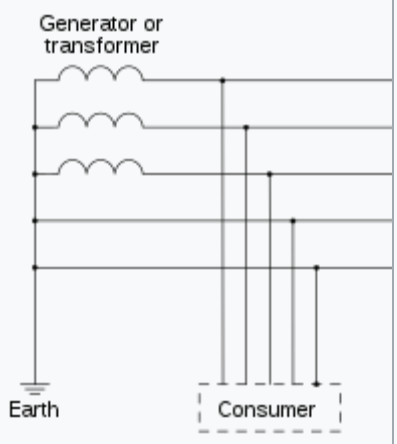
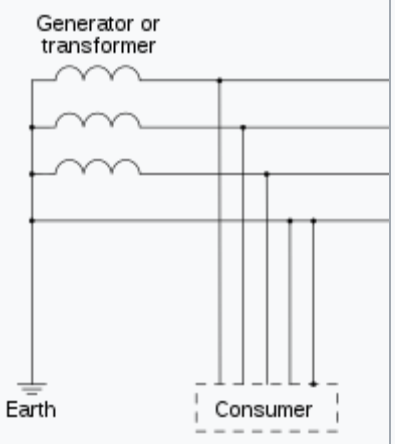
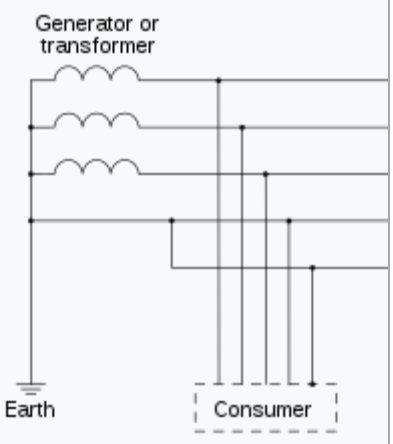
TN−C

A combined PEN conductor fulfills the functions of both a PE and an N conductor. (on 230/400 V systems normally only used for distribution networks)

TN−C−S

Part of the system uses a combined PEN conductor, which is at some point split up into separate PE and N lines. The combined PEN conductor typically occurs between the substation and the entry point into the building, and earth and neutral are separated in the service head.

In the UK, this system is also known as protective multiple earthing (PME), because of the practice of connecting the combined neutral-and-earth conductor via the shortest practicable route to local earth rods at the source and at intervals along the distribution networks to each premises, to provide both system earthing and equipment earthing at each of these locations.

		
TN-S: separate protective earth (PE) and neutral (N) conductors from transformer to consuming device, which are not connected together at any point after the building distribution point.	TN-C: combined PE and N conductor all the way from the transformer to the consuming device.	TN-C-S earthing system: combined PEN conductor from transformer to building distribution point, but separate PE and N conductors in fixed indoor wiring and flexible power cords.

It is possible to have both TN-S and TN-C-S supplies taken from the same transformer. For example, the sheaths on some underground cables corrode and stop providing good earth connections, and so homes where high resistance "bad earths" are found may be converted to TN-C-S.

This is only possible on a network when the neutral is suitably robust against failure, and conversion is not always possible. The PEN must be suitably reinforced against failure, as an open circuit PEN can impress full phase voltage on any exposed metal connected to the system earth downstream of the break.

The alternative is to provide a local earth and convert to TT. The main attraction of a TN network is the low impedance earth path allows easy automatic disconnection (ADS) on a high current circuit in the case of a line-to-PE short circuit as the same breaker or fuse will operate for either L-N or L-PE faults, and an RCD is not needed to detect earth faults.

TT network

i. In a TT (terre-terre) earthing system, the protective earth connection for the consumer is provided by a local earth electrode, (sometimes referred to as the Terra-Firma connection) and there is another independently installed at the generator.

ii. There is no 'earth wire' between the two. The fault loop impedance is higher, and unless the electrode impedance is very low indeed, a TT installation should always have an RCD (GFCI) as its first isolator.

iii. The big advantage of the TT earthing system is the reduced conducted interference from other users' connected equipment. TT has always been preferable for special applications like telecommunication sites that benefit from the interference-free earthing. Also, TT networks do not pose any serious risks in the case of a broken neutral. In addition, in locations where power is distributed overhead, earth conductors are not at risk of becoming live should any overhead distribution conductor be fractured by, say, a fallen tree or branch.

iv. In pre-RCD era, the TT earthing system was unattractive for general use because of the difficulty of arranging reliable automatic disconnection (ADS) in the case of a line-to-PE short circuit (in comparison with TN systems, where the same breaker or fuse will operate for either L-N or L-PE faults). But as residual current devices mitigate this disadvantage, the TT earthing system has become much more attractive providing that all AC power circuits are RCD-protected. In some countries (such as the UK) TT is recommended for situations where a low impedance equipotential zone is impractical to maintain by bonding, where there is significant outdoor wiring, such as supplies to mobile homes and some agricultural settings, or where a high fault current could pose other dangers, such as at fuel depots or marinas.

v. The TT earthing system is used throughout Japan, with RCD units in most industrial settings. This can impose added requirements on variable frequency drives and switched-mode power supplies which often have substantial filters passing high frequency noise to the ground conductor.

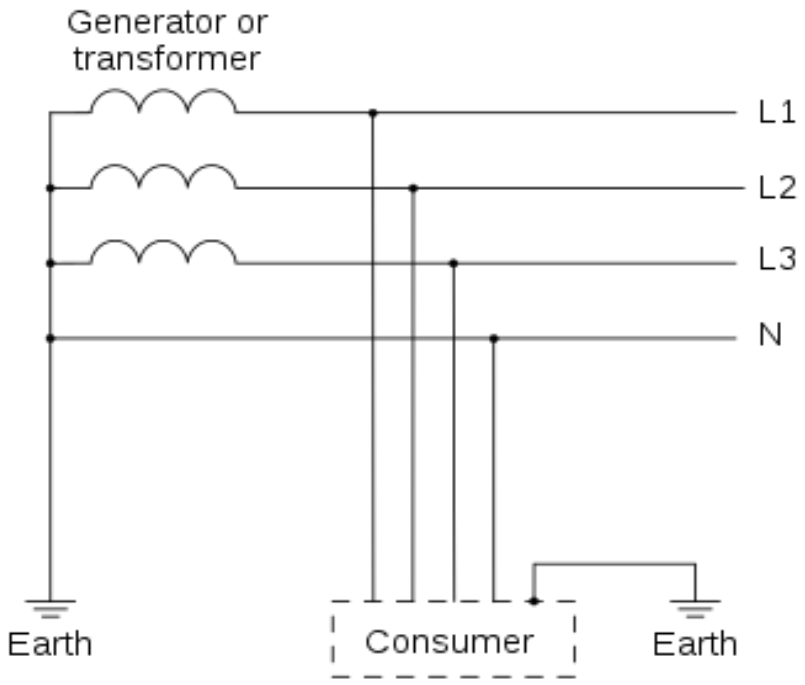


Figure 53: TT Network

The TT (terre-terre) earthing system

IT network

In an IT network (isolé-terre), the electrical distribution system has no connection to earth at all, or it has only a high impedance connection.

	TT	IT	TN-S	TN-C	TN-C-S
Earth fault loop impedance	High	Highest	Low	Low	Low
RCD preferred?	Yes	N/A	Optional	No	Optional
Need earth electrode at site?	Yes	Yes	No	No	Optional
PE conductor cost	Low	Low	Highest	Least	High
Risk of broken neutral	No	No	High	Highest	High

Safety	Safe	Less Safe	Safest	Least Safe	Safe
Electromagnetic interference	Least	Least	Low	High	Low
Safety risks	High loop impedance (step voltages)	Double fault, overvoltage	Broken neutral	Broken neutral	Broken neutral
Advantages	Safe and reliable	Continuity of operation, cost	Safest	Cost	Safety and cost

Table 5: Summary of Networks

Other terminologies

While the national wiring regulations for buildings of many countries follow the IEC 60364 terminology, in North America (United States and Canada), the term "equipment grounding conductor" refers to equipment grounds and ground wires on branch circuits, and "grounding electrode conductor" is used for conductors bonding an earth ground rod (or similar) to a service panel. "Grounded conductor" is the system "neutral". Australian and New Zealand standards use a modified PME earthing system called Multiple Earthed Neutral (MEN). The neutral is grounded (earthed) at each consumer service point thereby effectively bringing the neutral potential difference to zero along the whole length of LV lines. In the UK and some Commonwealth countries, the term "PNE", meaning Phase-Neutral-Earth is used to indicate that three (or more for non-single-phase connections) conductors are used, i.e., PN-S.

Resistance-earthed neutral

A resistance earth system is used for mining in India as per Central Electricity Authority Regulations. Instead of a solid connection of neutral to earth, a neutral grounding resistor (NGR) is used to limit the current to ground to less than 750 mA. Due to the fault current restriction, it is safer for gassy mines. Since the earth leakage is restricted, leakage protection devices can be set to less than 750 mA. By comparison, in a solidly earthed system, earth fault current can be as much as the available short-circuit current.

The neutral earthing resistor is monitored to detect an interrupted ground connection and to shut off power if a fault is detected.[11]

Earth leakage protection

To avoid accidental shock, current sensing circuits are used at the source to isolate the power when leakage current exceed a certain limit. Residual-current devices (RCDs, RCCBs or GFCIs) are used for this purpose. Previously, an earth leakage circuit breaker is used. In industrial applications, earth leakage relays are used with separate core balanced current transformers.[12] This protection works in the range of milli-Amps and can be set from 30 mA to 3000 mA.

Earth connectivity check

A separate pilot wire is run from distribution/ equipment supply system in addition to earth wire, to supervise the continuity of the wire. This is used in the trailing cables of mining machinery.[13] If the earth wire is broken, the pilot wire allows a sensing device at the source end to interrupt power to the machine. This type of circuit is a must for portable heavy electric equipment (like LHD (Load, Haul, Dump machine)) being used in underground mines.

Learning Activities

In a TN earthing system, one of the points in the generator or transformer is connected with earth, usually the star point in a three-phase system. The body of the electrical device is connected with earth via this earth connection at the transformer. This arrangement is a current standard for residential and industrial electric systems

Self-Assessment

1. What are the types of earthing methods to sub-distribution boards (3Marks)
2. What are the types of TN networks(7Marks)

Tools, Equipment and Materials

i. Multimeter
ii. Earth rod
iii. Screwdriver
iv. Level
v. Strippers
vi. Side cutters
vii. Hacksaw
viii. Lineman's pliers
ix. Raceway components
x. Wire nuts
xi. Electrician's tape
xii. Screws
xiii. Earthing cable

References

https://www.electrical-installation.org/enwiki/Residential_electrical_installation_-_Distribution_boards_components

Model Answers to Self-Assessment Questions

1. **Earthing methods to sub-distribution boards** **(3Marks)**

   Distribution, lighting and power panels are to be connected by protective conductors run together with incoming feeder cable, connecting, and earth terminals in panel boards with respective main distribution board earthing bar.

Types of TN networks **(7Marks)**

i. In a TN earthing system, one of the points in the generator or transformer is connected with earth, usually the star point in a three-phase system. The body of the electrical device is connected with earth via this earth connection at the transformer. This arrangement is a current standard for residential and industrial electric systems.

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