TVET CERTIFICATE III in DOMESTIC ELECTRICITY

ELECTRICAL INSTALLATION TESTING

ELCET302

Perform electrical installation testing

Competence

Credits: 4

Learning hours: 40

Sector: Energy

Sub-sector: Domestic electricity

Module Note Issue date: June, 2020

Purpose statement

This module describes the skills, knowledge and attitude required to perform electrical installation test. It is intended for learners who have successfully completed the 9 years basic education or its equivalent and pursuing TVET Certificate III in Domestic electricity or other related qualifications. At the end of this module, learners will be able to use of measuring instruments, check electrical installation system, test the earthing circuit protection, and test the earthing circuit protection. Qualified learners deemed competent to this competency may work alone or with others on routine tasks in various places such as Home buildings, shops, warehouses, supermarket, hospitals, pharmacies, banks, schools, garage, market, home, churches, and hotels under minimum supervision.

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	4.2 Proper identification of incoming power sources according the work done	
	4.3 Convenient verification of inlet and outlet according their characteristic	
	4.4 Correct checking final installation of Consumer Control Unity (CCU) according work installed.	

LU & PC is linked in LO inside the content

Total Number of Pages: 98

LU 1: Use of measuring instruments

LO 1.1: Implement hazard control safety measures related to electrical installation.

- **Topic 1: Description of Accident**

1. **Definition**

This is an unplanned and unpleasant event that happens unexpectedly which causes death, injury or damage.

2. **How do accidents occur?**

Most accidents occur as a result of human error and statistics prove that 98% of all accidents are avoidable.

3. **Causes of accidents:**

Electrical accidents are caused by a combination of three factors:

- Unsafe equipment and / or installation,
- Workplace made unsafe by the environment, and
- Unsafe work practices.

Other cause of accident

- Unawareness of danger: not knowing, not expecting.
- Disregard for safety: not treating as important
- Negligence: the failure to give something enough care.
- Lack of understanding of proper safety procedures.
- Untidy condition of workplace.
- Inadequate light and ventilation.
- Improper use of tools.
- Unsafe conditions.

4. **Safe attitudes**

People attitudes govern what they do or fail to do. Where someone is working with unsafe equipment then that person has allowed that state of affair to come about by something they have done or failed to do.

5. **Responsibilities**

Safety doesn't just happen. It has to be organized and achieved like a work process of which it forms part. The law states that both the employer and employees have a responsibility on safety.

6. **Employers' responsibilities:**

- Providing equipment
- Providing safe washing environment
- Giving instructions to employees on work
- Providing training on health and safety at work

7. Employees' responsibilities:

- Proper use of equipment provided.

- Substance of a good working environment

- Procedures and manner of doing work.

- General attitude to safety.

- **Topic 2: Identification of Safety Signs**

1. **Electrical safty signs and symbols**

Electrical safety labeling has many facets to it including identifying the hazard, identifying the right avoidance procedure for the situation you're trying to address, as well as identifying proper grounding, emergency stop buttons, work clearances, and potential arc flash hazards related to servicing the equipment and its electrical panels. We've made it simple to find all of your equipment's electrical safety labels by breaking the subject down into easily searchable categories.

2. **electrical safety precaution at the workplace (accident prevention) accidents**

2.1. Definitions

Electrical hazard: is a dangerous condition where a worker can or does make electrical contact with energized equipment or conductor

A hazard: is a source or potential source of human injury, ill health or disease. Anything which might cause injury or ill health to anyone at or near a workplace is a hazard.

2.2. Four main types of electrical injuries

- Electrocution or death due to electrical shock
- Electrical shock
- Burns
- Falls (caused by shock)

2.3. Preventing Electrical Hazards

- Wear nonconductive class E hardhat
- Wear electrical hazard (EH) rated foot protection.
- Use properly grounded or double-insulated power tools.
    - Tools with damage or worn power cords should be removed from service.
- Work on electrical equipment and circuits in a de-energized state using lockout and tag out procedures: When working on energized equipment is unavoidable, use the appropriate PPE including helmets, face shields, gloves and flame-resistant clothing.
- Beware of overhead power lines and buried electrical conductors.

3. **Safety signs**

There are four basic categories of signs:

1. Prohibition signs
2. Mandatory signs
3. Warning signs
4. Information signs or Advisory or Safe Condition Sign

3.1. Prohibition signs

These are must not do signs.   These are circular white signs with a red border and red cross-bar.

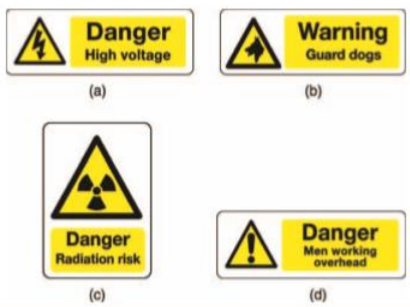
They indicate an activity which must not be done.

3.2. Mandatory signs

These are must do signs. These are circular blue signs with a white symbol. They give instructions which must be obeyed

3.3. Warning signs

They give safety information. These are triangular yellow signs with a black border and symbol.



3.4. Information Signs or Advisory or Safe Condition Sign

This gives safety information. These are square or rectangular green signs with a white symbol. They give information about safety provision.

4. Precautions when working on site

Installers should apply the safety principles learned so far in this to every work site. For each safety principle, there is a specific precaution to consider.

Before working on a specific site, find out what medical and emergency facilities are available nearby, or what measures would need to be in case of an injury. You should also inspect the site for hazards. You must mitigate or remove all hazards before work starts. For example, it might be a smart move at some point to check the junction box for snakes while using the appropriate safety gloves and equipment.

When checking the site for possible hazards, also check for any available safety equipment such as a fire extinguisher or a first-aid kit. Industrial settings often have

- **Topic 3: Lifting and handling loads**

The lifting and handling of loads also known as manual handling or manual materials handling. It includes lifting, lowering, pushing, pulling, carrying, holding, dragging and supporting objects.

1. Types of injuries

Manual handling causes over a third of all workplace injuries. These include work-related musculoskeletal disorders (MSDs) such as pain and injuries to arms, legs and joints, and repetitive strain injuries of various sorts.

1.1. Back injuries

When it comes to manual handling, your back is the weakest part of your body. Especially if you don't have good lifting technique. Or if what you are lifting is simply too heavy for your body to handle.
It's not just during lifting you need to watch your back. At any time you are carrying a load, poor posture can damage your back. Stooping or twisting can make your back more vulnerable to injury. Common back injuries include injuries to the spine and slipped discs.

1.2. Strains and sprains

Ever picked something up and regretted it after? Because it was much heavier or harder to grip than you realised? Or because over time, it became too much to handle? It is because overstretching your muscles beyond their capacity can lead to inflammation, bruising and pain.
Muscular strains and sprains can happen during manual handling, often in the back, arms or wrists.

1.3. Hand injuries

Lifting, carrying, pushing, pulling. Whichever type of manual handling activity you carry out, you usually grip with your hands. Depending on what it is you are touching, this could be a hazard in itself. If the load is hot, it could burn or scald your skin. If the load has sharp edges it could cut you.
Hand injuries don't always come from direct contact with the load, but also from where you are placing it. If the load is heavy, it could bruise you or even break a bone if you don't get your fingers out the way when you put it down. And your fingers could also get trapped between the load and other nearby obstacles like containers or walls. This is especially a concern during team lifts when other people are also moving the load.

1.4. Musculoskeletal disorders

Musculoskeletal disorders cover a range of issues and pain, in the upper limbs e.g. shoulders, neck, arms, wrists (upper limb disorders), the lower limbs e.g. hips, legs and toes (lower limb disorders), and back.

The term musculoskeletal disorders (MSDs) covers any injury, damage or disorder of the joints or other tissues in the upper/lower limbs or the back.

While we have already covered back injuries as a section on its own, musculoskeletal disorders can involve a range of symptoms that usually develop over time. It can be caused by repetitive lifting leading to damage, pain or stiffness in the joints or other tissues.
Musculoskeletal disorders (MSDs) are conditions that affect the nerves, tendons, muscles and supporting structures, such as the discs in your back. They result from one or more of these tissues having to work harder than they're designed to.

1.5. Slip, trip and fall injuries

Slips, trips and falls can happen at any time, whether you are manual handling or not. And, they usually have their own causes. A spillage. A trailing cable. An uneven floor. Manual handling can increase the risk of this type of accident, and the resulting injuries.

Often, when you are carrying a load, some of your visibility is blocked. Especially at ground level. You might not see that cable on the floor, or that spillage, or notice your shoelace has come undone. Always assess the environment as part of your manual handling assessment, as the surrounding workplace can add additional hazards to your task.
And the consequences of a slip or trip when you are manual handling is higher. You don't have a free hand to hold a handrail or put out to break your fall.

1.6. Hernias

A hernia occurs when an internal part of the body pushes through a weakness in the muscle or surrounding tissue wall.
Repeated strain on the tummy can be the cause of a hernia, and most hernias will not get better without surgery. Over straining by lifting loads heavier than you can handle can result in a hernia, and you are at higher risk as you get older.
Manual handling activities should always be assessed, considering the load and the individual to make sure it is safe and lifting aids provided as necessary.

1.7. Foot injuries

You might not lift with your feet, but foot injuries still make into our 7 types of manual handling injuries.
When manual handling causes a fracture, it's usually to the foot due to dropping of the load. This is an even bigger risk if you are not wearing protective footwear.
Lifting heavy loads, dropping loads from height (rather than carefully lowering them) and not getting a good grip can all lead to crushing, bruising or broken bones in the feet.

2. Preparing to lift

Manual handling injuries can have serious implications for the employer and the person who has been injured. They can occur almost anywhere in the workplace and heavy manual labour, awkward postures, repetitive movements of arms, legs and back or previous/existing injury can increase the risk.

To help prevent manual handling injuries in the workplace, you should avoid such tasks as far as possible. However, where it is not possible to avoid handling a load, employers must look at the risks of that task and put sensible health and safety measures in place to prevent and avoid injury.

For any lifting activity, always take into account**:**

- individual capability
- the nature of the load
- environmental conditions
- training
- work organisation

If you need to lift something manually

- Reduce the amount of twisting, stooping and reaching
- Avoid lifting from floor level or above shoulder height, especially heavy loads
- Adjust storage areas to minimise the need to carry out such movements
- Consider how you can minimise carrying distances
- Assess the weight to be carried and whether the worker can move the load safely or needs any help. Maybe the load can be broken down to smaller, lighter components

If you need to use lifting equipment

- Consider whether you can use a lifting aid, such as a forklift truck, electric or hand-powered hoist, or a conveyor
- Think about storage as part of the delivery process. Heavy items could be delivered directly, or closer, to the storage area
- Reduce carrying distances where possible

3. Good handling technique for lifting

There are some simple things to do before and during the lift/carry:

- Remove obstructions from the route.
- For a long lift, plan to rest the load midway on a table or bench to change grip.
- Keep the load close to the waist. The load should be kept close to the body for as long as possible while lifting.
- Keep the heaviest side of the load next to the body.
- Adopt a stable position and make sure your feet are apart, with one leg slightly forward to maintain balance

4. Weight a person can carry

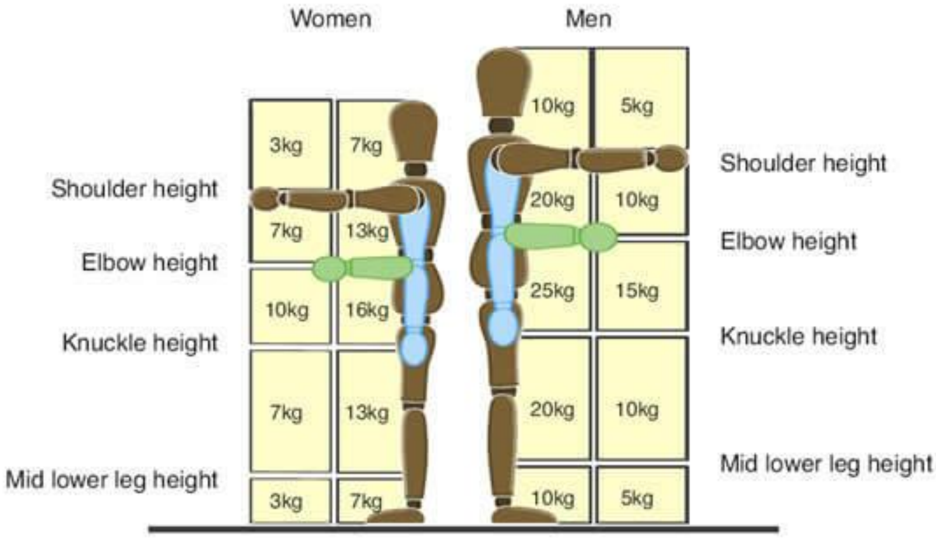
There is no legal maximum weight to lift at work. There are, however, guidelines which set out the recommended safe maximum weight for lifting at work.

Manual Handling Guidelines set out recommended safe lifting limits for men and women.

The recommended maximum weight limit should be adjusted depending on how the load is being lifted, how close to the body the weight is held, and how high or how low the weight is lifted.

The guidelines suggest that the maximum weight men should lift at work is 25kg. This relates to loads held close to the body at around waist height. The recommended maximum weight is reduced to 5kg for loads being held at arms length or above shoulder height.

Maximum weight guidelines recommend lower weights for women. The suggested maximum weight for women is 16kg for loads held at waist height.



5. Moving heavy equipment

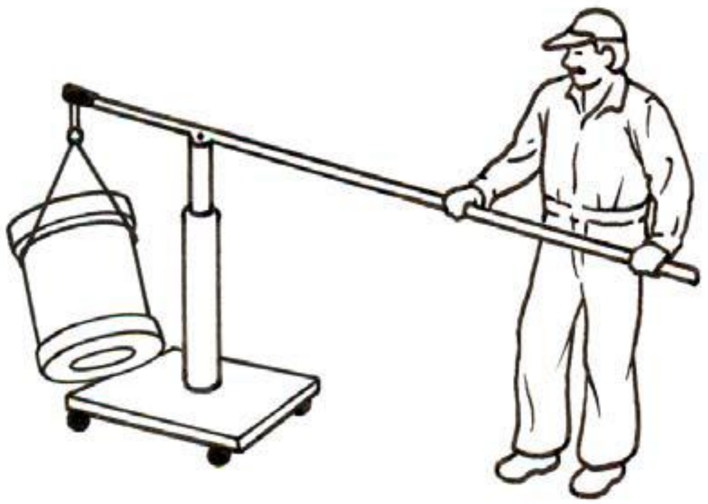
The lifting and handling of loads, usually called manual materials handling, is often physically demanding work. Lifting and handling involves the activities of lifting, pushing, pulling, carrying, handling or transporting loads. The intent of this subsection is for employers to reduce the amount and type of manual handling that workers must do.

By doing so, workers and employers may experience a reduction in the number of worker injuries (fewer sprains, strains, back injuries), a reduction in the number of lost-time claims, increases in efficiency and productivity, and fewer product losses through damage.

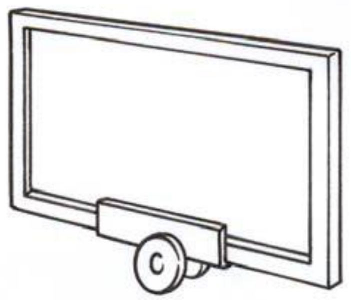
To accomplish this, employers must provide, where reasonably practicable, appropriate equipment that will help workers lift, lower, push, pull, carry, handle or transport heavy or awkward loads. In many cases the equipment will cost little; in others a meaningful investment may be necessary.

Figures below show examples of the type of equipment that can be used to eliminate or minimize the lifting and handling of loads.

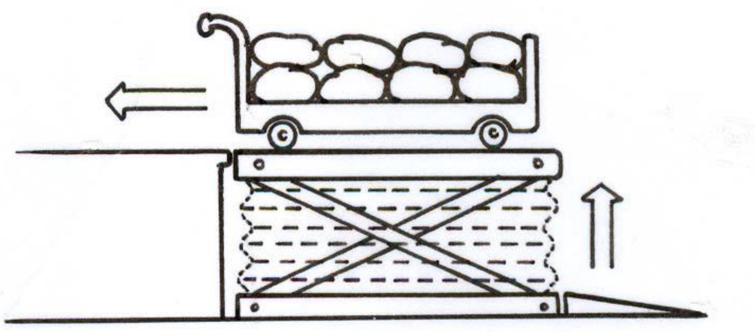
- **Lever to lift and transport heavy objects**



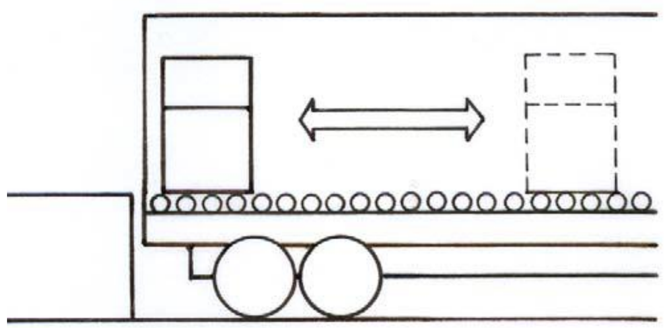
- **Two-wheeled trolley for moving doors and windows**



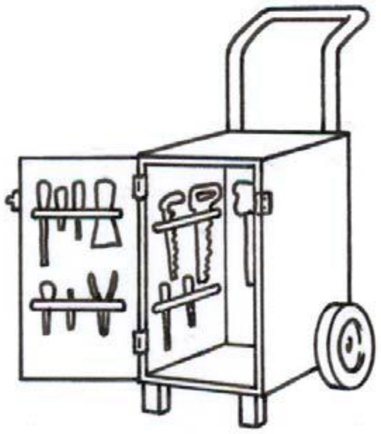
- **Scissor lift to raise load at loading dock**



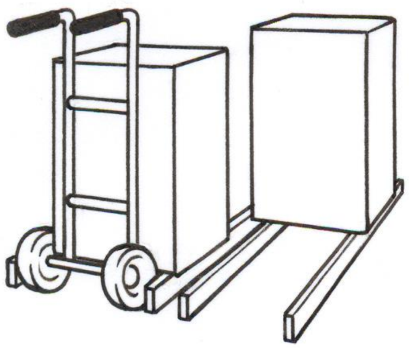
- **Rollers in floor of cargo truck**



- **Cart modified as tool caddy**

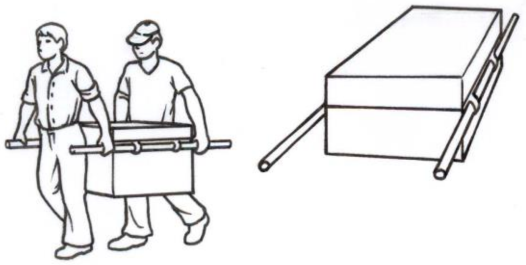


- **Hand truck with loads raised off the floor**

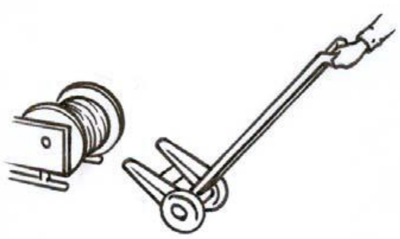


- **Hand trolley for bagged materials**

- **Oversized box modified for two-person lifting**

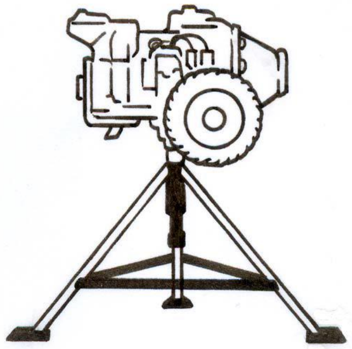


- **Specialized hand truck for moving spooled wire**

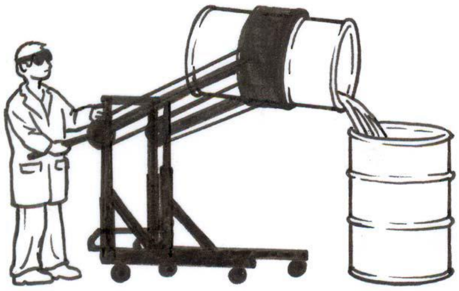


- **Wheeled dolly for awkward access**

- **Jig for holding and securing work piece**



- **Drum lifter for pouring liquids**



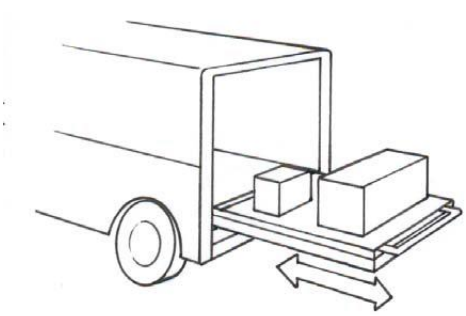
- **Rotating pallet holder**

- **Magnetic handles for carrying sheet metal**

- **Magnetic lifting head on overhead crane**

- **Spring-loaded hand truck platform that eliminates stooping**

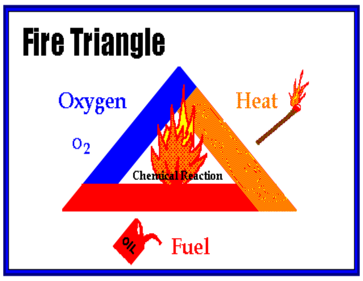
- **Sliding cargo floor**



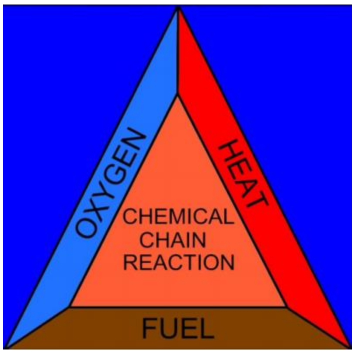
- **Topic 4: Fire and fire extinguishers**

1. **Fire**

Fire is a self-sustaining, chemical chain reaction with varying degrees of light and heat.
It requires fuel, oxygen (air) and heat. This is shown by the 'fire triangle‟



Or



The “Fire Triangle” identifies the three components of any fire:

- Fuel paper, wood, flammable gas, energized electrical equipment, etc...
- Energy (heat), sufficient to support combustion. Often referred to as the ignition source.
- Oxidizer (air)

If any one of these is missing, a fire cannot continue.

In case of fire the 3 A’s method is Followed:

- Activate
- Assist and
- Attempt

Activate:

Activate the buildings fire alarm system.

Fire alarm

Assist:

Assist those who are in immediate danger or who are incapacitated. Do this with out risk to yourself.

Attempt:

Attempt to fight a fire only after the first two steps have been completed and you feel confident in yourself to do so. Always have an exit to your back in case you need to escape. Never attempt to fight a fire if there is a heavy smoke condition. Smoke can be extremely toxic and will reduce your visibility. Only fight small fires, no larger than the size of a small waste basket. Small fires will grow big very fast.

1.1. Different causes of fire in electrical equipments

1. Most electrical fires are caused by faulty electrical outlets and old, outdate appliances.
    - Removing the grounding plug from a cord so it can be used in a two-prong electrical outlet can also cause a fire.
2. Light fixtures, lamps and light bulbs are another common reason for electrical fires.
    - Installing a bulb with a wattage that is too high for the lamps and light fixtures is a leading cause of electrical fires.
    - Always check the maximum recommended bulb wattage on any lighting fixture or lamp and never go over the recommended amount.
3. Misuse of extension cords is another electrical fire cause.

- Appliances should be plugged directly into outlet and not plugged into an extension cord for any length of time.
- Only use extension cords as a temporary measure.
- If you do not have the appropriate type of outlets for your appliances, hire an electrician to install new ones.

4. Space heaters are a major cause of electrical fires.
   - Because these types of heaters are portable, many times people put them too close to combustible surfaces such as clothing, chairs, and rugs.
   - Coil space heaters are especially dangerous. If you do use space heaters, use the radiator-type that diffuse heat over the entire surface of the appliance.
5. Outdated wiring often causes electrical fires.
   - Breakers should be triggered when circuits get overloaded by too much electricity,
   - Outdated breaker boxes often have worn connectors that do not work, causing the system to overload and start an electrical fire.

1.2. Types of fire

Class A fires: freely burning fires fuelled by ordinary combustible materials such as cloth, wood, paper and fabric.

Class B fires: fires fuelled by flammable liquids such as oils, spirits and petrol.

Class C fires: fires fuelled by flammable gases such as propane, butane and North Sea gas.

Class D fires: fires involving flammable metals such as Magnesium, Lithium or Aluminum powders.

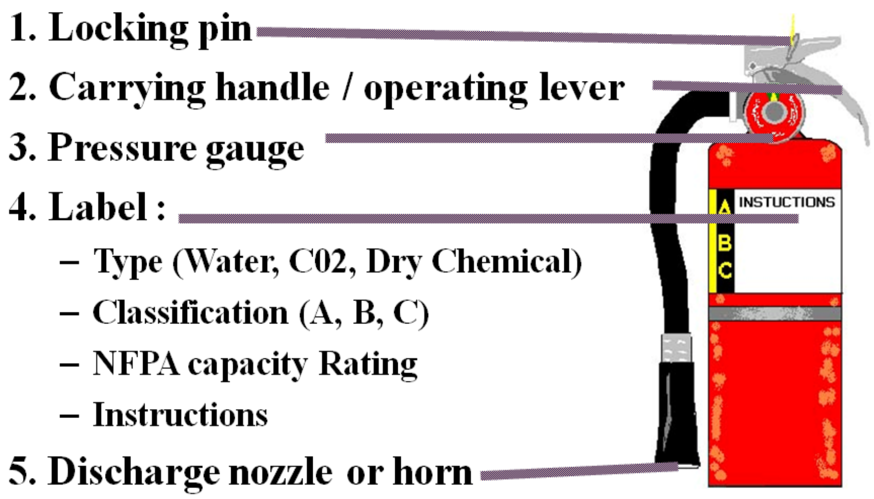
Class E fires: Fires involving electrical hazards.

Class F fires: fires fuelled by cooking oils and fats. Use of a wet chemical is the most effective way of extinguishing this type of fire.

2. Fire extinguishers

Fire extinguishers are portable devices used to extinguish small fires or reduce their destruction before firefighters arrive at the scene. These are kept handy at places, namely fire points, in buildings, factories, public places or transportation. The types and numbers of extinguishers legally required for an area are governed by the safety regulations in force in that particular area.

2.1. Extinguisher Common features:



2.2. Types of Extinguishers

Now that you have a basic understanding of the various types of fire and why different extinguishers are necessary, 6 main types of fire extinguishers and their uses will be discussed:

1. ABC powder fire extinguisher

An ABC powder fire extinguisher has numerous advantages as it is a multi-purpose extinguisher and is therefore one of the most common extinguishers to have on hand.

A powder extinguisher sprays a very fine chemical powder composed most commonly of monoammonium phosphate. This acts to blanket the fire and suffocate it.

Powder extinguishers are effective for class A, B and C fires, since it is not an electrical conductor and since it can effectively break the chain reaction in a liquid or gas fire, something a water extinguisher cannot do.

2. CARBON DIOXIDE fire extinguisher

A carbon dioxide fire extinguisher (CO_2) is one of the cleanest types of extinguishers to use as it leaves no residue and requires no cleanup.

The CO_2 extinguisher does exactly that – extinguishes CO_2. By doing so, it removes oxygen from the fire, effectively suffocating it of oxygen. It is perfect for use on class B fires that involve flammable liquids and on electrical fires.

3. Wet chemical fire extinguisher

The wet chemical extinguisher is a specialized type primarily focused on class K fires, those involving cooking media such as animal and vegetable fats or oils.

These extinguishers contain a solution composed of potassium that effectively launches a two-pronged assault on fires.

First, the liquid mist it sprays acts to cool the fire. Second, due to the chemical reaction of the solution with the cooking medium, a thick soap-like substance forms, sealing the surface of the liquid to prevent re-ignition.

The wet chemical extinguisher, then, is ideal for a kitchen setting and class K fires. However, it can also be effective for class A fires where a material such as wood or paper has caught fire.

4. Water mist fire extinguisher

The most versatile of the set, the water mist extinguisher, uses a newer technology that works across most classes of fire.

This type of extinguisher releases microscopic water molecules that fight the fire on a variety of levels. First, because so much water is dispersed in such a microscopic fog-like form, the level of oxygen in the air is decreased, which helps to suffocate the fire.

Second, the water particles are drawn to the fire and, as water always does, acts to cool it, reducing the temperature.

Finally, and perhaps what is most unique about the water mist extinguishers, is that the water has been de-ionized (the minerals have been removed). As a result, it can actually be used on electrical fires, as the de-ionized water will not act as a conductor, as well as on burning liquids/gases that a standard water extinguisher could not be applied to.

Thus, a water mist extinguisher is safe and effective for use on classes A, B, C and K fires.

5. Foam fire extinguisher

Foam fire extinguishers are suitable for class A and the flammable liquids of class B, though not effective for gaseous fires.

They spray a type of foam that expands when it hits the air and blankets the fire. This blanket prevents the vapors from rising off the liquid to feed the fire, thus starving it of fuel. Also, because the foam is mixed with water, it has a cooling effect as well.

Foam extinguishers are some of the best for liquid fires, such as gasoline fires, but can also be used on Class A fires involving solid combustibles like wood.

6. Clean agent fire extinguisher

A clean agent fire extinguisher is a type of gaseous fire suppression. Stored in its liquid form, when it is sprayed and hits the air, it converts to its gas form which is non-conductive, safe for use while humans are present, leaves no residue, and has a very short atmospheric lifetime, making it eco-friendly.

The gas, often composed of Halon, extinguishes fire by reducing the oxygen levels and impeding the chain reaction. Because it is non-conductive and so clean, it is ideal for rooms or businesses filled with electrical and computer equipment. They are most commonly used for class B and C fires.

7.Fire blanket

A fire blanket is a safety device designed to extinguish incipient (starting) fires. It consists of a sheet of a fire retardant material which is placed over a fire in order to smother it.

Small fire blankets, such as for use in kitchens and around the home are usually made of fiberglass and sometimes kevlar, and are folded into a quick-release contraption for ease of storage.

Fire blankets, along with fire extinguishers, are fire safety items that can be useful in case of a fire. These nonflammable blankets are helpful in temperatures up to 900 degrees and are useful in smothering fires by not allowing any oxygen to the fire. Due to its simplicity, a fire blanket may be more helpful for someone who is inexperienced with fire extinguishers.

Larger fire blankets, for use in laboratory and industrial situations, are often made of wool (sometimes treated with a flame retardant fluid). These blankets are usually mounted in vertical quick-release container so that they can be easily pulled out and wrapped round a person whose clothes are on fire.

- **Topic 5: Electric shock**

1. **introduction**

An electric shock happens when an electric current passes through a human body. This can burn both internal and external tissue and cause organ damage.

A range of things can cause an electric shock, including:

- power lines
- lightning
- electric machinery
- electric weapons, such as Tasers
- household appliances
- electrical outlets

factors that affect how serious an electric shock is, including:

- voltage
- length of time in contact with the source
- overall health
- electricity's path through your body
- type of current (an alternating current is often more harmful than a direct current because it causes muscle spasms that make it harder to drop the source of electricity)

2. The symptoms of an electric shock

The symptoms of an electric shock depend on how severe it is.

Potential symptoms of an electric shock include:

- loss of consciousness
- muscle spasms
- numbness or tingling
- breathing problems
- headache
- problems with vision or hearing
- burns
- seizures
- irregular heartbeat

3. Effects of electric shock

➢ Muscle spasms

Muscles are stimulated by electricity. The effect depends on the intensity of the current and the type of muscle it travels through.

We've all felt a buzzing or tingling sensation that doesn't cause injury. That's the effect of a current as low as 0.25 milliamperes (mA) entering the body.

When a current above 10 mA travels through flexor muscles, such as the ones in our forearms that close the fingers, it causes a sustained contraction. The victim may be unable to let go of the source of the current, making the duration of the contact longer and increasing the severity of the shock.

When a current above 10 mA travels through extensor muscles, it causes a violent spasm. If the muscles affected are the hip extensors that lengthen the limbs away from the body, the victim may be propelled, sometimes many metres away!

Muscles, ligaments and tendons may tear as a result of the sudden contraction caused by an electric shock. Tissue can also be burned if the shock is lasting or the current is high.

- Cardiac arrest

If a current of 50 mA passes through the heart, it can cause cardiac arrest.

The heart is also a muscle, which beats to pump blood through the body. The rhythm of our heartbeat is controlled by electric impulses. It is these impulses that are monitored by an electrocardiogram. If a current from outside the body passes through the heart, it can mask these impulses and disturb the heart's rhythm. This irregular heartbeat is called arrhythmia and can even manifest as a total disorganization of the rhythm, known as ventricular fibrillation.

When ventricular fibrillation occurs, the heart stops pumping and the blood stops circulating. The victim rapidly loses consciousness and dies if a healthy heartbeat is not restored with a device called a defibrillator.

The arrhythmia can occur at the time of the shock or in the hours following the electric shock.

- Burns of tissues and organs

When a current above 100 mA passes through the body, it leaves marks at the points of contact with the skin. Currents above 10,000 mA (10 A) cause serious burns that may require amputation of the affected limb.

Some burns are easy to recognize because they look like the burns you can get from contact with heat. **Others may seem harmless but aren't: tiny charred craters indicate the presence of much more serious internal burns.**

Electrical burns often affect internal organs. They are caused by the heat generated from the body's resistance to the current passing through it. Internal damage may be much more serious than the external injuries suggest.

Internal burns often have serious consequences: scarring, amputation, loss of function, loss of sensation and even death. For example, if a lot of tissue is destroyed, the large amount of waste generated can cause serious kidney or blood circulation disorders.

- Effect on nervous system

Nerves are tissue that offers very little resistance to the passage of an electric current. When nerves are affected by an electric shock, the consequences include pain, tingling, numbness, weakness or difficulty moving a limb. These effects may clear up with time or be permanent.

Electric injury can also affect the central nervous system. When a shock occurs, the victim may be dazed or may experience amnesia, seizure or respiratory arrest.

Long-term damage to the nerves and the brain will depend on the extent of the injuries and may develop up to several months after the shock. This type of damage can also cause psychiatric disorders.

- Other unexpected consequences

Other disorders can appear in the weeks or months following the shock, depending on which organs the current passed through. For example, if the current passed through the eyes, cataracts may develop over time.

4. Treatment of electric shock

If someone receives a shock, keep several things in mind to both help them and keep yourself safe:

- Don't touch someone who has been shocked if they're still in contact with the source of electricity.
- Don't move someone who has been shocked, unless they're in danger of further shock.
- Turn off the flow of electricity if possible. If you can't, move the source of electricity away from the person using a non-conducting object. Wood and rubber are both good options. Just make sure you don't use anything that's wet or metal based.
- Stay at least 20 feet away if they've been shocked by high-voltage power lines that are still on.
- Call local emergency services if the person was struck by lightning or isf they came into contact with high-voltage electricity, such as power lines.
- Call local emergency services if the person has trouble breathing, loses consciousness, has seizures, has muscle pain or numbness, or is feeling symptoms of a heart issue, including a fast heartbeat.
- Check the person's breathing and pulse. If necessary, start CPR until emergency help arrives.
- If the person is showing signs of shock, such as vomiting or becoming faint or very pale, elevate their legs and feet slightly, unless this causes too much pain.
- Cover burns with sterile gauze if you can. Don't use Band-Aids or anything else that might stick to the burn.
- Keep the person warm.

- **Topic 6: PPE (Personal Protective Equipment**

Employers have duties concerning the provision and use of personal protective equipment (PPE) at work.

- PPE is equipment that will protect the user against health or safety risks at work.
- It can include items such as safety helmets, gloves, eye protection, high-visibility clothing, safety feet wear etc.
- It also includes respiratory protective equipment (RPE).

1. Some of PPE

1.1. Overcoat and overall

It is a type of long coat used to protect body and is intended to extend below the knee.

1.2. Gloves

It is Hand protection equipment that are used for tasks that can damage hands. Wearing the proper work gloves when performing industrial tasks like handling caustic chemicals, hot materials or sharp objects will promote worker's efficiency.

1.3. Safety shoes

Safety boots and shoes are used to protect feet against any accident. Footwear can have a variety of sole patterns and materials that prevent slips in different conditions, including oil - or chemical-resistant soles. It can also be anti-static, electrically or thermally insulating. Appropriate footwear should be selected for the risks identified

1.4. Helmet

Is PPE that used to protect head all kind of object that can fall on the head.

1.5. Earmuff

Is one of a pair of ear coverings connected by a flexible band and worn as protection against cold or noises

1.6. **Goggles** or **safety glasses**

There are forms of protective eyewear that usually enclose or protect the area surrounding the eye in order to prevent particulates, water or chemicals from striking the eyes.

1.7. Nose protection mask or a facemask

is protective equipment that a physical barrier between the mouth and Nose.

2. How to use Safety equipment

Training for the use of personal protective equipment (PPE) is essential. Users should know how to use equipment properly, including how to fit and remove it. They should also be aware of why they use the equipment, when they should use. They should also be aware of why they use the equipment, when they should use it and what its limits are. Training should discuss whether any equipment will interfere with the job and if so whether there is alternative equipment available.

LO 1. 2: Select tools, materials and equipment based on the electrical installation

- **Topic 1: Types of electrical tools and their use**

Electrical tools are the core tools all electricians use on a daily basis. Electrical tools are classified into 3 categories:

- ✓ **Working tools (hand tools):** a tool held in the hand and operated without electricity or other power.
- ✓ **Measuring tools:** A measuring tool is a devise used to take a count of quantitative data, such as current, voltage, power and so on.
- ✓ **Power tools:** **s**A power tool is a tool that is actuated by an additional power source and mechanism other than the solely manual labour used with hand tools. The most common types of power tools use electric motors.

1. **hand tools:**

- **Stripping plier**
- **Side cutter plier**
- **Combination plier**
- **Long nose plier**
- **Electrician knife**
- **Measuring tape**
- **Screw drives**
- **Hammer**
- **Spirit level**

1.1. Pliers

➢ **Wire strippers**

Used for stripping insulation from conductors, cutting small conductors and crimping wire lugs


➢ **Side cutter pliers (Lineman's pliers)**

Used for cutting large conductors, forming loops on large conductors and pulling and holding large conductors


➢ **Diagonal cutting pliers (dykes)**

Used for cutting small conductors, cutting conductors in limited spaces

- **Needle-nose pliers**

Used for forming loops on small conductors, cutting and stripping small conductors.

- **Combination pliers**

Heavy duty pliers for general use in bending, cutting, crimping and pulling wire

- **Automatic Stripping pliers**

Used to strip the insulation from the wire without damaging the wire

- **Stripping pliers**

Used to strip the insulation from the wire without damaging the wire

1.2. Screwdrivers

A screwdriver is a tool, manual or powered, used for screwing and unscrewing screws. A typical simple screwdriver has a handle and a shaft, ending in a tip the user puts into the screw head before turning the handle.

- **Flat-blade screwdriver**

Used to drive slot-head screws

- Phillips screwdriver

Used to drive Philips-head screws

- **Rotating speed screwdrivers**

Used for trim work, installing switch and receptacles

- **Star screwdrivers**

Used to driver the screw of plat heads

- **Other types**

1.3. Hacksaw

A hacksaw is a fine-toothed saw, originally and mainly made for cutting metal. The equivalent saw for cutting wood is usually called bow saw. Most hacksaws are hand saws with a C-shaped walking frame that holds a blade under tension.

It is user for cutting large conductors and cables, Cutting conduit, metal, or bolt.

1.4. Voltage tester

Test the presence of voltage in conductors

1.5. No contact voltage tester

Used to indicate if wire is live or not

1.6. Electrician Scissors

Used for cutting thick gauged wire

1.7. Electrical Knife

Used to strip cable and insulation

1.8. Electrician Hammer

Used to fixe certain equipment such as junction box

1.9. Tin Snips

Used to cut straight edge in sheet metal

2. **Measuring tools**

2.1. Tape measure

Used for measuring wires, conduit, trunking, and different distance in electrical installation

2.2. Fiberglass surveyors tape

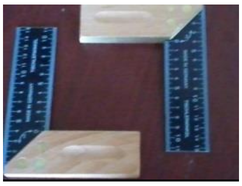
Used for measuring wires, conduit, trunking, tray and different distance in electrical installation

2.3.Sprit level

Used to measure horizontality, verticality of different accessories in electrical installation

2.4.Tri-square

Used to measure the right angle in electrical installation



3. **Power tools:**

- **Crimping tools**
- **Drilling machine**

- **Electric screw driver**

4. Factors to consider when Purchasing Tools

Factors to consider when purchasing tools are size, design, and quality. Always purchase the correct sized tools for the work to be done. Tools should be designed specifically for electrical work. Ex: Insulated handles, hammers with straight claws. The purchase of quality tools last longer which saves replacement cost.

LO1.3: Use insulation resistance tester in accordance to the standard value

- **Topic 1: Function and application of insulation resistance tester**

1. **introduction**

The insulation resistance (IR) test is the oldest and most widely used test for assessing the quality of insulation. The Insulation Resistance Test is the second test required by the electrical safety testing standards.

The Insulation Resistance Test consists in measuring the Insulation resistance of a device under test, while phase and neutral are short circuited together. The measured resistance has to be higher than the indicated limit from the international standards. A megohmmeter (also called insulation resistance tester, teraohmmeter) is used to measure the ohmic value of an insulator under a direct voltage of great stability.

Insulation cannot be perfect in the same way that something cannot be frictionless. This means that there will always be a little bit of current travelling through. This is known as “leakage current”. It’s acceptable with good insulation, but if the insulation deteriorates, leakage can start causing trouble. So what makes “good” insulation is a high resistance to current, and it needs to be able to sustain high resistance for a long time

2. **Why Insulation Resistance Test is Done?**

Insulation starts to age as soon as it’s made. As it ages, its insulating performance deteriorates. Any harsh installation environments, especially those with temperature extremes and/or chemical contamination, accelerates this process.

Stresses due to different factors like:

- **Electrical stresses:** Mainly linked to overvoltage and undervoltage.
- **Mechanical stresses:** Frequent start-up and shutdown sequences can cause mechanical stresses.
- Balancing problems on rotating machinery and any direct stress to the cables and the installations in general.
- **Chemical stresses:** The proximity of chemicals, oils, corrosive vapours and dust, in general, affects the insulation performance of the materials.
- **Stresses linked to temperature variations:** When combined with the mechanical stresses caused by the start-up and shutdown sequences, expansion and contraction stresses affect the properties of the insulating materials. Operation at extreme temperatures also leads to aging of the materials.
- Environmental contamination causes aging acceleration of insulation.

Topic 2: Types of insulation resistance tester

There are three types of resistance tests

1. **Short-time or spot-reading test**

A short-time or spot-reading test is performed by simply connecting a Megger insulation tester across the insulation that is being tested. It is then to be operated for a short, specific time period, usually 60 seconds. During this test, it’s important to remember that temperature, humidity and the condition of the insulation are affecting the reading.

2. **Time-resistance method**

A time-resistance method is fairly independent of temperate and often gives conclusive information without records from prior tests. This method is based on absorption effect of good insulation compared to contaminated insulation. During this test, the Megger insulation tester will take successive readings at specific times and note the differences. This test should display a continual increase in resistance over a period of time if insulation is good.

3. **Dielectric absorption ratio**

A dielectric absorption ratio is the ratio of two time-resistances readings. For example, a 60-second reading divided by a 30-second reading, A Megger insulation tester makes a dielectric absorption ratio test easier and is known for giving best results. For example, a Megger insulation tester can run for 60 seconds; however, it allows you to record readings at the 30-second interval and at the 60-second interval.

- **Topic 3: Techniques of testing**

A megohmmeter usually is equipped with three terminals.

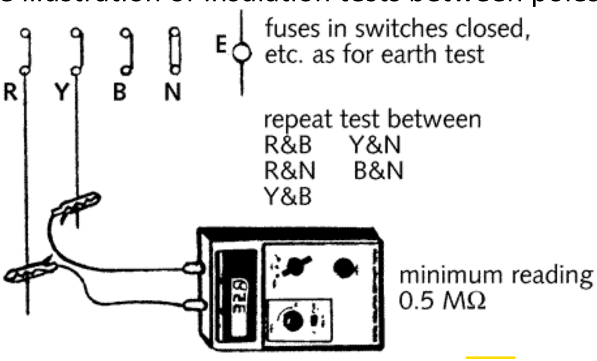
1. The "LINE" (or "L") terminal is the so-called "hot" terminal and is connected to the conductor whose insulation resistance you are measuring. Remember: These tests are performed with the circuit deenergised.
2. The "EARTH" (or "E") terminal is connected to the other side of the insulation, the ground conductor.
3. The "GUARD" (or "G") terminal provides a return circuit that bypasses the meter. For example, if you are measuring a circuit having a current that you do not want to include, you connect that part of the circuit to the "GUARD" terminal. This is the simplest of the tests.

1. **Insulation resistance tests between poles**

A low resistance between phase and neutral conductors, or from live conductors to earth, will result in a leakage current.
This current could cause deterioration of the insulation, as well as involving a waste of energy which would increase the running costs of the installation.
Thus, the resistance between poles or to earth must never be less than half of one meg ohm (0.5 M Ohms) for the usual supply voltages.

In addition to the leakage current due to insulation resistance, there is a further current leakage in the reactance of the insulation, because it acts as the dielectric of a capacitor. This current dissipates no energy and is not harmful, but we wish to measure the resistance of the insulation, so a direct voltage is used to prevent reactance from being included in the measurement

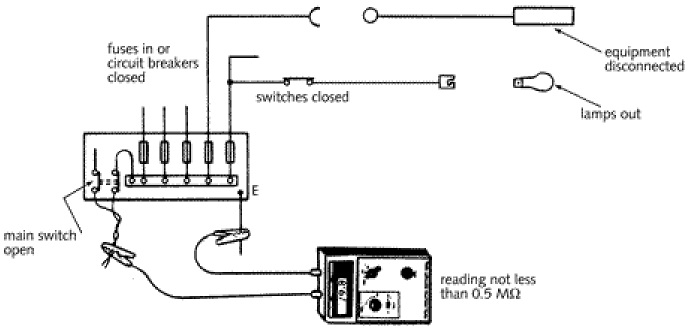
The illustration of Insulation tests between poles is shown below



2. **Insulation resistance tests to earth**

Where any equipment is disconnected for testing purposes, it must be subjected to its own insulation test, using a voltage which is not likely to result in damage. The result must conform with being at least 0.5 M Ohms if there is no any Standard.
The test to earth must be carried out on the complete installation with the main switch off, with phase and neutral connected together, with lamps and other equipment disconnected, but with fuses in, circuit breakers closed and all circuit switches closed.

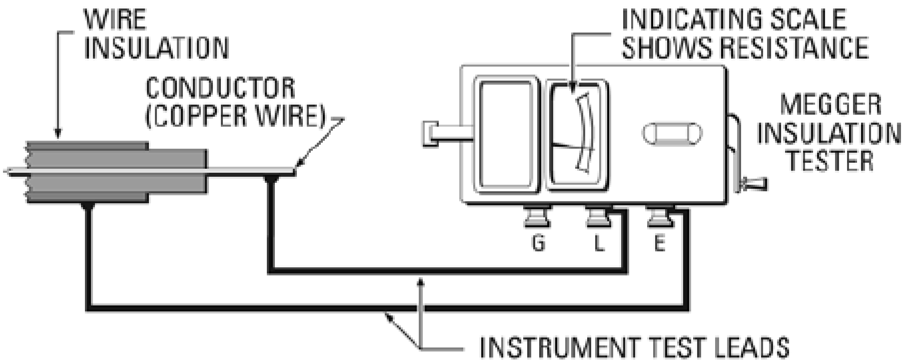
Below is the diagram of Insulation test to earth



- **Topic 4: Principles of insulation testing and influencing factors**

1. **Principle of insulation testing and influencing factors**

Insulation resistance measurement is based on Ohm's Law. By injecting a known DC voltage lower than the voltage for dielectric testing and then measuring the current flowing, it is very simple to determine the value of the resistance. In principle, the value of the insulation resistance is very high but not infinite, so by measuring the low current flowing, the megohmmeter indicates the insulation resistance value, providing a result in kW, MW, GW and also TW (on some models).



This resistance characterizes the quality of the insulation between two conductors and gives a good indication of the risks of leakage currents flowing.

A number of factors affect the value of the insulation resistance and therefore the value of the current flowing when a constant voltage is applied to the circuit being tested. These factors, such as temperature or humidity for example, may significantly affect the measurement result.

By analyzing the nature of the currents flowing during an insulation measurement, using the hypothesis that these factors do not influence the measurement, the total current flowing in the insulating material will depend on three factors:

- **Capacitance:** The capacitance charging current necessary to charge the capacitance of the insulation being tested. This is a transient current which starts relatively high and falls exponentially towards a value close to zero once the circuit being tested is charged electrically. After a few seconds or tenths of seconds, this current becomes negligible compared with the current to be measured.

- **Absorption:** The absorption current, corresponding to the additional energy necessary for the molecules of the insulating material to reorient themselves under the effect of the electrical field applied. This current falls much more slowly than the capacitance charging current, sometimes requiring several minutes to reach a value close to zero.

- **Leakage current:** The leakage current or conduction current. This current characterizes the quality of the insulation and is stable over time.

2. **Safety Requirements for Insulation Resistance Measurement**

- All equipment under test must be disconnected and isolated.
- Equipment should be discharged (shunted or shorted out) for at least as long as the test voltage was applied in order to be absolutely safe for the person conducting the test.
- Never use Megger in an explosive atmosphere.
- Make sure all switches are blocked out and cable ends marked properly for safety.
- Make sure when testing for earth, that the far end of the conductor is not touching, otherwise the test will show faulty insulation when such is not actually the case.
- Make sure that all connections in the test circuit are tight.
- Cable ends to be isolated shall be disconnected from the supply and protected from contact to supply, or ground, or accidental contact.
- Erection of safety barriers with warning signs, and an open communication channel between testing personnel.

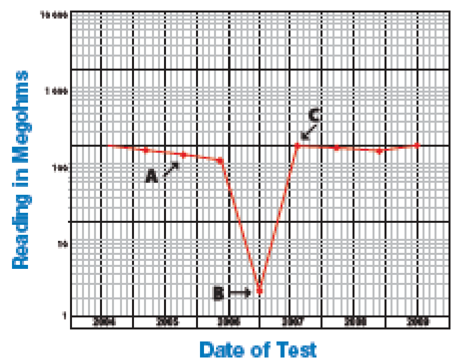
- **Topic 5: Measuring methods and interpretation of results**

1. **Short-Time or Spot-Reading Test**

In this method, the Megger is simply connected across the insulation to be tested and operate it for a short.
It involves applying the test voltage for a short time (30 or 60 seconds) and noting the insulation resistance reading at that moment. This direct measurement of the insulation resistance is significantly affected by the temperature and humidity, so the measurement should be standardized at a reference temperature and the level of humidity should be noted for comparison with the previous measurements.

With this method, it is possible to analyze insulation quality by comparing the current measured value with several previous test results. This trend, over time, is more representative of the evolution of the insulation characteristics on the installation or equipment being tested than a single test.

The graph below shows an example of the insulation resistance readings on an electric motor.



At A, the insulation resistance decreases due to aging and dust accumulation.

The sharp fall at B indicates there was an insulation fault.

At C, the fault has been repaired (rewinding of the motor) so the insulation resistance has returned to a higher value and has remained stable over time, indicating a good conition.

2. **Time-Resistance Method**

This method is fairly independent of temperature and often can give you conclusive information without records of past tests. It is based on the absorption effect of good insulation compared to that of moist or contaminated insulation. Tests by this method are sometimes referred to as absorption tests.
This test is of value also because it is independent of equipment size. The increase in resistance for clean and dry insulation occurs in the same manner whether a motor is large or small. You can, therefore, compare several motors and establish standards for new ones, regardless of their horsepower ratings.

Insulation Resistance should be done to prevent hazards such as electric shock and short-circuits caused when the insulation in electrical devices, parts, and equipment used in industrial plants, buildings, and other settings degrades over long periods of use.

3. **Dielectric Discharge (DD) Test method**

The dielectric discharge (DD) test, also known as the re-absorption current test, is performed by measuring the current during dielectric discharge of the equipment being tested. As all three components of the current (capacitance charging current, polarization current and leakage current) are present during a standard insulation test, the determination of the polarization or absorption current may be affected by the presence of the leakage current. Instead of trying to measure the polarization current during the insulation test, the dielectric discharge (DD) test measures the depolarization current and the capacitance discharging current after the insulation test.

The measurement principle is as follows: the equipment to be tested is first charged for long enough to reach a stable state (capacitance charging and polarization are completed and the only current flowing is the leakage current). The equipment is then discharged through a resistor inside the megohmmeter and the current that flows is measured. This current is made up of the capacitance charging current and the re-absorption current, which combine to give the total dielectric discharge current. This current is measured after a standard time of 1 minute. The current depends on the overall capacitance and the final test voltage.

The value DD is calculated using the formula:

$$DD = \text{Current after 1 minute} / (\text{Test voltage} \times \text{Capacitance})$$

The DD test can identify excess discharge currents occurring when one of the layers of multi-layer insulation is damaged or contaminated.

The discharge current will be higher for a given voltage and capacitance if one of the insulation layers is damaged. The time constant of this individual layer will no longer match that of the other layers, leading to a higher current value than for undamaged insulation.
Homogeneous insulation will have a DD value close to zero, while acceptable multi-layer insulation will have a DD value of up to 2.
The table below indicates the sanctions according to the DD value obtained.

DD	***Condition***
> 7	Bad
4 to 7	Poor
2 to 4	Questionable
< 2	OK

Caution: This measurement method is temperature dependent, so every attempt should be made to perform the test at a standard temperature or at least to note the temperature alongside the test result.

LO1.4: Use of multimeter based on the required electrical quantities

- **Topic 1: Defining the multimeter**

A Multimeter is an electronic instrument, every electronic technician and engineers widely used piece of test equipment.

A multimeter is mainly used to measure the three basic electrical characteristics of voltage, current, and resistance. It can also be used to test continuity between two points in an electrical circuit. This post mainly introduces the basic information of multimeters, applications, and types of multimeters are in.

The multimeter has multi functionalities like, it acts like ammeter, voltmeter, and ohmmeter. It is a handheld device with positive and negative indicator needle over a numeric LCD digital display. Multimeters can be used for testing batteries, household wiring, electric motors, and power supplies.

- **Topic 2: Application of multimeter**

The applications of ammeter mainly involve in various electrical and electronic projects for components testing and also used in different measurement applications in the multimeter.

1. Temperature and Environmental Applications
   - Low-cost weather station
   - DMM internal temperature
2. Voltage Measurements
   - High and low-value DC measurement
   - Peak to Peak and DC average measurement
3. Current Measurements
   - DC measurement
   - True RMS AC
4. Resistance Measurement
   - Micro ohmmeter
   - Measuring resistance with constant voltage
   - Measuring resistance with constant current
5. Time and Frequency measurement
   - Fast frequency
   - Time measurement

2.1. Types of Multimeters:

There are different types of multimeters like Analog, Digital, and Fluke multimeters.

2.1.1. Digital Multimeter:

The mostly used multimeter is a digital multimeter (DMM). The DMM performs all functions from AC to DC other than analog. It has two probes positive and negative indicated with black and red color is shown in the figure. The black probe connected to COM JACK and red probe connected by user requirement to measure ohm, volt, or amperes. The jack marked VΩ and the **COM** jack on the right of the picture are used for measuring voltages, resistance, and for testing a diode. The two jacks are utilized when an LCD that shows what is being measured (volts, ohms, amps, etc.). Overload protection prevents damage to the meter and the circuit and protects the user.

To measure the resistance, current flows from a constant current source through the unknown resistor and the voltage across the resistor are amplified and fed to an Analog to Digital Converter and the resultant output in form of resistance is displayed on the digital display.

To measure an unknown AC voltage, the voltage is first attenuated to get the suitable range and then rectified to DC signal and the analog DC signal is fed to A/D converter to get the display, which indicates the RMS value of the AC signal.

Similarly to measure an AC or DC, the unknown input is first converted to a voltage signal and then fed to an analog to digital converter to get the desired output(with rectification in case of AC signal).

Advantages of a Digital Multimeter are its output display which directly shows the measured value, high accuracy, ability to read both positive and negative values.

2.1.2. Analog Multimeter:

The Analog Multimeter or VOM (Volt-Ohm-Milliammeter) is constructed using a moving coil meter and a pointer to indicate the reading on the scale. The moving coil meter consists of a coil wound around a drum placed between two permanent magnets. As current passes through the coil, the magnetic field is induced in the coil which reacts with the magnetic field of the permanent magnets and the resultant force causes the pointer attached to the drum to deflect on the scale, indicating the current reading. It also consists of springs attached to the drum which provides an opposing force to the motion of the drum to control the deflection of the pointer.

For the measurement of DC, the D Arsonval movement described above can be directly used. However, the current to be measured should be lesser than the full-scale deflection current of the meter. For higher currents, the current divider rule is applied. Using different values of shunt resistors, the meter can also be used for multi-range current measurements. For current measurement, the instrument is to be connected in series with the unknown current source.

For measurement of DC voltage, a resistor is connected in series with the meter, and the meter resistance is taken into account such that the current passing through the resistor is the same as the current passing through the meter and the whole reading indicates the voltage reading.

For voltage measurement, the instrument is to be connected in parallel with the unknown voltage source. For multirange measurement, different resistors of different values can be used, which are connected in series with the meter.

For measurement of resistance, the unknown resistance is connected in series with the meter and across a battery, such that the current passing through the meter is directly proportional to the unknown resistance. For AC voltage or current measurement, the same principle is applied, except for the fact that the AC parameter to be measured is first rectified and filtered to get the DC parameter and the meter indicates the RMS value of the AC signal.

Advantages of an Analog Multimeter are that it is inexpensive, doesn't require a battery, can measure fluctuations in the readings.

The two main factors affecting the measurement are sensitivity and accuracy. Sensitivity refers to the reciprocal of the full-scale deflection current and is measured in ohms per volt.

2.1.3. Fluke Multimeter:

The fluke multimeters are protected against the transient voltage. It is a small portable device used to measure voltage, current, and test diodes. The multimeter has multi selectors to select the desired function. The fluke MM automatically ranges to select most measurements. This means the magnitude of the signal does not have to be known or determined to take an accurate reading, it directly moved to the appropriate port for the desired measurement. The fuse is protected to prevent damage if connected to the wrong port.

- **Topic 3: Polarity and connection probes of measurement instruments**

1. **Introduction**

Voltage is a difference in energy level between two different points in a circuit. Voltage has not only a value, but also a polarity. One of the points will have a higher energy level (or a higher voltage) than the other.

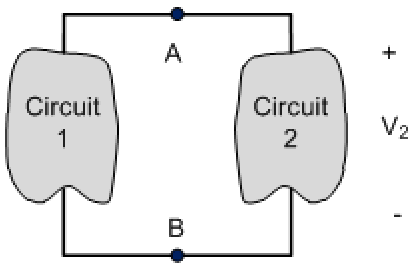
The voltage polarity must be accounted for when making a measurement. When you connect your DMM to a circuit, you will be *assuming* a particular polarity. The sign of the reading displayed on the DMM reflects this assumption. If the actual and assumed polarities are the same, the displayed number will be positive. Conversely, if the number displayed is negative, the actual polarity is opposite to your assumption.

Voltages are measured simply by connecting the DMM probes to the points (or terminals) in the circuit between which the voltage difference is to be measured. The way in which the probes are connected to your circuit defines the assumed polarity of the voltage measurement:

- The **V-Ω** port is connected to the point which is assumed to be at the *higher* voltage.
- The **COM** port is connected to the point which is assumed to be at the *lower* voltage.

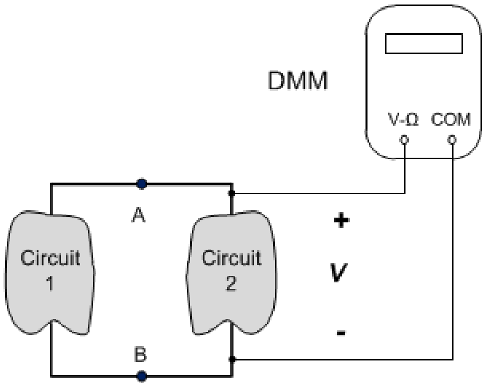
2. Probe Connections

To connect the DMM probes to a circuit at the points between which the voltage is to be measured. the DMM leads are placed *across* the component(s) whose voltage difference want to be measure. The "V- Ω" terminal is connected to the *assumed* positive voltage terminal in the circuit, and the "COM" terminal is connected to the *assumed* negative voltage terminal in the circuit. The figure below shows how to measure the voltage difference between terminals A and B of the circuit.



(a) Voltage to be measured

If the polarity of the voltage difference is define to be such that node A is at a higher voltage than node B, the V-Ω probe of the DMM will connect to point A and the COM probe of the DMM to point B, as shown below.



(b) Voltmeter indicated

3. Important Points

When measuring voltage using a DMM:

- The DMM function selection should be set at $\overline{V}$.
- The V-Ω and COM ports are used.
- The V-Ω port is connected to the terminal in the circuit which is assumed to be at the higher voltage.
- The COM port is connected to the terminal in the circuit which is assumed to be at the lower voltage.

- **Topic 4: Types errors**

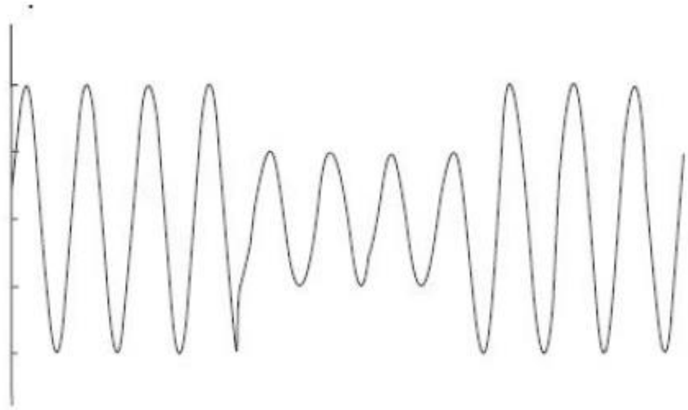
While conducting measurements in experiments, there are generally two different types of errors: random (or chance) errors and systematic (or biased) errors.

Every measurement has an inherent uncertainty. We therefore need to give some indication of the reliability of measurements and the uncertainties of the results calculated from these measurements. To better understand the outcome of experimental data, an estimate of the size of the systematic errors compared to the random errors should be considered.
Random errors are due to the precision of the equipment.
Systematic errors are due to how well the equipment was used or how well the experiment was controlled.

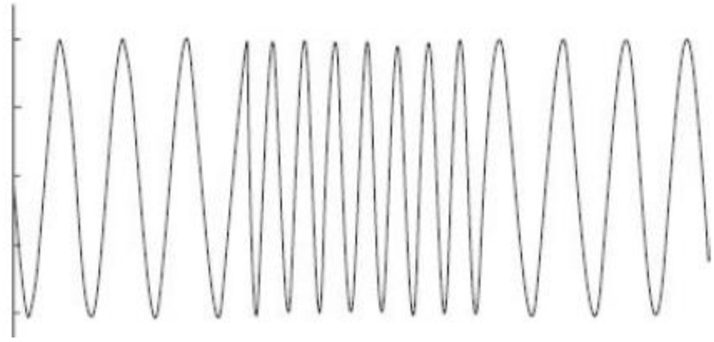
LO1.5: Use tone generator to detect/diagnose the fault.

A signal generator is numerously known as test signal generator, tone generator, arbitrary waveform generator, frequency generator, digital pattern generator, function generator, etc. It is an electronic device which produces repeating or non-repeating electronic signals (either analog or in digital patterns). These signals are utilised in testing, designing, troubleshooting and repairing electronic devices; apart from their artistic uses as well. Signal generators also modulate sinusoidal output signal with other signals. This feature is the main distinguisher between the signal generator and oscillator. When an unmodulated sinusoidal output is generated by the signal generators then they are said to be producing CW (continuous height wave) signal. When they produce modulated output signals then they can be in the form of square waves, externally applied sine waves, pulses, triangular waves, or more complex signals, as well as internally generated sine waves. Although Amplitude Modulation (AM) or Frequency Modulation (FM) can be used, yet amplitude modulation is generally employed. In Figures below the principles of amplitude modulation and frequency modulation are shown respectively.

Amplitude modulation



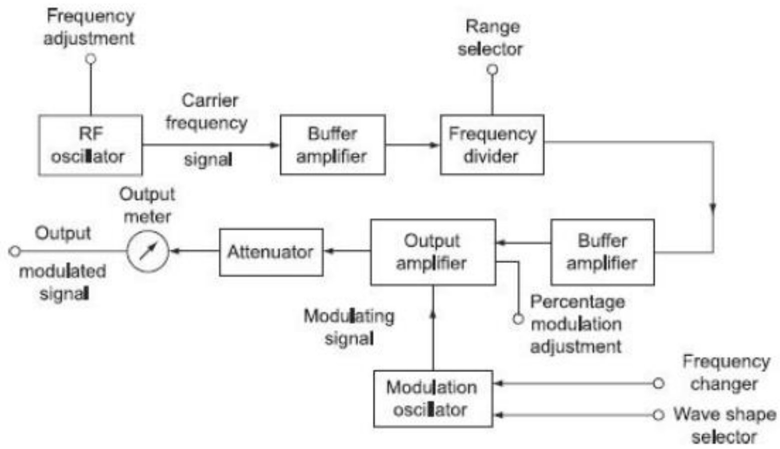
Frequency modulation



For providing appropriate signals for calibration and testing, signal generators are mainly employed. They are also used for troubleshooting of the amplifier circuits used in electronic and communications circuit amplifiers. Signal generators also measure the features of antennas and transmission lines.

Figure below illustrates the block diagram of a signal generator. A Radio Frequency (RF) oscillatoris applied for producing a carrier waveform whose frequency can be attuned typically from about 100 kHz to 40 MHz. With the help of vernier dial setting and range selector switch, carrier wave frequencies can be varied and displayed. Frequency dividers are employed to determine the range. An oscillator s frequency stability is kept very high at all frequency ranges.

Block diagram of an AM signal generator



The following measures are taken in order to attain stable frequency output.

1. Regulated power supply is employed to reduce the change in supply voltage as it changes frequency of output voltage.
2. To separate the oscillator circuit from output circuit, buffer amplifiers are used. This is done so that any change in the circuit linked to the output does not affect the amplitude and frequency of the oscillator.
3. Temperature compensating devices are used to stable the temperature which causes change in oscillator frequency.
4. In place of an LC oscillator, a quartz crystal oscillator is employed to achieve high Qfactor, for instance, 20000.
5. When an audio frequency modulating signal is generated in another very stable oscillator, it is called the modulation oscillator. For changing the amplitude and the frequency of the produced signal, provision is made in the modulation oscillator.
6. Provision is also employed to get several types of waveforms such as the pulses, square, triangular oscillator. The modulation frequency and radio frequency signals are applied to a broadband amplifier, called the output amplifier. Modulation percentage is indicated and adjusted by the meter.
7. A control device can adjust modulation level up to 95%. The amplifier output is then sent to an attenuator and at last the signal reaches the output of the signal generator. An output meter reads or displays the final output signal.
8. An important specification of the signal generator performance is depending by the accuracy to which the frequency of the RF oscillator is tuned. Most laboratory-type signal generators are generally calibrated to be within 0.5–1.0% of the dial setting. For most measurements, this accuracy is sufficient. If greater accuracy is required then a crystal oscillator (frequency
9. Depending upon the different purposes and applications, various types of signal generators are available, however no device is suitable for all possible applications.

Though traditional signal generators have embedded hardware units, with the advancement of multimedia-computers, audio software, tone generators signal generators have become more user-friendly and versatile.

LO1.6: Use ground tester based on regulation.

- **Topic 1: Function and application of ground/earth tester**

1. **Definition**

The earth tester is one type of equipment, used to measure earth resistance. If the earth resistance value is very low then this tester is also known as ground resistance tester

2. **Construction of Earth Tester**

The earth tester uses the dc generator, rotational current reverser, rectifier, and potential coil. The main parts of this tester are current reverser and rectifier, these two parts are mounted on the dc generator shaft. This tester consists of two pressures coils like p1 and p2 and two current coils like C1 and C2. These two coils are placed across the permanent magnet. Both the pressure and current coils have two terminals, the one end of both coils connected to a rectifier and other ends are connected to earth electrodes.
The potential coil is connected to the dc generator directly and it is placed between permanent magnets 'N' and 'S'.

The pointer coil position is fixed on the calibrated scale. The magnitude of the resistance is indicated by the pointer. The resistance of the earth is defined as the ratio of potential to earth electrode and current, or the ratio of voltage and current. The circuit diagram of the earth tester is shown below.

3. **Applications of Earth Tester**

The applications of earth tester are

- Pad and Pole mounted transformers
- Cell towers
- Street lights and street cabinets
- Lightning protection
- Telephone pedestals

- **Topic 2: Methods and principles of ground tester**

The ability to properly measure ground resistance is essential in preventing costly downtime due to service interruptions caused by poor grounds.

The procedures for earth resistance testing are referenced in IEEE Standard No. 81. Four of the most common methods of ground resistance testing used by test technicians are discussed below:

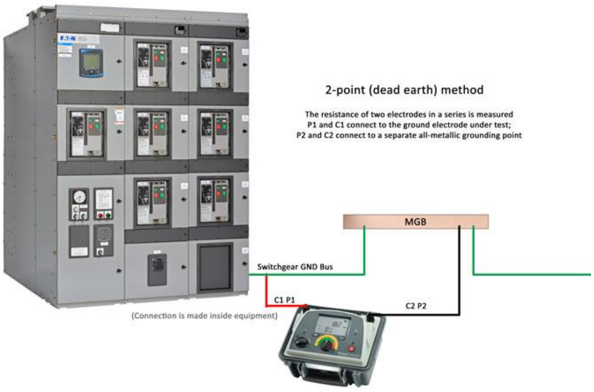
1. 2-point (dead earth) method

In areas where driving ground rods may be impractical, the two-point method can be used.

With this method, the resistance of **two electrodes** in a series is measured by connecting the **P1 and C1** terminals to the ground electrode under test; **P2 and C2** connect to a separate **all-metallic grounding point** (like a water pipe or building steel).

The dead earth method is the simplest way to obtain a ground resistance reading but is not as accurate as the three-point method and should only be used as a last resort, it is most effective for quickly testing the connections and conductors between connection points.

Note: The earth electrode under test must be far enough away from the secondary grounding point to be outside its sphere of influence to obtain an accurate reading.



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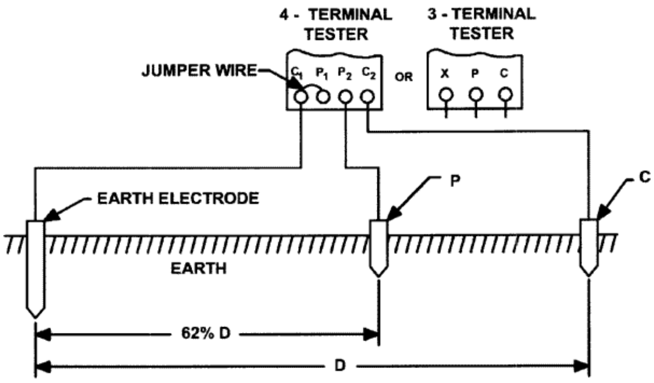
2. 3-point (Fall-of-potential) method

The three-point method is the most thorough and reliable test method; used for measuring resistance to earth of an installed grounding electrode.

With a four terminal tester, **P1 and C1** terminals on the instrument are jumpered and connected to the earth electrode under test while the **C2** reference rod is driven into the earth straight out as far from the electrode under test as possible. Potential reference **P2** is then driven into the earth, at a set number of points, roughly on a straight line between C1 and C2. Resistance readings are logged for each P2 point.



Measurements are plotted on a curve of resistance vs. distance. Correct earth resistance is read from the curve for the distance that is roughly **62% of the total distance** between C1 and C2. There are three basic types of the fall-of-potential method:

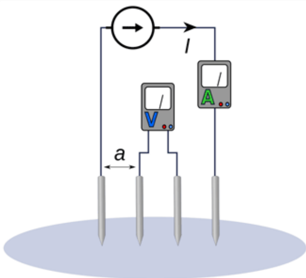
- **Full fall-of-potential:** A number of tests are made a different spaces of P and a full resistance curve is plotted.
- **Simplified fall-of-potential:** Three measurements are made at defined distances of P and mathematical calculations are used to determine the resistance.

- **61.8 Rule:** A single measurement is made with P at a distance 61.8% (62%) of the distance between C1 and C2.

3. 4-point method

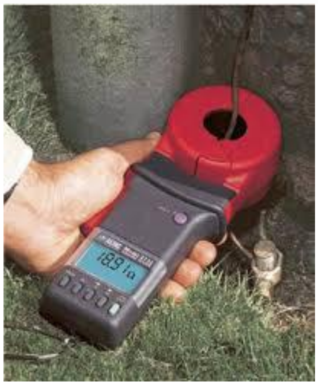
This method is the most commonly used for measuring **soil resistivity,** which is important for designing electrical grounding systems. In this method, four small-sized electrodes are driven into the earth at the same depth and equal distance apart - in a straight line - and a measurement is taken.

The amount of moisture and salt content of soil radically affects its resistivity. Soil resistivity measurements will also be affected by existing nearby grounded electrodes. Buried conductive objects in contact with the soil can invalidate readings if they are close enough to alter the test current flow pattern. This is particularly true for large or long objects.



4. Clamp-on method

The clamp on method is unique in that it offers the ability to measure resistance without disconnecting the ground system. It is quick, easy, and also includes the bond to ground and overall grounding connection resistances in its measurement.



Measurements are made by "clamping" the tester around the grounding electrode under test, similar to how you would measure current with a multi-meter current clamp.

The tester applies a known voltage without a direct electrical connection via a transmit coil and measures the current via a receive coil. The test is carried out at a high frequency to enable the transformers to be as small and practical as possible.

For the clamp-on method to be effective, there must be a complete grounding circuit in place. The tester measures the complete resistance path (loop) that the signal is taking. All elements of the loop are measured in series. It is important for the operator to understand the limitations of the test method so that he/she does not misuse the instrument and get erroneous or misleading readings.

Some limitations of the clamp-on method include:

1. effective only in situations with multiple grounds in parallel.
2. cannot be used on isolated grounds, not applicable for installation checks or commissioning new sites.
3. cannot be used if an alternate lower resistance return exists not involving the soil, such as with cellular towers or substations.
4. results must be accepted on "faith."

- **Topic 3: Probes connection**

The most important precautions to be taken before starting the measurement is

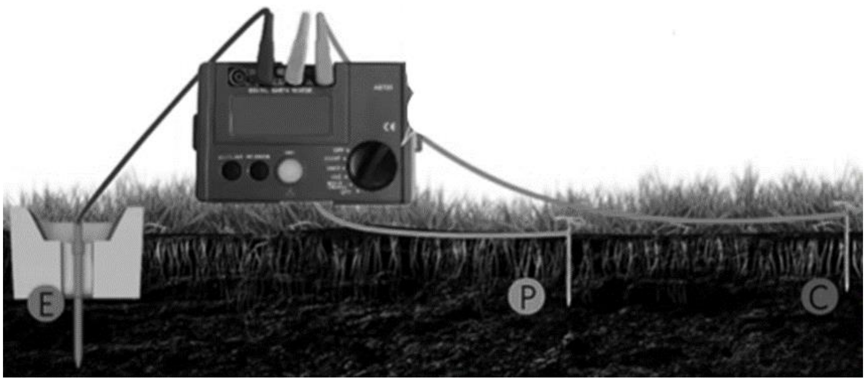
Step1: Disconnect the electrode from the load so that we can get the actual value of the earth.

Step2: Insert the current spike at a distance of 30 meters from the electrode. This distance is considered as 100% of the distance for this test.

Step3: Insert the potential or voltage pipe at a distance of 62% of 30 meters between the electrode and current spike. As per Dr.Tagg, when a potential spike is inserted at a 62% distance in the total distance between the electrode and current spike, we get stable results for earth resistance.

Connections

- Connect 'E' terminal of the tester to the earth electrode under test.
- Connect the 'P' terminal wire of the tester to the potential spike.
- Connect 'C' terminal of the tester to the current spike.
- After connections are done, now select the proper range of 20 ohms by rotating the knob switch.
- After selecting the initial range, press the test button of the meter. When we press the test button, the AC current flows from electrode to potential spike from the soil. The voltage between 'E' (Electrode Under Test) and the 'P' (Potential Spike) is measured by the meter.



- **Topic 4: Earth Resistivity and factors affecting resistivity**

Soil resistivity is how resistive the soil is to the flow of electricity. In the majority of applications, a low ground resistance is preferred or even require, therefore more often than not **a low resistivity is preferred**. In a number of applications, the ground resistance itself is not as critical as the grounding layout (i.e. grid, mesh, etc.). However, despite this, a **high soil resistivity** still represents challenges to these designs and can exasperate shortcomings or under design.

1. Factors affecting soil resistivity

As Soil resistivity is the resistance of certain volume of the soil between opposite faces of the cube of soil with a volume of $1m^3$. Soil resistivity vary widely. Soil resistivity varies significantly with increase in the depth. Some of the important significant factors that affect the soil resistivity are listed below:

1.1. Moisture content:

Moisture content in the soil is one of the major factors that determine the soil resistivity. The dryer the soil the more is the resistivity of the soil, wet soil will have low soil resistivity. Change in the moisture level of the soil through out the year during different seasons is the biggest reason for change in the ground electrode resistance. With increase in the moisture content in the soil, ground resistance or soil resistance decreases and about after 22% of moisture content there will be very little change in the soil resistivity

1.2. Temperature:

Above the freezing point of the water, temperature does not impact the soil resistivity significantly but the temperature below the freezing point of the water soil resistivity rises and will have significant impact

1.3. Salts in Soil:

The presence of soluble salts in the soil will significantly impact the resistivity of the soil. One of the option to reduce the electrode resistivity is by chemical treatment of soil near the electrode. Bentonite backfilles or salt treatment such as sodium chloride or calcium chloride can significantly reduce the soil resistivity. The only disadvantage is some chemicals enhance the metal corrosion rate which can damage the grounding rod to corrode.

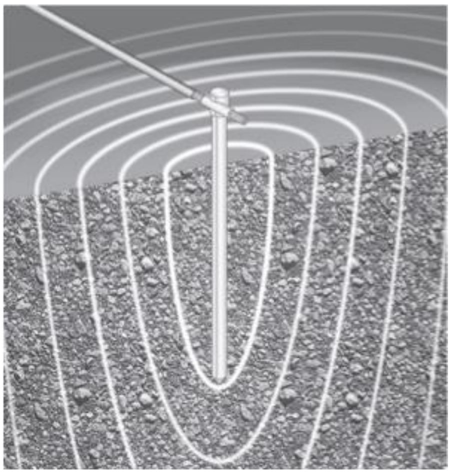
If the grounding rod sustains significant current, the current flowing through the grounding rod may dry out the surrounding soil and that can increase the resistance of the electrode. When high currents flowing through the grounding rod or earthing electrode, this may be due to lightning or from faults the soil surrounding the electrode breaks resulting in the increase in the resistance.

2. *Typical resistivity for various soil types*

SOIL TYPE	Resistivity ohm-cm: Average	Min.	Max.
Fills – ashes, cinders, brine wastes	2,370	590	7,000
Clay, shale, gumbo, loam	4,060	340	16,300
Clay, shale, gumbo, loam with varying proportions of sand and gravel	15,800	1,020	135,000
Gravel, sand, stones, with little clay or loam	94,000	59,000	458,000

U.S. Bureau of Standards Technical Report 108

3. Why Soil Resistivity Matters for Grounding

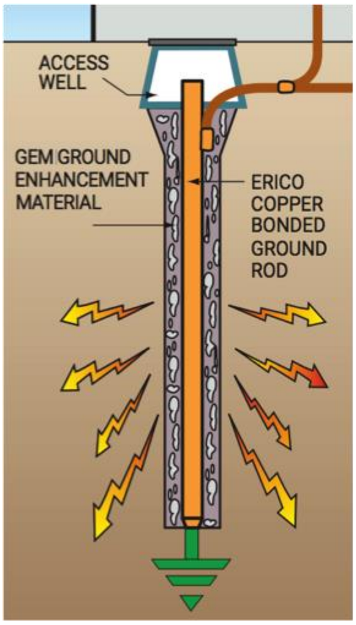


When currents flow from a ground electrode into the surrounding soil, they're often described as flowing through a series of concentric shells of increasing diameter. Each successive shell has a greater area for current flow and consequently, lower resistance. At some point distant from the earth conductor, the current dissipation becomes large enough and the current density small enough that the resistance is negligible.

If the soil has high resistivity, and the ground electrode not sufficiently arranged to offset this, the dissipation of the electrical current running through the system will result in a higher voltage on the grounding system. This has implications in certain application such as higher touch or step potentials, or in more extreme cases failure of reliable operation of over-current or over voltage devices.

4. The Most Cost-Effective Grounding Solution for High Resistivity Soil

To finalize the dissipation of a lightning current safely into the earth, high conductivity ground must be present. Conductive enhancement materials are some of the most cost-effective ways to overcome high soil resistivity. These materials are ideal for use in areas with high resistivity soils, including rocky earth, mountaintops and sandy soil. These products can be referred to as "grounding" or "earthing" enhancement materials.



Low ground resistance can also be achieved with other techniques, such as:

- Deeper driven electrodes
- Multiple rods bonded together
- Counterpoise system
- Coupled rods
- Chemical rods

Depending on the application, conductive ground enhancement material is often preferred over the aforementioned options. Due to the conductive benefits of the material, fewer grounding electrodes may be required to achieve the targeted ground resistance saving both time and money on the total installation.

- **Topic 5: Electrode location**

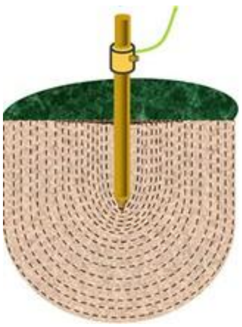
An earth electrode and earth electrode resistance are defined as:

Earth electrode is a conductive part, which may be embedded in the soil or in a specific conductive medium, e.g. concrete or coke, in electrical contact with the Earth.
Earth electrode resistance is the resistance of an earth electrode to Earth.

The depth that the rod can be driven will depend on the soil conditions (rocks etc.) and the need to get to soil of suitable resistivity. For example, in the Middle East it is usual to drive a rod to below the level of the summer water table as the dry ground above has an extremely high resistivity.

It should also be noted that the length of the rod has significantly more effect on the electrode resistance value than the rod diameter.

A simple earth electrode



LO1.7: Use frequency meter based on regulation

- **Topic 1: Function and application of frequency meter**

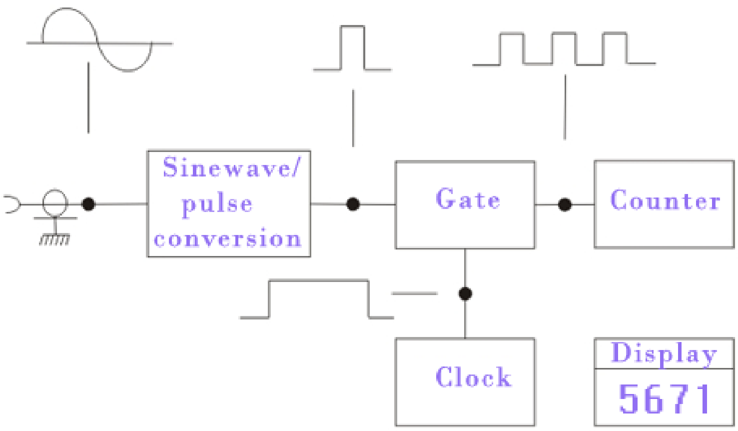
1. **Definition**

Digital frequency meter is a general purpose instrument that displays the frequency of a periodic electrical signal to an accuracy of three decimal places.

2. Operating Principle of Digital Frequency Meter

A frequency meter has a small device which converts the sinusoidal voltage of the frequency into a train of unidirectional pulses. The frequency of input signal is the displayed count, averaged over a suitable counting interval out of 0.1, 1.0, or 10 seconds. These three intervals repeat themselves sequentially.

As the ring counting units reset, these pulses pass through the time-base-gate and then entered into the main gate, which opens for a certain interval. The time base gate prevents a divider pulse from opening the main gate during the display time interval. The main gate acts as a switch when the gate is open; pulses are allowed to pass. When the gate is closed, pulses are not allowed to pass that means the flow of pulses get obstructed.
The functioning of the gate is operated by the main-gate flip-flop. An electronic counter at the gate output that counts the number of pulses passed through the gate while it was open. As the main gate flip-flop receives next divider pulse, the counting interval ends, and divider pulses are locked out. The resultant value displayed on a display screen which has the ring counting units of scale-of-ten circuits and each unit couples to a numeric indicator, which provides the digital display. As the reset pulse generator is triggered, ring counters get reset automatically, and the same procedure starts again.



The range of modern **digital frequency meter** is between the range from10^4 to 10^9 hertz. The possibility of relative measurement error ranges between from 10^{-9} to 10^{-11} hertz and a sensitivity of 10^{-2} volt.

3. Use of Digital Frequency Meter

- For testing radio equipment
- Measuring the temperature, pressure, and other physical values.
- Measuring vibration, strain
- Measuring transducers

- **Topic 2: Probes connection**

Digital multimeters with a frequency symbol on the dial

1. Turn the dial to Hz.

- It usually shares a spot on the dial with at least one other function.
- Some meters enter the frequency through a secondary function accessed by pushing a button and setting the rotary switch to ac or dc.

2. First insert the black test lead into the COM jack.
3. Then insert the red lead into the V Ω jack.
   - When finished, remove the leads in reverse order: red first, then black.
4. Connect the black test lead first, the red test lead second.
   - When finished, remove the leads in reverse order: red first, then black.
5. Read the measurement in the display.
   - The abbreviation Hz should appear to the right of the reading.

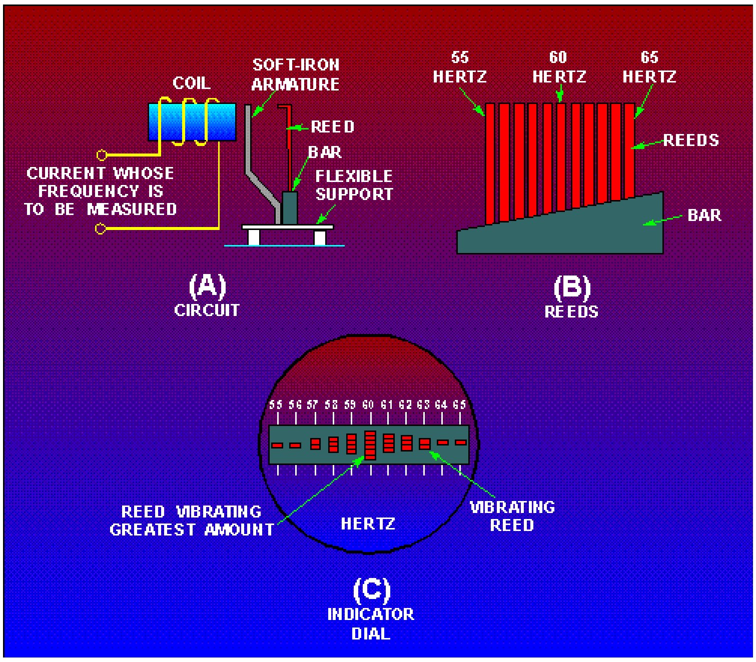
- **Topic 3: Methods and importance of frequency meter**

1. Types of Frequency meter

All alternating voltage sources are generated at a set frequency or range of frequencies. A frequency meter provides a means of measuring this frequency. Two common types of frequency meters are the vibrating-reed frequency meter and the moving-disk frequency meter.

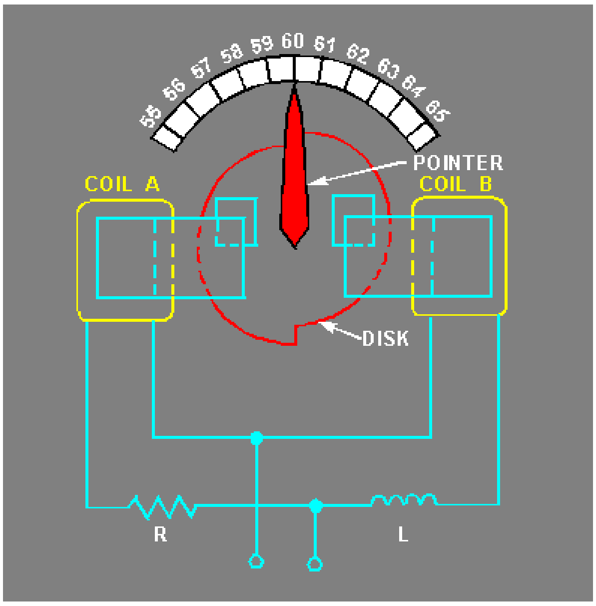
1.1. Vibrating-Reed Frequency Meter

The vibrating-reed frequency meter is one of the simplest devices for indicating the frequency of an ac source. Vibrating-reed frequency meters are usually in-circuit meters. They are used on power panels to monitor the frequency of ac.



1.2. Moving-Disk Frequency Meter

Moving-Disk Frequency Meter They can be used to spot check the frequency of power sources or equipment signals. One coil tends to turn the disk clockwise, and the other, counterclockwise. Magnetizing coil A is connected in series with a large value of resistance. Coil B is connected in series with a large inductance and the two circuits are supplied in parallel by the source.



- **Topic 4: Reading manufacturer's manual**

Every manufacturer's product is a little book containing vital information for the effective use of their products. This is usually referred to as the manufacturer's manual or the operational instructions. This consists of the basic operational guide, rules to be followed in order to avoid damages, and if there are major malfunctions, you are requested to consult the manufacturers. And this is because the manufacturer knows the product more than the proposed user. And quite often when these instructions are carefully followed the best performance are usually obtained. Thus we can make a statement of fact like this: Every product is at its best performance when put fully into its original use intended by the manufacturer.

- **Topic 6: Errors that occur during measurement**

While conducting measurements in experiments, there are generally two different types of errors: random (or chance) errors and systematic (or biased) errors.
Every measurement has an inherent uncertainty. We therefore need to give some indication of the reliability of measurements and the uncertainties of the results calculated from these measurements. To better understand the outcome of experimental data, an estimate of the size of the systematic errors compared to the random errors should be considered.
Random errors are due to the precision of the equipment.
Systematic errors are due to how well the equipment was used or how well the experiment was controlled.

LU 2: Check electrical installation system

LO 2.1: Implement hazard control safety measures related to electrical installation.

- **Topic 1: Description of Accident**

1. **Definition**

This is an unplanned and unpleasant event that happens unexpectedly which causes death, injury or damage.

2. **How do accidents occur?**

Most accidents occur as a result of human error and statistics prove that 98% of all accidents are avoidable.

3. **Causes of accidents:**

Electrical accidents are caused by a combination of three factors:

- Unsafe equipment and / or installation,
- Workplace made unsafe by the environment, and
- Unsafe work practices.

Other cause of accident

- Unawareness of danger: not knowing, not expecting.
- Disregard for safety: not treating as important
- Negligence: the failure to give something enough care.
- Lack of understanding of proper safety procedures.
- Untidy condition of workplace.
- Inadequate light and ventilation.
- Improper use of tools.
- Unsafe conditions.

4. **Safe attitudes**

People attitudes govern what they do or fail to do. Where someone is working with unsafe equipment then that person has allowed that state of affair to come about by something they have done or failed to do.

5. **Responsibilities**

Safety doesn't just happen. It has to be organized and achieved like a work process of which it forms part. The law states that both the employer and employees have a responsibility on safety.

6. **Employers' responsibilities:**

- Providing equipment
- Providing safe washing environment
- Giving instructions to employees on work
- Providing training on health and safety at work

7. Employees' responsibilities:

- Proper use of equipment provided.

- Substance of a good working environment

- Procedures and manner of doing work.

- General attitude to safety.

- **Topic 2: Identification of Safety Signs**

1. **Electrical safty signs and symbols**

Electrical safety labeling has many facets to it including identifying the hazard, identifying the right avoidance procedure for the situation you're trying to address, as well as identifying proper grounding, emergency stop buttons, work clearances, and potential arc flash hazards related to servicing the equipment and its electrical panels. We've made it simple to find all of your equipment's electrical safety labels by breaking the subject down into easily searchable categories.

2. **electrical safety precaution at the workplace (accident prevention) accidents**

2.1. Definitions

Electrical hazard: is a dangerous condition where a worker can or does make electrical contact with energized equipment or conductor

A hazard: is a source or potential source of human injury, ill health or disease. Anything which might cause injury or ill health to anyone at or near a workplace is a hazard.

2.2. Four main types of electrical injuries

- Electrocution or death due to electrical shock
- Electrical shock
- Burns
- Falls (caused by shock)

2.3. Preventing Electrical Hazards

- Wear nonconductive class E hardhat
- Wear electrical hazard (EH) rated foot protection.
- Use properly grounded or double-insulated power tools.
  - Tools with damage or worn power cords should be removed from service.
- Work on electrical equipment and circuits in a de-energized state using lockout and tag out procedures: When working on energized equipment is unavoidable, use the appropriate PPE including helmets, face shields, gloves and flame-resistant clothing.
- Beware of overhead power lines and buried electrical conductors.

3. **Safety signs**

There are four basic categories of signs:

5. Prohibition signs
6. Mandatory signs
7. Warning signs
8. Information signs or Advisory or Safe Condition Sign

3.1. Prohibition signs

These are must not do signs. These are circular white signs with a red border and red cross-bar.

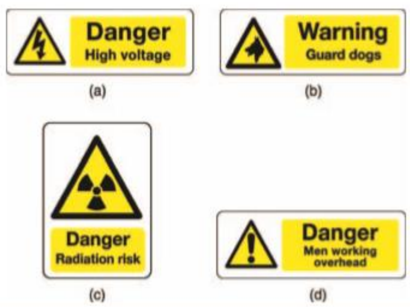
They indicate an activity which must not be done.

3.2. Mandatory signs

These are must do signs. These are circular blue signs with a white symbol. They give instructions which must be obeyed

3.3. Warning signs

They give safety information. These are triangular yellow signs with a black border and symbol.



3.4. Information Signs or Advisory or Safe Condition Sign

This gives safety information. These are square or rectangular green signs with a white symbol. They give information about safety provision.

4. Precautions when working on site

Installers should apply the safety principles learned so far in this to every work site. For each safety principle, there is a specific precaution to consider.

Before working on a specific site, find out what medical and emergency facilities are available nearby, or what measures would need to be in case of an injury. You should also inspect the site for hazards. You must mitigate or remove all hazards before work starts. For example, it might be a smart move at some point to check the junction box for snakes while using the appropriate safety gloves and equipment.

When checking the site for possible hazards, also check for any available safety equipment such as a fire extinguisher or a first-aid kit. Industrial settings often have

- **Topic 3: Lifting and handling loads**

The lifting and handling of loads also known as manual handling or manual materials handling. It includes lifting, lowering, pushing, pulling, carrying, holding, dragging and supporting objects.

6. Types of injuries

Manual handling causes over a third of all workplace injuries. These include work-related musculoskeletal disorders (MSDs) such as pain and injuries to arms, legs and joints, and repetitive strain injuries of various sorts.

6.1. Back injuries

When it comes to manual handling, your back is the weakest part of your body. Especially if you don't have good lifting technique. Or if what you are lifting is simply too heavy for your body to handle.
It's not just during lifting you need to watch your back. At any time you are carrying a load, poor posture can damage your back. Stooping or twisting can make your back more vulnerable to injury. Common back injuries include injuries to the spine and slipped discs.

6.2. Strains and sprains

Ever picked something up and regretted it after? Because it was much heavier or harder to grip than you realised? Or because over time, it became too much to handle? It is because overstretching your muscles beyond their capacity can lead to inflammation, bruising and pain.
Muscular strains and sprains can happen during manual handling, often in the back, arms or wrists.

6.3. Hand injuries

Lifting, carrying, pushing, pulling. Whichever type of manual handling activity you carry out, you usually grip with your hands. Depending on what it is you are touching, this could be a hazard in itself. If the load is hot, it could burn or scald your skin. If the load has sharp edges it could cut you.
Hand injuries don't always come from direct contact with the load, but also from where you are placing it. If the load is heavy, it could bruise you or even break a bone if you don't get your fingers out the way when you put it down. And your fingers could also get trapped between the load and other nearby obstacles like containers or walls. This is especially a concern during team lifts when other people are also moving the load.

6.4. Musculoskeletal disorders

Musculoskeletal disorders cover a range of issues and pain, in the upper limbs e.g. shoulders, neck, arms, wrists (upper limb disorders), the lower limbs e.g. hips, legs and toes (lower limb disorders), and back.

The term musculoskeletal disorders (MSDs) covers any injury, damage or disorder of the joints or other tissues in the upper/lower limbs or the back.

While we have already covered back injuries as a section on its own, musculoskeletal disorders can involve a range of symptoms that usually develop over time. It can be caused by repetitive lifting leading to damage, pain or stiffness in the joints or other tissues.
Musculoskeletal disorders (MSDs) are conditions that affect the nerves, tendons, muscles and supporting structures, such as the discs in your back. They result from one or more of these tissues having to work harder than they're designed to.

6.5. Slip, trip and fall injuries

Slips, trips and falls can happen at any time, whether you are manual handling or not. And, they usually have their own causes. A spillage. A trailing cable. An uneven floor. Manual handling can increase the risk of this type of accident, and the resulting injuries.

Often, when you are carrying a load, some of your visibility is blocked. Especially at ground level. You might not see that cable on the floor, or that spillage, or notice your shoelace has come undone. Always assess the environment as part of your manual handling assessment, as the surrounding workplace can add additional hazards to your task.
And the consequences of a slip or trip when you are manual handling is higher. You don't have a free hand to hold a handrail or put out to break your fall.

6.6. Hernias

A hernia occurs when an internal part of the body pushes through a weakness in the muscle or surrounding tissue wall.
Repeated strain on the tummy can be the cause of a hernia, and most hernias will not get better without surgery. Over straining by lifting loads heavier than you can handle can result in a hernia, and you are at higher risk as you get older.
Manual handling activities should always be assessed, considering the load and the individual to make sure it is safe and lifting aids provided as necessary.

6.7. Foot injuries

You might not lift with your feet, but foot injuries still make into our 7 types of manual handling injuries.
When manual handling causes a fracture, it's usually to the foot due to dropping of the load. This is an even bigger risk if you are not wearing protective footwear.
Lifting heavy loads, dropping loads from height (rather than carefully lowering them) and not getting a good grip can all lead to crushing, bruising or broken bones in the feet.

7. Preparing to lift

Manual handling injuries can have serious implications for the employer and the person who has been injured. They can occur almost anywhere in the workplace and heavy manual labour, awkward postures, repetitive movements of arms, legs and back or previous/existing injury can increase the risk.

To help prevent manual handling injuries in the workplace, you should avoid such tasks as far as possible. However, where it is not possible to avoid handling a load, employers must look at the risks of that task and put sensible health and safety measures in place to prevent and avoid injury.

For any lifting activity, always take into account**:**

- individual capability
- the nature of the load
- environmental conditions
- training
- work organisation

If you need to lift something manually

- Reduce the amount of twisting, stooping and reaching
- Avoid lifting from floor level or above shoulder height, especially heavy loads
- Adjust storage areas to minimise the need to carry out such movements
- Consider how you can minimise carrying distances
- Assess the weight to be carried and whether the worker can move the load safely or needs any help. Maybe the load can be broken down to smaller, lighter components

If you need to use lifting equipment

- Consider whether you can use a lifting aid, such as a forklift truck, electric or hand-powered hoist, or a conveyor
- Think about storage as part of the delivery process. Heavy items could be delivered directly, or closer, to the storage area
- Reduce carrying distances where possible

8. Good handling technique for lifting

There are some simple things to do before and during the lift/carry:

- Remove obstructions from the route.
- For a long lift, plan to rest the load midway on a table or bench to change grip.
- Keep the load close to the waist. The load should be kept close to the body for as long as possible while lifting.
- Keep the heaviest side of the load next to the body.
- Adopt a stable position and make sure your feet are apart, with one leg slightly forward to maintain balance

9. Weight a person can carry

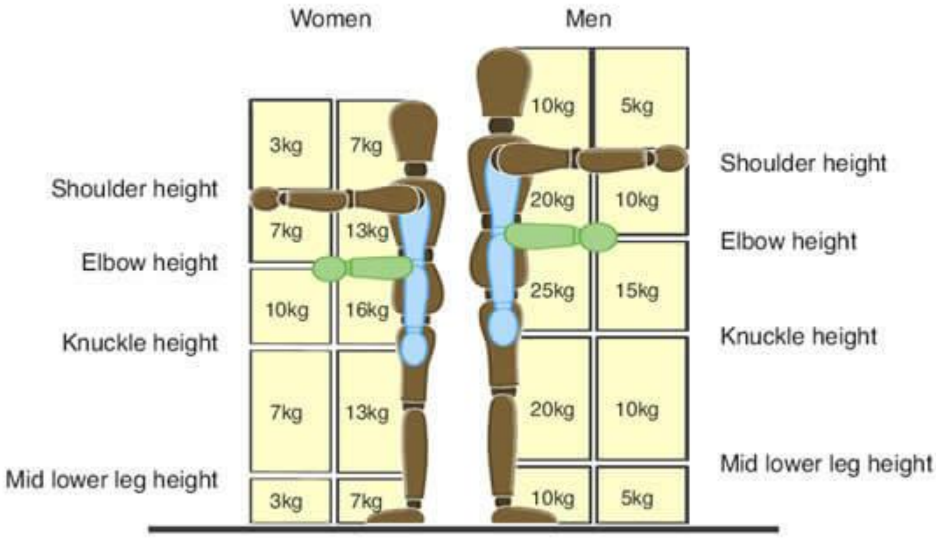
There is no legal maximum weight to lift at work. There are, however, guidelines which set out the recommended safe maximum weight for lifting at work.

Manual Handling Guidelines set out recommended safe lifting limits for men and women.

The recommended maximum weight limit should be adjusted depending on how the load is being lifted, how close to the body the weight is held, and how high or how low the weight is lifted.

The guidelines suggest that the maximum weight men should lift at work is 25kg. This relates to loads held close to the body at around waist height. The recommended maximum weight is reduced to 5kg for loads being held at arms length or above shoulder height.

Maximum weight guidelines recommend lower weights for women. The suggested maximum weight for women is 16kg for loads held at waist height.



10. Moving heavy equipment

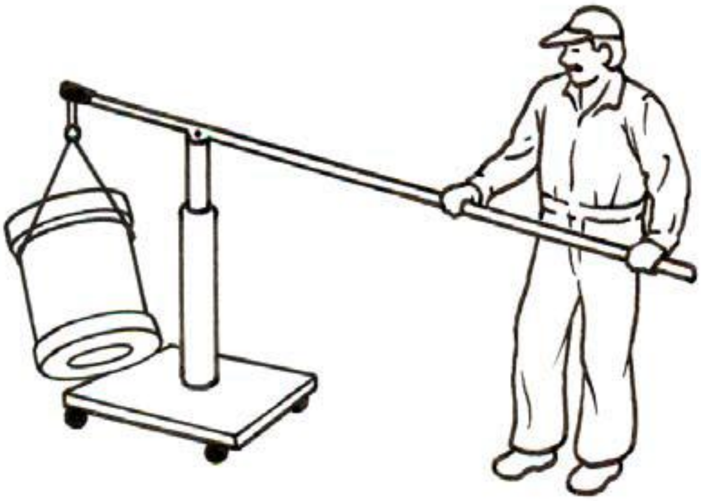
The lifting and handling of loads, usually called manual materials handling, is often physically demanding work. Lifting and handling involves the activities of lifting, pushing, pulling, carrying, handling or transporting loads. The intent of this subsection is for employers to reduce the amount and type of manual handling that workers must do.

By doing so, workers and employers may experience a reduction in the number of worker injuries (fewer sprains, strains, back injuries), a reduction in the number of lost-time claims, increases in efficiency and productivity, and fewer product losses through damage.

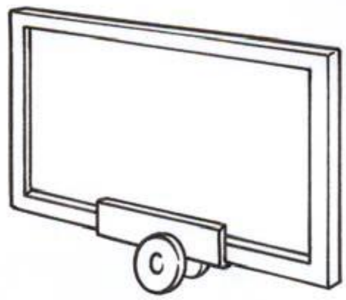
To accomplish this, employers must provide, where reasonably practicable, appropriate equipment that will help workers lift, lower, push, pull, carry, handle or transport heavy or awkward loads. In many cases the equipment will cost little; in others a meaningful investment may be necessary.

Figures below show examples of the type of equipment that can be used to eliminate or minimize the lifting and handling of loads.

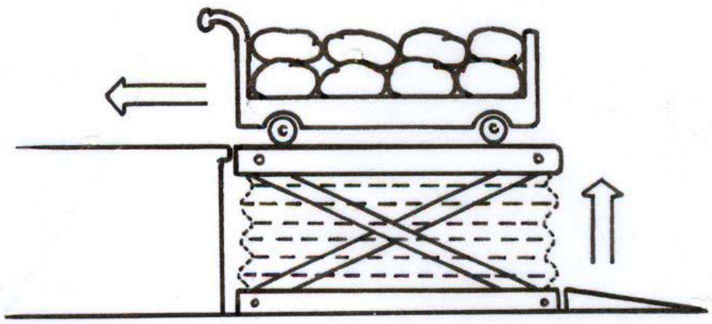
- **Lever to lift and transport heavy objects**



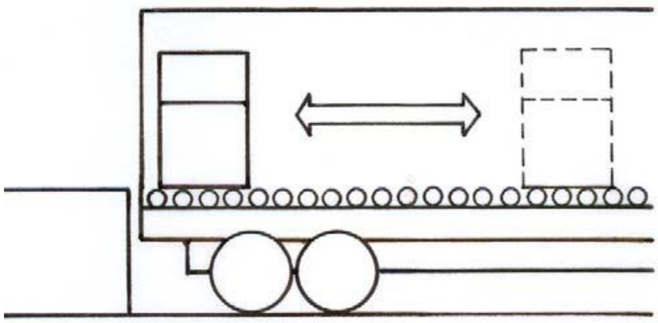
- **Two-wheeled trolley for moving doors and windows**



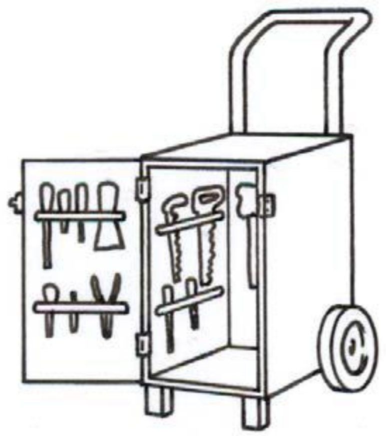
- **Scissor lift to raise load at loading dock**



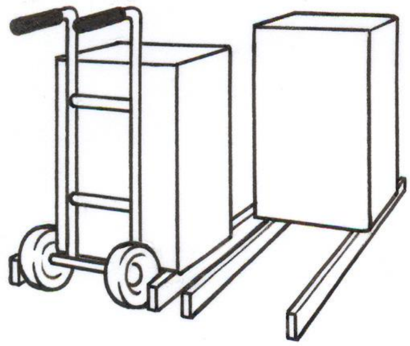
- **Rollers in floor of cargo truck**



- **Cart modified as tool caddy**

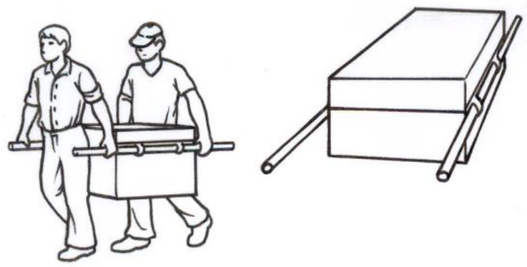


➢ **Hand truck with loads raised off the floor**

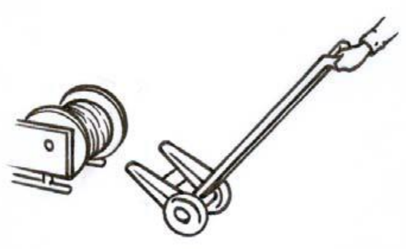


➢ **Hand trolley for bagged materials**

➢ **Oversized box modified for two-person lifting**

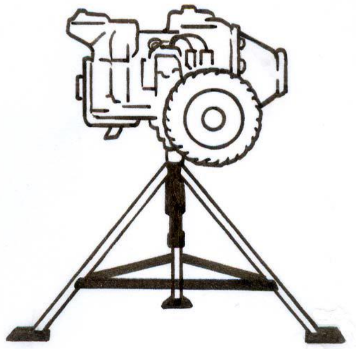


➢ **Specialized hand truck for moving spooled wire**

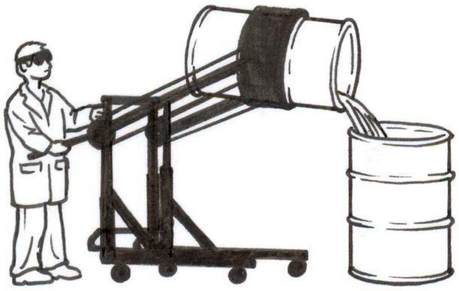


➢ **Wheeled dolly for awkward access**

- **Jig for holding and securing work piece**



- **Drum lifter for pouring liquids**



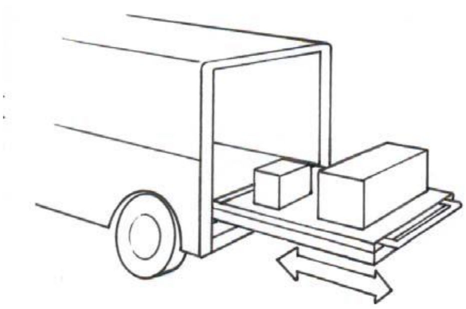
- **Rotating pallet holder**

- **Magnetic handles for carrying sheet metal**

- **Magnetic lifting head on overhead crane**

- **Spring-loaded hand truck platform that eliminates stooping**

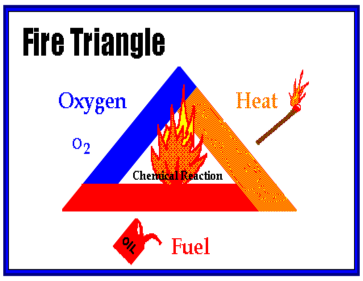
- **Sliding cargo floor**



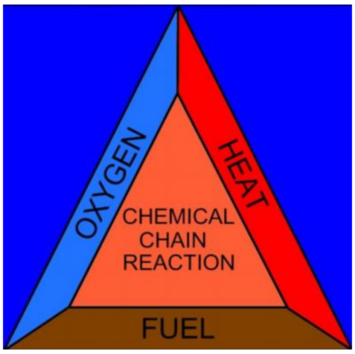
- **Topic 4: Fire and fire extinguishers**

3. Fire

Fire is a self-sustaining, chemical chain reaction with varying degrees of light and heat. It requires fuel, oxygen (air) and heat. This is shown by the 'fire triangle‟



Or



The “Fire Triangle” identifies the three components of any fire:

- Fuel paper, wood, flammable gas, energized electrical equipment, etc...
- Energy (heat), sufficient to support combustion. Often referred to as the ignition source.
- Oxidizer (air)

If any one of these is missing, a fire cannot continue.

In case of fire the 3 A’s method is Followed:

- Activate
- Assist and
- Attempt

Activate:
Activate the buildings fire alarm system.

Fire alarm

Assist:
Assist those who are in immediate danger or who are incapacitated. Do this with out risk to yourself.
Attempt:
Attempt to fight a fire only after the first two steps have been completed and you feel confident in yourself to do so. Always have an exit to your back in case you need to escape. Never attempt to fight a fire if there is a heavy smoke condition. Smoke can be extremely toxic and will reduce your visibility. Only fight small fires, no larger than the size of a small waste basket. Small fires will grow big very fast.

3.1. Different causes of fire in electrical equipments

6. Most electrical fires are caused by faulty electrical outlets and old, outdate appliances.
   - Removing the grounding plug from a cord so it can be used in a two-prong electrical outlet can also cause a fire.
7. Light fixtures, lamps and light bulbs are another common reason for electrical fires.
   - Installing a bulb with a wattage that is too high for the lamps and light fixtures is a leading cause of electrical fires.
   - Always check the maximum recommended bulb wattage on any lighting fixture or lamp and never go over the recommended amount.
8. Misuse of extension cords is another electrical fire cause.

- Appliances should be plugged directly into outlet and not plugged into an extension cord for any length of time.
- Only use extension cords as a temporary measure.
- If you do not have the appropriate type of outlets for your appliances, hire an electrician to install new ones.

9. Space heaters are a major cause of electrical fires**.**

- Because these types of heaters are portable, many times people put them too close to combustible surfaces such as clothing, chairs, and rugs.
- Coil space heaters are especially dangerous. If you do use space heaters, use the radiator-type that diffuse heat over the entire surface of the appliance**.**

10. Outdated wiring often causes electrical fires.

- Breakers should be triggered when circuits get overloaded by too much electricity,
- Outdated breaker boxes often have worn connectors that do not work, causing the system to overload and start an electrical fire.

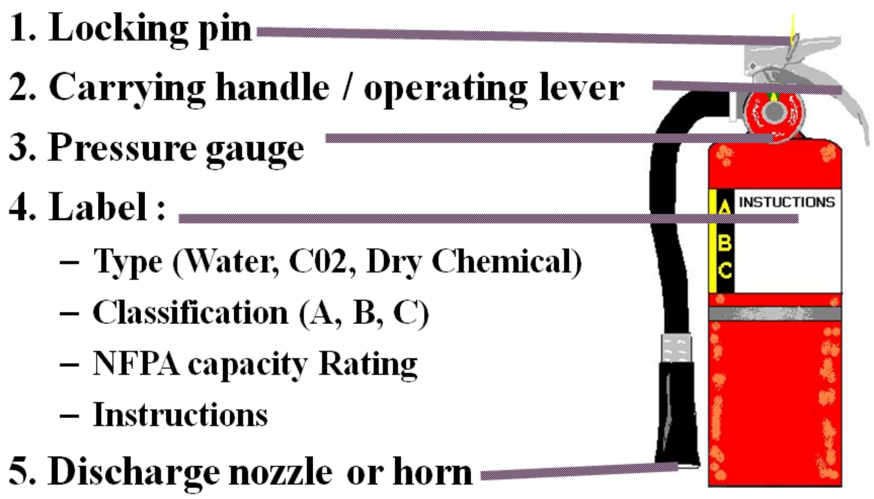
3.2. Types of fire

Class A fires: freely burning fires fuelled by ordinary combustible materials such as cloth, wood, paper and fabric.
Class B fires: fires fuelled by flammable liquids such as oils, spirits and petrol.
Class C fires: fires fuelled by flammable gases such as propane, butane and North Sea gas.
Class D fires: fires involving flammable metals such as Magnesium, Lithium or Aluminum powders.
Class E fires: Fires involving electrical hazards.
Class F fires: fires fuelled by cooking oils and fats. Use of a wet chemical is the most effective way of extinguishing this type of fire.

4. Fire extinguishers

Fire extinguishers are portable devices used to extinguish small fires or reduce their destruction before firefighters arrive at the scene. These are kept handy at places, namely fire points, in buildings, factories, public places or transportation. The types and numbers of extinguishers legally required for an area are governed by the safety regulations in force in that particular area.

4.1. Extinguisher Common features:



4.2. Types of Extinguishers

Now that you have a basic understanding of the various types of fire and why different extinguishers are necessary, 6 main types of fire extinguishers and their uses will be discussed:

1. ABC powder fire extinguisher

An ABC powder fire extinguisher has numerous advantages as it is a multi-purpose extinguisher and is therefore one of the most common extinguishers to have on hand.

A powder extinguisher sprays a very fine chemical powder composed most commonly of monoammonium phosphate. This acts to blanket the fire and suffocate it.

Powder extinguishers are effective for class A, B and C fires, since it is not an electrical conductor and since it can effectively break the chain reaction in a liquid or gas fire, something a water extinguisher cannot do.

2. CARBON DIOXIDE fire extinguisher

A carbon dioxide fire extinguisher (CO_2) is one of the cleanest types of extinguishers to use as it leaves no residue and requires no cleanup.

The CO_2 extinguisher does exactly that – extinguishes CO_2. By doing so, it removes oxygen from the fire, effectively suffocating it of oxygen. It is perfect for use on class B fires that involve flammable liquids and on electrical fires.

3. Wet chemical fire extinguisher

The wet chemical extinguisher is a specialized type primarily focused on class K fires, those involving cooking media such as animal and vegetable fats or oils.

These extinguishers contain a solution composed of potassium that effectively launches a two-pronged assault on fires.

First, the liquid mist it sprays acts to cool the fire. Second, due to the chemical reaction of the solution with the cooking medium, a thick soap-like substance forms, sealing the surface of the liquid to prevent re-ignition.

The wet chemical extinguisher, then, is ideal for a kitchen setting and class K fires. However, it can also be effective for class A fires where a material such as wood or paper has caught fire.

4. Water mist fire extinguisher

The most versatile of the set, the water mist extinguisher, uses a newer technology that works across most classes of fire.

This type of extinguisher releases microscopic water molecules that fight the fire on a variety of levels. First, because so much water is dispersed in such a microscopic fog-like form, the level of oxygen in the air is decreased, which helps to suffocate the fire.

Second, the water particles are drawn to the fire and, as water always does, acts to cool it, reducing the temperature.

Finally, and perhaps what is most unique about the water mist extinguishers, is that the water has been de-ionized (the minerals have been removed). As a result, it can actually be used on electrical fires, as the de-ionized water will not act as a conductor, as well as on burning liquids/gases that a standard water extinguisher could not be applied to.

Thus, a water mist extinguisher is safe and effective for use on classes A, B, C and K fires.

5. Foam fire extinguisher

Foam fire extinguishers are suitable for class A and the flammable liquids of class B, though not effective for gaseous fires.

They spray a type of foam that expands when it hits the air and blankets the fire. This blanket prevents the vapors from rising off the liquid to feed the fire, thus starving it of fuel. Also, because the foam is mixed with water, it has a cooling effect as well.

Foam extinguishers are some of the best for liquid fires, such as gasoline fires, but can also be used on Class A fires involving solid combustibles like wood.

6. Clean agent fire extinguisher

A clean agent fire extinguisher is a type of gaseous fire suppression. Stored in its liquid form, when it is sprayed and hits the air, it converts to its gas form which is non-conductive, safe for use while humans are present, leaves no residue, and has a very short atmospheric lifetime, making it eco-friendly.

The gas, often composed of Halon, extinguishes fire by reducing the oxygen levels and impeding the chain reaction. Because it is non-conductive and so clean, it is ideal for rooms or businesses filled with electrical and computer equipment. They are most commonly used for class B and C fires.

7.Fire blanket

A fire blanket is a safety device designed to extinguish incipient (starting) fires. It consists of a sheet of a fire retardant material which is placed over a fire in order to smother it.

Small fire blankets, such as for use in kitchens and around the home are usually made of fiberglass and sometimes kevlar, and are folded into a quick-release contraption for ease of storage.

Fire blankets, along with fire extinguishers, are fire safety items that can be useful in case of a fire. These nonflammable blankets are helpful in temperatures up to 900 degrees and are useful in smothering fires by not allowing any oxygen to the fire. Due to its simplicity, a fire blanket may be more helpful for someone who is inexperienced with fire extinguishers.

Larger fire blankets, for use in laboratory and industrial situations, are often made of wool (sometimes treated with a flame retardant fluid). These blankets are usually mounted in vertical quick-release container so that they can be easily pulled out and wrapped round a person whose clothes are on fire.

- **Topic 5: Electric shock**

5. introduction

An electric shock happens when an electric current passes through a human body. This can burn both internal and external tissue and cause organ damage.

A range of things can cause an electric shock, including:

- power lines
- lightning
- electric machinery
- electric weapons, such as Tasers
- household appliances
- electrical outlets

factors that affect how serious an electric shock is, including:

- voltage
- length of time in contact with the source
- overall health
- electricity's path through your body
- type of current (an alternating current is often more harmful than a direct current because it causes muscle spasms that make it harder to drop the source of electricity)

6. The symptoms of an electric shock

The symptoms of an electric shock depend on how severe it is.

Potential symptoms of an electric shock include:

- loss of consciousness
- muscle spasms
- numbness or tingling
- breathing problems
- headache
- problems with vision or hearing
- burns
- seizures
- irregular heartbeat

7. Effects of electric shock

➢ Muscle spasms

Muscles are stimulated by electricity. The effect depends on the intensity of the current and the type of muscle it travels through.

We've all felt a buzzing or tingling sensation that doesn't cause injury. That's the effect of a current as low as 0.25 milliamperes (mA) entering the body.

When a current above 10 mA travels through flexor muscles, such as the ones in our forearms that close the fingers, it causes a sustained contraction. The victim may be unable to let go of the source of the current, making the duration of the contact longer and increasing the severity of the shock.

When a current above 10 mA travels through extensor muscles, it causes a violent spasm. If the muscles affected are the hip extensors that lengthen the limbs away from the body, the victim may be propelled, sometimes many metres away!

Muscles, ligaments and tendons may tear as a result of the sudden contraction caused by an electric shock. Tissue can also be burned if the shock is lasting or the current is high.

➢ Cardiac arrest

If a current of 50 mA passes through the heart, it can cause cardiac arrest.

The heart is also a muscle, which beats to pump blood through the body. The rhythm of our heartbeat is controlled by electric impulses. It is these impulses that are monitored by an electrocardiogram. If a current from outside the body passes through the heart, it can mask these impulses and disturb the heart's rhythm. This irregular heartbeat is called arrhythmia and can even manifest as a total disorganization of the rhythm, known as ventricular fibrillation.

When ventricular fibrillation occurs, the heart stops pumping and the blood stops circulating. The victim rapidly loses consciousness and dies if a healthy heartbeat is not restored with a device called a defibrillator.

The arrhythmia can occur at the time of the shock or in the hours following the electric shock.

➢ Burns of tissues and organs

When a current above 100 mA passes through the body, it leaves marks at the points of contact with the skin. Currents above 10,000 mA (10 A) cause serious burns that may require amputation of the affected limb.

Some burns are easy to recognize because they look like the burns you can get from contact with heat. **Others may seem harmless but aren't: tiny charred craters indicate the presence of much more serious internal burns.**

Electrical burns often affect internal organs. They are caused by the heat generated from the body's resistance to the current passing through it. Internal damage may be much more serious than the external injuries suggest.

Internal burns often have serious consequences: scarring, amputation, loss of function, loss of sensation and even death. For example, if a lot of tissue is destroyed, the large amount of waste generated can cause serious kidney or blood circulation disorders.

➢ Effect on nervous system

Nerves are tissue that offers very little resistance to the passage of an electric current. When nerves are affected by an electric shock, the consequences include pain, tingling, numbness, weakness or difficulty moving a limb. These effects may clear up with time or be permanent.

Electric injury can also affect the central nervous system. When a shock occurs, the victim may be dazed or may experience amnesia, seizure or respiratory arrest.

Long-term damage to the nerves and the brain will depend on the extent of the injuries and may develop up to several months after the shock. This type of damage can also cause psychiatric disorders.

- Other unexpected consequences

Other disorders can appear in the weeks or months following the shock, depending on which organs the current passed through. For example, if the current passed through the eyes, cataracts may develop over time.

8. Treatment of electric shock

If someone receives a shock, keep several things in mind to both help them and keep yourself safe:

- Don't touch someone who has been shocked if they're still in contact with the source of electricity.
- Don't move someone who has been shocked, unless they're in danger of further shock.
- Turn off the flow of electricity if possible. If you can't, move the source of electricity away from the person using a non-conducting object. Wood and rubber are both good options. Just make sure you don't use anything that's wet or metal based.
- Stay at least 20 feet away if they've been shocked by high-voltage power lines that are still on.
- Call local emergency services if the person was struck by lightning or isf they came into contact with high-voltage electricity, such as power lines.
- Call local emergency services if the person has trouble breathing, loses consciousness, has seizures, has muscle pain or numbness, or is feeling symptoms of a heart issue, including a fast heartbeat.
- Check the person's breathing and pulse. If necessary, start CPR until emergency help arrives.
- If the person is showing signs of shock, such as vomiting or becoming faint or very pale, elevate their legs and feet slightly, unless this causes too much pain.
- Cover burns with sterile gauze if you can. Don't use Band-Aids or anything else that might stick to the burn.
- Keep the person warm.

- **Topic 6: PPE (Personal Protective Equipment**

Employers have duties concerning the provision and use of personal protective equipment (PPE) at work.

- PPE is equipment that will protect the user against health or safety risks at work.
- It can include items such as safety helmets, gloves, eye protection, high-visibility clothing, safety feet wear etc.
- It also includes respiratory protective equipment (RPE).

1. Some of PPE

2.2. Overcoat and overall

It is a type of long coat used to protect body and is intended to extend below the knee.

2.3. Gloves

It is Hand protection equipment that are used for tasks that can damage hands. Wearing the proper work gloves when performing industrial tasks like handling caustic chemicals, hot materials or sharp objects will promote worker's efficiency.

2.4. Safety shoes

Safety boots and shoes are used to protect feet against any accident. Footwear can have a variety of sole patterns and materials that prevent slips in different conditions, including oil - or chemical-resistant soles. It can also be anti-static, electrically or thermally insulating. Appropriate footwear should be selected for the risks identified

2.5. Helmet

Is PPE that used to protect head all kind of object that can fall on the head.

2.6. Earmuff

Is one of a pair of ear coverings connected by a flexible band and worn as protection against cold or noises

2.7. Goggles or **safety glasses**

There are forms of protective eyewear that usually enclose or protect the area surrounding the eye in order to prevent particulates, water or chemicals from striking the eyes.

2.8. Nose protection mask or a facemask

is protective equipment that a physical barrier between the mouth and Nose.

3. How to use Safety equipment

Training for the use of personal protective equipment (PPE) is essential. Users should know how to use equipment properly, including how to fit and remove it. They should also be aware of why they use the equipment, when they should use. They should also be aware of why they use the equipment, when they should use it and what its limits are. Training should discuss whether any equipment will interfere with the job and if so whether there is alternative equipment available.

LO 2. 2: Select tools, materials and equipment based on the electrical installation

- **Topic 1: Types of electrical tools and their use**

Electrical tools are the core tools all electricians use on a daily basis. Electrical tools are classified into 3 categories:

- ✓ **Working tools (hand tools):** a tool held in the hand and operated without electricity or other power.
- ✓ **Measuring tools:** A measuring tool is a devise used to take a count of quantitative data, such as current, voltage, power and so on.
- ✓ **Power tools: s**A power tool is a tool that is actuated by an additional power source and mechanism other than the solely manual labour used with hand tools. The most common types of power tools use electric motors.

5. **hand tools:**

- **Stripping plier**
- **Side cutter plier**
- **Combination plier**
- **Long nose plier**
- **Electrician knife**
- **Measuring tape**
- **Screw drives**
- **Hammer**
- **Spirit level**

1.2. Pliers

- ➢ **Wire strippers**

Used for stripping insulation from conductors, cutting small conductors and crimping wire lugs


- ➢ **Side cutter pliers (Lineman's pliers)**

Used for cutting large conductors, forming loops on large conductors and pulling and holding large conductors


- ➢ **Diagonal cutting pliers (dykes)**

Used for cutting small conductors, cutting conductors in limited spaces

- **Needle-nose pliers**

Used for forming loops on small conductors, cutting and stripping small conductors.

- **Combination pliers**

Heavy duty pliers for general use in bending, cutting, crimping and pulling wire

- **Automatic Stripping pliers**

Used to strip the insulation from the wire without damaging the wire

- **Stripping pliers**

Used to strip the insulation from the wire without damaging the wire

5.2. Screwdrivers

A screwdriver is a tool, manual or powered, used for screwing and unscrewing screws. A typical simple screwdriver has a handle and a shaft, ending in a tip the user puts into the screw head before turning the handle.

- **Flat-blade screwdriver**

Used to drive slot-head screws

- Phillips screwdriver

Used to drive Philips-head screws

- **Rotating speed screwdrivers**

Used for trim work, installing switch and receptacles

- **Star screwdrivers**

Used to driver the screw of plat heads

- **Other types**

5.3. Hacksaw

A hacksaw is a fine-toothed saw, originally and mainly made for cutting metal. The equivalent saw for cutting wood is usually called bow saw. Most hacksaws are hand saws with a C-shaped walking frame that holds a blade under tension.

It is user for cutting large conductors and cables, Cutting conduit, metal, or bolt.

5.4. Voltage tester

Test the presence of voltage in conductors

5.5. No contact voltage tester

Used to indicate if wire is live or not

5.6. Electrician Scissors

Used for cutting thick gauged wire

5.7. Electrical Knife

Used to strip cable and insulation

5.8. Electrician Hammer

Used to fixe certain equipment such as junction box

5.9. Tin Snips

Used to cut straight edge in sheet metal

6. **Measuring tools**

3.1. Tape measure

Used for measuring wires, conduit, trunking, and different distance in electrical installation

2.2. Fiberglass surveyors tape

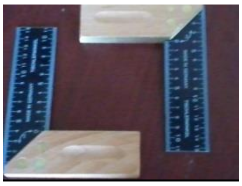
Used for measuring wires, conduit, trunking, tray and different distance in electrical installation

2.3.Sprit level

Used to measure horizontality, verticality of different accessories in electrical installation

2.4.Tri-square

Used to measure the right angle in electrical installation



7. **Power tools:**

- **Crimping tools**
- **Drilling machine**

- **Electric screw driver**

8. Factors to consider when Purchasing Tools

Factors to consider when purchasing tools are size, design, and quality. Always purchase the correct sized tools for the work to be done. Tools should be designed specifically for electrical work. Ex: Insulated handles, hammers with straight claws. The purchase of quality tools last longer which saves replacement cost.

LO2.3: Test the control system (Consumer Control Unity) based on regulation

- **Topic 1: Troubleshooting of CCU**

1. **Introduction**

A consumer unit is a type of distribution board (a component of an electrical power system within which an electrical power feed provides supply to subsidiary circuits).

Current flows in a closed circuit between two electrically unequal potential points. Points A and B are any two points across which voltage is measured. The conductor offers resistance to this flow of electrons (i.e., current) depending upon the material.

Generally electrical problems can be classified under two broad types.

1. A connection does not exist where it should. This is an open circuit fault and can be detected using a continuity tester (Figure 3.2 illustrates this type of fault).
2. A connection exists where none should. This is called a short-circuit fault and can lead to excessive current accompanied by mechanical forces and heating of circuit conductors. Such fault happen due to insulation failures and can be detected using insulation testing instruments.

The process of detecting these faults and rectifying the circuit to restore normal operating condition is called troubleshooting. We will discuss about the open circuit fault first. Current has a tendency to flow between two points that are at an unequal potential (electrically), provided the path between the two points is electrically conductive.

- Resistance offered by the path is known as 'Resistance' ohm)
- Electrical potential is denoted as 'volts'
- Flow of electrons between two points is termed as 'Current' (amp).

Therefore, while troubleshooting, the following points have to be checked:

- Continuity of path (i.e., resistance)
- Electric potential at two points of the path (i.e., voltage)
- Flow of electrons through the path (i.e., current).

- **Topic 2: Techniques of testing protective devices**

Testing of circuit breakers is more difficult as compared to other electrical equipment like transformer or machine because the short circuit current is very large. Testing of the transformer is mainly divided into two groups, type tests, and routine tests.

1. **Type Tests of Circuit Breaker**

Type tests are conducted for the purpose of proving the capabilities and confirming the rated characteristic of the circuit breaker. Such tests are conducted in the specially built testing laboratory.Type tests can be broadly classified as the mechanical performance test, thermal test, dielectric or insulating test, short circuit test for checking the making capacity, breaking capacity, short time rating current and operating duty.

1.1. Mechanical Test

It is mechanical ability type test involving the repeated opening and closing of the breaker. A circuit breaker must open and close at the correct speed and perform its designated duty and operation without mechanical failure.

1.2. Thermal Test

Thermal tests are carried out to check the thermal behavior of the circuit breakers. The breaker under test deal with the steady-state temperature rises due to the flow of its rated current through its pole in a rated condition. The temperature rise for rated current should not exceed 40° for current less than 800A normal current and 50° for normal value of current 800A and above.

1.3. Dielectric Test

These tests are performed to check power frequency and impulse voltage withstand capacity. Power frequency tests are kept on a new circuit breaker; the test voltage changes with a circuit breaker rated voltage.

The test voltage with a frequency between 15-100Hz is applied as follows.

- ✓ between poles with circuit breaker closed
- ✓ between pole and earth with circuit breaker open, and
- ✓ across terminals with circuit breaker open.

In impulse tests impulse voltage of specified magnitude is applied to the breaker. For outdoor circuit dry and wet tests are conducted.

1.4. Short -Circuit Test

Circuit breakers are subjected to sudden short-circuits in short-circuit test laboratories, and oscillograms are taken to know the behavior of the circuit breakers at the time of switching in, during contact breaking and after the arc extinction.

The oscillograms are studied with particular reference to the making and breaking currents, both symmetrical and asymmetrical restriking voltages, and switchgear is sometimes tested at rated conditions.

2. Routine Tests of a Circuit Breaker

Routine tests are also performed as per recommendations of the standards of Indian Engineering Service and Indian Standards. These tests are performed on the manufacturers' premises.

Routine tests confirm the proper functioning of the circuit breaker. The routine tests confirm the proper functioning of the circuit breaker.

Power frequency voltage test being the same as mentioned under the heading of type tests, the millivolt drop test is performed to determine the voltage drop within the current path of the breaker mechanism. Operational test is performed on the breaker by simulating its tripping by artificially closing the contacts of the relays.

- **Topic 3: Continuity test**

This is to be performed on a dead circuit for checking continuity. Using an 'Audible Continuity Tester' can do it. This tester consists of a battery as a source of energy, an audible device, and two test leads.

By this test, the continuity of an electrical circuit is checked to ensure that the electrical path is complete. If the path is continuous, then an audio sound is emitted to confirm path continuity and the non-existence of an open circuit. In some devices, along with the audio indication, an LED or some other visual indication is provided.

- **Topic 5: Insulation test**

This is another test performed on a dead circuit only. The objective is to check for insulation of cables or a power circuit. The device used to check integrity of insulation is known as an 'Insulation-Resistance Tester'.

LO2.4: Test lighting control system based on regulation

- **Topic 1: Checking the output of lighting control system**

The two main types of lighting control systems are Analog lighting controls like 0-10V and Digital lighting controls like DALI.

1. DALI system

DALI based digital control systems are the most popular ones among all. Abbreviated for Digital Addressable Lighting Interface, it's an open-standard digital lighting control protocol, interoperable with fixtures from various manufacturers

- It consists of a controller, a power supply, and one or more slave devices with DALI interfaces to control light intensity, CCT, and color. The DALI systems address individual fixtures or multiple fixtures via multicast and broadband messages. It can be arranged in a bus or star topology or a combination of both and reduce multiple wiring demands and expenditures. It's also a bi-directional system, that enables the controller to monitor and control each device for troubleshooting.

1.1. Advantages of DALI systems

- Open IEC standard and be used by all users
- Digitally addressable
- Easy commissioning and greater control flexibility
- Polarity independent two-wire control
- Constantly improving and extending

DALI systems generally accommodate 64 fixtures in a single DALI line for controlling and allow users to set 16 groups and 16 scenes. However, a larger number of light fixtures can also be controlled using this system with the help of additional bridges.

2. 0-10V system

0-10V lighting control is the most commonly used method among all Analog dimming systems. Controllers in this system connect to each fixture through separate wires, where DC voltage signal varies between 0-volt to 10-volts. Each value of voltage corresponds to a specific light or brightness level, meaning, 0-volt corresponds to turn off, 1-volt corresponds to dim light, and 10-Volt corresponds to bright light. 0-10V is much simpler than other lighting systems and can be best used to control individual lights.

Unlike digital systems, 0-10V dimming is not addressable. It dims or brightens all the light fixtures in the chain at the same time, and, at the same levels. 0-10V can be employed in facilities requiring one-action for all-devices and reduce operational complexities.

2.1. Advantages of 0-10V systems

- A simple workflow for dimming
- Need not pair devices
- Cost-effective dimming method
- Easy to troubleshoot

- Seamless installation

It varies the intensity or CCT of luminaires, as the voltage signal only allows a single range of lighting levels. It's typically used in commercial and industrial lighting with fixtures that have an LED driver designed for 0-10V DC dimming input.

- **Topic 2: Rectification of malfunctioning part**

Here are six very common places that wire connection problems occur.

- **Loose Wire Connections at Switches and Outlets**

By far the most common problem is when screw terminal connections at wall switches and outlets become loose. Because these fixtures get the most use within an electrical system, these are the places to look first if you suspect wire connection problems.

Loose wire connections at a switch, outlet, or light fixture are often signaled by a buzzing or crackling sound or by a light fixture that flickers.

To address this problem, it involves first turning off the power to the suspected wall switch, light fixture, or outlet. With the power shut off, you can remove the cover plate and use a flashlight to carefully examine the screw terminals inside where the wires are connected. If you find any that are loose, carefully tighten the screw terminals down onto the wires. In all likelihood, this will fix the problem.

Sometimes, you may find that the wire connections are made via push-in fittings on the back of the switch or outlet. This method of connection is notorious for being prone to failure. so much so that most professional electricians don't use the push-in fittings at all, but instead make all wire connections with the screw terminal connections on the sides of the switch or outlet. If you find that your device is made with the push-in fittings, you might want to remove them and reconnect the wires to the screw terminals on the device.

Finally, if there are pass-through wire connections inside the box that are made with wire nuts or another type of connector, check these to make sure the wires are tightly joined together. A loose connector is also a common source of problems.

- **Wire Connections Made With Electrical Tape**

A classic wire connection error is when wires are joined together with electrical tape rather than a wire nut or other sanctioned connector.

To fix the problem, first, turn off the power to the circuit. Then, remove the electrical tape from the wires and clean them. Make sure there is the proper amount of exposed wire showing (for most connectors, this means about 3/4 inch), then join the wires together with a wire nut or other approved connector (there are now push-in connectors that some pros like to use).

If the wire ends are damaged, you can cut off the ends of the wires and strip off about 3/4 inch of insulation to make a proper wire nut connection.

- **Two or More Wires Under One Screw Terminal**

Another common wire connection problem is when you find two or more wires held under a single screw terminal on a switch or outlet. This is a clear sign of amateur work and a distinct fire hazard. It is allowable to have a single wire under each of the two screw terminals on the side of an outlet or switch, but it is a code violation to have two wires wedged under a single screw. This is most often seen when two bare copper grounding wires are found under the grounding screw on the outlet or switch, but you also may occasionally find hot wires or neutral wires connected to a single screw terminal.

To fix this problem, once again, this repair involves first shutting off the power. Then, the two offending wires are removed from their screw terminal. Cut a 6-inch pigtail wire of the same color as the two wires (use a green pigtail if you are joining two bare copper grounding wires). Strip 3/4 inch of insulation from each end of the pigtail, then join one end to the two wires you just disconnected, using a wire connector (wire nut). Now, attach the free end of the pigtail wire to the screw terminal that once held the two wires.

You have essentially created a bridge, or pathway, that connects both wires to the desired screw terminal on the outlet or switch.

- **Exposed Wires**

It is quite common, especially with amateur electrical work, to see a screw terminal connection or wire nut connection where it has too much (or too little) exposed copper wire showing at the wires. With screw terminal connections, there should be enough bare copper wire stripped to wrap entirely around the screw terminal but not so much that excess bare copper wire extends out from the screw. The excess exposed wire can short out if it touches a metal box or other wires. Wires should be wrapped clockwise around the screw terminals; if they are reversed, they can be prone to loosening.

With wire nut connections, all of the bare copper wire should be hidden under the plastic cap, with no exposed wire showing at the bottom of the wire nut.

To fix the problem, turn off the power to the device, then disconnect the wires and either clip off the excess wire or strip off additional insulation so the proper amount of wire is exposed. Then, reconnect the wires to their screw terminal or wire nut. Tug lightly on the wires to make sure they are securely connected.

- **Loose Connections on Circuit Breaker Terminals**

A less common problem is when the hot wires on circuit breakers in the main service panel are not tightly connected to the breaker. When this happens, you may notice lights flickering or service problems on fixtures all along the circuit. When making connections to circuit breakers, be sure to strip the proper amount of wire insulation from the wire and make sure that only the bare wire is placed under the terminal slot before tightening. Insulation under the connection slot is a code violation.

To fix the problem, repairs at the main service panel should be handled by a professional electrician. Amateurs should attempt these repairs only if they are quite experienced and knowledgeable about electrical systems.

The electrician will address this problem by turning off the breaker then unclipping it from the hot bus bar in the main service panel. He or she will check the hot wire connected to the breaker to make sure that the screw is tight and that there is no insulation under the terminal and no excess bare copper wire exposed. With repair complete, the electrician will snap the breaker back into place on the hot bus bar and turn the breaker back on.

- **Faulty Neutral Wire Connections at Circuit Breaker Panels**

Another less common problem that is usually handled by a pro, is when the white circuit wire is not correctly mounted to the neutral bus bar in the main service panel. Symptoms here will be similar to those with a faulty hot wire.

To fix this problem, the electrician will check to make sure the neutral wire is sufficiently stripped and correctly attached to the neutral bus bar.

- **Topic 3: Luminosity test**

The easiest way to understand how light is measured is by picturing the typical light bulb with a filament that heats up producing light (Incandescent if you read the previous section). The filament is the source of the light and is at the centre of a sphere with light being emitted in every direction. The total amount of energy of all the light produced is known as the "luminous flux".

You are probably familiar with the Lumen; this is the measure of light intensity people have generally heard of. The base unit of luminous intensity is the candela, (a single lit candle gives off roughly 1 candela). One candela per steradian (an area in a cone shape starting from the source of light) is known as a lumen.

When we measure light, we are interested in how many Lumens fall on a surface; this is what we know as lux. One lux is one lumen per square meter.

A working example, We have a light source whose total light produced (luminous flux) is 1000 lumens. If we could focus this onto the surface of 1 square metre we would have an illuminance of 1000 lux. However if the same light was spread out over 10 square meters, we would only have an illuminance of 100 lux.

- **Topic 4: Application of testing regulations**

1. **Testing an electrical installation**

The visual inspection is carried out first, to confirm that permanently-wired electrical equipment is compliant with the safety requirements and not visibly damaged, and that fire barriers, protective, monitoring, isolating and switching devices and the relevant documentation are present. Electrical testing may commence after this inspection.

Other methods are not precluded, provided that they give equally valid results. When testing is undertaken it should be ensured that adequate precautions are taken to avoid damage or injury to people, equipment or property, and ensured that unauthorised persons are kept away from danger.

Continuity

Continuity testing of protective conductors is normally carried out with an instrument able to generate a no-load voltage in the range 4 to 24 V (DC or AC), with a minimum current of 0,2 A. The most common continuity test is to measure the resistance of protective conductors, which involves first confirming the continuity of all protective conductors in the installation, and then testing the main and supplementary equipotential bonding conductors.

All circuit conductors in the final circuit are also tested and the resistance of the test leads must be compensated for as continuity testing measures very low resistances.

Insulation resistance

Insulation integrity is critical to prevent electric shock. It is generally measured between live conductors and between each live conductor and earth. The installation must be switched off, all lamps removed and all equipment disconnected to measure the insulation resistance between live conductors and earth. All fuses must be left in, and circuit breakers and final circuit switches closed.

With direct current, measurements are taken with instruments able to supply test voltages of 1000, 500 or 250 V, depending on the nominal circuit voltage. On single-phase supply systems, insulation testing is normally done using a 500 V test voltage.

Before testing, disconnect equipment and take measures to prevent the test voltage damaging voltage-sensitive devices such as dimmer switches, delay timers and electronic starters for fluorescent lighting.

LO 2.5: Test power socket system based on regulation

- **Topic 1: Checking the output voltage**

The output voltage is checked using multimeter.

A multimeter can help to determine:

- If power is actually reaching an outlet
- If the outlet is properly grounded
- Whether wiring within the outlet is reversed

Test of Outlet with a Multimeter follows 8 Simple Steps

1. **Learn the essentials of outlet testing safety**.
   Because you will be performing these tests on a live outlet, ensure safety by holding both meter probes in the same hand. This will prevent shock from passing through your body. Never allow the metal portion of the probes to brush each other or touch, as this can create a dangerous short circuit.
2. **Get to know outlet geography**.
   Modern outlets have three slots: one for hot, one for neutral, and one for ground. The rounded half circle is the ground, the longer slot (left) is the neutral and the shorter slot (right) is hot. Remember that any of the three wires can carry current, so treat each one with caution.
3. **Adjust your multimeter.**
   Set your meter to measure voltage. Select the alternating current (AC) function on the multimeter, which is often depicted with a wavy line. The DC function will have a solid and a dashed line.
4. **Connect the leads.**
   Push the short, thick connector (called a 'banana plug') of the BLACK lead into the connector labeled 'COM' (it may have a minus "-" sign beside it). Then, plug in the RED connector labeled with a "+" or horseshoe symbol
5. **Measure the voltage to determine if the outlet has power.**
   Using one hand, insert a probe into each vertical slot on the outlet. Red goes in the smaller slot, black into the larger one. A properly functioning outlet will give a reading of 110-120 volts. If there is no reading, either something is wrong with the wiring in the outlet or the circuit breaker is tripped.
6. **Determine if the outlet is properly grounded.**
   Keep the red lead in the small slot and move the black lead and place it in the ground (U-shaped) outlet slot. The reading should remain the same. If it doesn't, the outlet is improperly grounded.
7. **Check if the wiring is reversed.**
   Place the red lead into the large slot and the black lead into small slot. If you get a reading, the wiring is reversed. This won't affect simple equipment like lamps but can cause issues for more sophisticated appliances and electronics.
8. **Determine problems with a particular appliance.**

- **Topic 2: Rectification of malfunctioning part**

7 Steps For Electrical Troubleshooting

1. Gather Information. The first step of any electrical system troubleshooting exercise involves gathering as much information about the problem as possible

2. Understand the malfunction and the role the malfunctioning equipment plays within the entire process. When you understand how the equipment and process is supposed to work, you can better understand what part of it is not functioning correctly.
3. Identify what can be measured so that you can identify items that are outside the acceptable range. For example, are there voltage readings or temperature readings that would help you evaluate the source of the problem?
4. Identify the source of the problem using available data and analytical tools to isolate the defective component. This could involve isolating components and evaluating their circuit parameters or isolating the circuits by group when dealing with a complicated circuit.
5. Correct/repair the damaged component.
6. Verify the repair after completion. Once the repair has been performed, start the system to ensure it now runs as required. This is important because there may have been other underlying problems. For example, there may be an issue with a circuit causing a fuse to blow (such as a shorted electrical connection). If this is the case, additional troubleshooting will be required.
7. Perform root cause analysis to determine what really caused the problem. Since one of the objectives of troubleshooting is to ensure the problem doesn't reoccur, it is important to determine what really caused the malfunction and take action to ensure a permanent solution is found.

- **Topic 3: Polarity test**

This test will verify that all the switches installed in the system are connected in current carrying conductor and not in neutral. For example, if you isolate or switch the neutral of a circuit via a single-pole circuit breaker or switch, it would appear that the circuit is dead where in fact it is still live.

If polarity is not correctly determined there may be a risk of electric shock during maintenance procedures.

We perform following steps for polarity testing:

Step 1: Polarity by Visual Inspection

By using our knowledge and sight, correct termination of cables relating to core colours can be established. It is essential that polarity is checked visually during the process of installation, especially in cases where checking by testing is impractical.

Step 2: Polarity by Continuity Testing

If visual inspection is not possible, we will need to use a low-resistance ohmmeter for this test. When we perform continuity test radial and ring final circuits, part of the process is to test and visually inspect the polarity of fixed equipment and socket outlets.

While conducting polarity by Continuity Testing, the following steps are followed:

- We switch off the circuit breaker supplying the circuit.
- From the specific circuit, we put a temporary link that will connect the line conductor and the CPC or any equipotential bonding conductors. It will serve as a testing point for convenience.
- Continuity test is conducted by placing the test leads across the line conductor and the nearest CPC or any exposed conductive parts of the circuit.
- If the instrument shows zero reading (with continuity sound) then the switch is connected properly to the line conductor.
- If the instrument shows some significant ohmic value then the switch is not connected to the line conductor. We will interchange the connections to fix the problem.

Step 3: Live Testing for Polarity

If the two methods are not possible due to urgency we can perform live polarity testing by using the approved voltmeter.

. **While conducting polarity by** Continuity Testing, the following steps are followed:

- Test the voltage between LINE and NEUTRAL terminals.
- Test the voltage between LINE and EARTH terminals.
- Test the voltage between NEUTRAL and EARTH terminals.

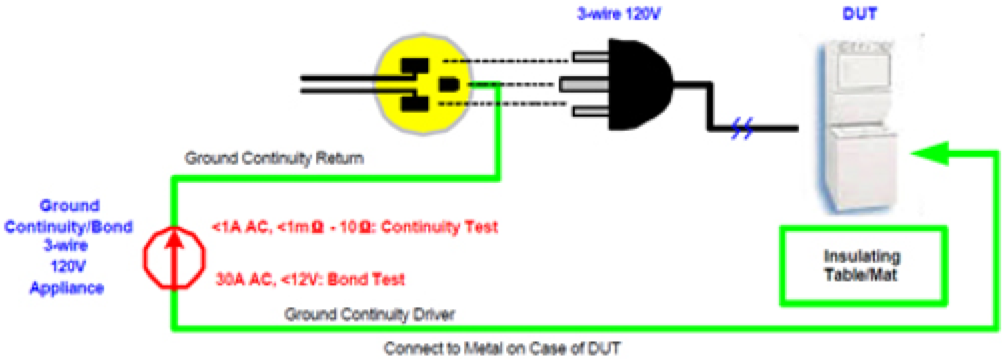
The test instrument should indicate full voltage (230V) between Line-Neutral and Line-Earth conductors. No voltage should be detected between Neutral-Earth

The requirements for polarity test are:

- All fuses and single pole switches are in the phase conductor.
- The centre contact of equipment like lamp holder is connected to the phase conductor.
- All socket outlets and similar accessories are correctly wired.

LO 2.6: Test grounding system based on regulation

- **Topic 1: Test the continuity of ground wire**



Since many older homes may be wired as 2-wire systems without solid ground connections, regulatory agencies require all products manufactured with 3-wire cords to pass the same hipot tests as ungrounded products.

In such cases, the user is protected by the electrical insulation rather than by the safety ground. Ground continuity tests are normally performed with a low current DC signal that checks to ensure that the ground connection has a resistance of less than 1 ohm. Ground continuity testing is not only helpful in determining how well a product will fare during a laboratory investigation, but also is useful in a production line environment to ensure quality and user safety.

- **Topic 2: Checking the status of connectors**

To maintain the grounding system, check the following:

- The electrical contact between the metallic parts and the cabinet body. The metallic parts and the cabinet body must be well contacted. The contact points such as screw holes, guide lanes, and lifting ears must not be painted. Otherwise, bad electrical contact may occur.
- The grounding terminals at the front and back doors and the side doors. These terminals must be well connected with the grounding wires.
- The grounding buses of combined neighboring cabinets. If cabinets are combined, the neighboring cabinets must be connected by a grounding bus.
- The yellow and green protecting ground cables. One end of a ground cable should connect the PGND grounding bus of the power distribution cabinet in the equipment room, and the other end connects the grounding terminal of the cabinet. The screws that fix the ground cable should not be loose.

Topic 3: Rectification of malfunctioning parts

Here are six very common places that wire connection problems occur.

Loose Wire Connections at Switches and Outlets

By far the most common problem is when screw terminal connections at wall switches and outlets become loose. Because these fixtures get the most use within an electrical system, these are the places to look first if you suspect wire connection problems.

Loose wire connections at a switch, outlet, or light fixture are often signaled by a buzzing or crackling sound or by a light fixture that flickers.

To address this problem, it involves first turning off the power to the suspected wall switch, light fixture, or outlet. With the power shut off, you can remove the cover plate and use a flashlight to carefully examine the screw terminals inside where the wires are connected. If you find any that are loose, carefully tighten the screw terminals down onto the wires. In all likelihood, this will fix the problem.

Sometimes, you may find that the wire connections are made via push-in fittings on the back of the switch or outlet. This method of connection is notorious for being prone to failure—so much so that most professional electricians don't use the push-in fittings at all, but instead make all wire connections with the screw terminal connections on the sides of the switch or outlet. If you find that your device is made with the push-in fittings, you might want to remove them and reconnect the wires to the screw terminals on the device.

Finally, if there are pass-through wire connections inside the box that are made with wire nuts or another type of connector, check these to make sure the wires are tightly joined together. A loose connector is also a common source of problems.

Wire Connections Made With Electrical Tape

A classic wire connection error is when wires are joined together with electrical tape rather than a wire nut or other sanctioned connector.

To fix the problem, first, turn off the power to the circuit. Then, remove the electrical tape from the wires and clean them. Make sure there is the proper amount of exposed wire showing (for most connectors, this means about 3/4 inch), then join the wires together with a wire nut or other approved connector (there are now push-in connectors that some pros like to use).

If the wire ends are damaged, you can cut off the ends of the wires and strip off about 3/4 inch of insulation to make a proper wire nut connection.

Two or More Wires Under One Screw Terminal

Another common wire connection problem is when you find two or more wires held under a single screw terminal on a switch or outlet. This is a clear sign of amateur work and a distinct fire hazard. It is allowable to have a single wire under each of the two screw terminals on the side of an outlet or switch, but it is a code violation to have two wires wedged under a single screw. This is most often seen when two bare copper grounding wires are found under the grounding screw on the outlet or switch, but you also may occasionally find hot wires or neutral wires connected to a single screw terminal.

To fix this problem, once again, this repair involves first shutting off the power. Then, the two offending wires are removed from their screw terminal. Cut a 6-inch pigtail wire of the same color as the two wires (use a green pigtail if you are joining two bare copper grounding wires). Strip 3/4 inch of insulation from each end of the pigtail, then join one end to the two wires you just disconnected, using a wire connector (wire nut). Now, attach the free end of the pigtail wire to the screw terminal that once held the two wires.

You have essentially created a bridge, or pathway, that connects both wires to the desired screw terminal on the outlet or switch.

Exposed Wires

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With wire nut connections, all of the bare copper wire should be hidden under the plastic cap, with no exposed wire showing at the bottom of the wire nut.

To fix the problem, turn off the power to the device, then disconnect the wires and either clip off the excess wire or strip off additional insulation so the proper amount of wire is exposed. Then, reconnect the wires to their screw terminal or wire nut. Tug lightly on the wires to make sure they are securely connected.

Loose Connections on Circuit Breaker Terminals

A less common problem is when the hot wires on circuit breakers in the main service panel are not tightly connected to the breaker. When this happens, you may notice lights flickering or service problems on fixtures all along the circuit. When making connections to circuit breakers, be sure to strip the proper amount of wire insulation from the wire and make sure that only the bare wire is placed under the terminal slot before tightening. Insulation under the connection slot is a code violation.

To fix the problem, repairs at the main service panel should be handled by a professional electrician. Amateurs should attempt these repairs only if they are quite experienced and knowledgeable about electrical systems.

The electrician will address this problem by turning off the breaker then unclipping it from the hot bus bar in the main service panel. He or she will check the hot wire connected to the breaker to make sure that the screw is tight and that there is no insulation under the terminal and no excess bare copper wire exposed. With repair complete, the electrician will snap the breaker back into place on the hot bus bar and turn the breaker back on.

Faulty Neutral Wire Connections at Circuit Breaker Panels

Another less common problem—and another that is usually handled by a pro—is when the white circuit wire is not correctly mounted to the neutral bus bar in the main service panel. Symptoms here will be similar to those with a faulty hot wire.

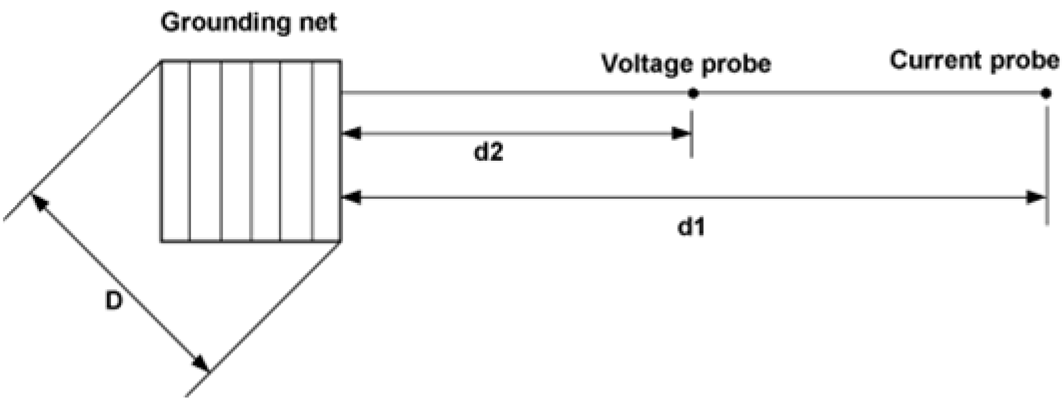
To fix this problem, the electrician will check to make sure the neutral wire is sufficiently stripped and correctly attached to the neutral bus bar.

- **Topic 3: Ground resistance test**

The grounding resistance of a comprehensive communication building should be no more than 1 Ω; that of a common communication station, no more than 5 Ω; that of the place with high earth resistibility, no more than 10 Ω.

To measure the grounding resistance, use an earth resistance tester.

Figure below shows the arrangement of the probes of an earth resistance tester.



- If the distance between the current probe and the rim of a grounding net is d1 and the length of the maximum diagonal line of a grounding net is D: d1 is normally four to five times as much as D.
- If the distance between the probe and the side of a grounding net is d2, then d2 is 50% to 60% of d1.
- In measurement, move the voltage probe along the line connecting the grounding net and the current probe for three times; each movement is about 5% of d1. If the three resistance values are similar, it means that the grounding resistance is normal.

  - **Topic 4: Earth electrode test**

To connect the metallic (conductive) Parts of an Electric appliance or installations to the earth (ground) is called **Earthing** or **Grounding**.
In other words, to connect the metallic parts of electric machinery and devices to the earth plate or earth electrode (which is buried in the moisture earth) through a thick conductor wire (which has very low resistance) for safety purpose is known as *Earthing or grounding.*
To earth or earthing rather, means to connect the part of electrical apparatus such as metallic covering of metals, earth terminal of socket cables, stay wires that do not carry current to the earth. Earthing can be said as the connection of the neutral point of a power supply system to the earth so as to avoid or minimize danger during discharge of electrical energy.

LU 3: Test the earthing circuit protection

LO3.1: Test earthing resistance in accordance with standards

- **Topic 1: Continuity test**

Every protective conductor, including all conductors and any extraneous conductive parts used for equipotential bonding should be tested for continuity. The test should be made by connecting together the neutral and protective conductors at the mains position and checking between earth and neutral at every outlet by a continuity tester, which should show a reading near zero.

- **Topic 2: Polarity test**

A test of polarity should be carried out to verify that:

(a) every fuse and single-pole control and protective device connected in the phase conductor only,

(b) centre-contact bayonet and Edison-type screw lampholders to IEC 60238 in circuits having an earthed neutral conductor, have their outer or screwed contacts connected to that neutral conductor, and

(c) wiring has been correctly connected to socket outlets and similar accessories.

- **Topic 4: Earth resistance test**

A proper earth electrode resistance tester should be used to measure earth electrode resistance. An alternating current at 50 Hz of a steady value is passed between the earth electrode T and an auxiliary earth electrode T1 placed at a separation distance recommended by the manufacturer of the tester but in any case should not be less than 20 metres away. A second auxiliary earth electrode T2, which may be a metal spike driven into the ground, is then inserted half-way between T and T1, and the voltage drop between T and T2, divided by the current flowing between T and T1, gives a measured earth electrode resistance of earth electrode T. For an electrical installation having four or more earth electrodes which are installed more or less in line, following a general direction not exceeding 15° deviation and with separation between adjacent electrodes not less than the recommended distance by the manufacturer of the tester but in any case not less than 20 metres, these electrodes can be used in turn as the auxiliary electrodes for the purpose of measuring the earth electrode resistances. The following alternative method for measuring the earth electrode resistance may be used if the electricity supply is connected. A loop impedance tester should be connected between the phase conductor at the origin of the installation and the earth electrode with the test link open, and a test performed. This impedance reading could be treated as the electrode resistance.

LO 3.2: Test ground wire (Continuity test) in accordance with regulations

- **Topic 1: Electrode test**

Earthing can be done in many ways and there are different types of earthing electrodes used for different types of electrical earthing

1. **Plate Earthing:**

In plate earthing system, a plate made up of either copper with dimensions 60cm x 60cm x 3.18mm (i.e. 2ft x 2ft x 1/8 in**)** or galvanized iron (GI) of dimensions 60cm x 60cm x 6.35 mm (2ft x 2ft x ¼ in) is buried vertical in the earth (earth pit) which should not be less than 3m (10ft) from the ground level.For proper earthing system, follow the above mentioned steps in the(EarthPlate introduction) to maintain the moisture condition around the earth electrode or earth plate.

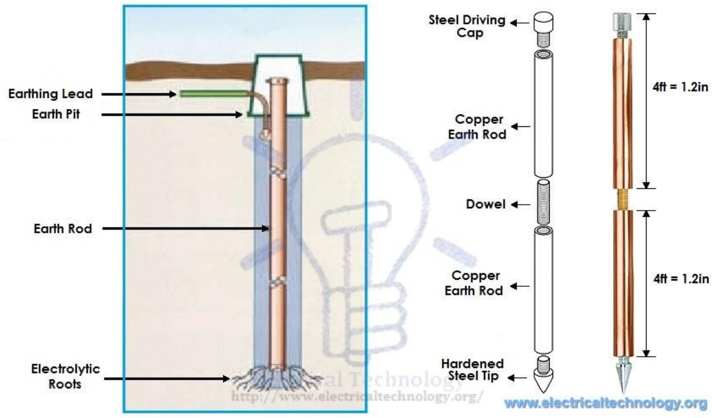
2. **Pipe Earthing*:***

A galvanized steel and a perforated pipe of approved length and diameter is placed vertically in a wet soil in this kind of system of earthing. It is the most common system of earthing.

The size of pipe to use depends on the magnitude of current and the type of soil. The dimension of the pipe is usually 40mm (1.5in) in diameter and 2.75m (9ft) in length for ordinary soil or greater for dry and rocky soil. The moisture of the soil will determine the length of the pipe to be buried but usually it should be 4.75m (15.5ft).

3. **Rod Earthing**

it is the same method as pipe earthing. A copper rod of 12.5mm (1/2 inch) diameter or 16mm (0.6in) diameter of galvanized steel or hollow section 25mm (1inch) of GI pipe of length above 2.5m (8.2 ft) are buried upright in the earth manually or with the help of a pneumatic hammer. The length of embedded electrodes in the soil reduces earth resistance to a desired value.



Copper Rod Electrode Earthing System

4. **Earthing through the Waterman**

In this method of earthing, the waterman (Galvanized GI) pipes are used for earthing purpose. Make sure to check the resistance of GI pipes and use earthing clamps to minimize the resistance for proper earthing connection.

If stranded conductor is used as earth wire, then clean the end of the strands of the wire and make sure it is in the straight and parallel position which is possible then to connect tightly to the waterman pipe.

5. **Strip or Wire Earthing:**

In this method of earthing, strip electrodes of cross-section not less than 25mm x 1.6mm (1in x 0.06in) is buried in a horizontal trenches of a minimum depth of 0.5m. If copper with a cross-section of 25mm x 4mm (1in x 0.15in) is used and a dimension of 3.0mm^2 if it's a galvanized iron or steel.

If at all round conductors are used, their cross-section area should not be too small, say less than 6.0mm^2 if it's a galvanized iron or steel. The length of the conductor buried in the ground would give a sufficient earth resistance and this length should not be less than 15m.

LO3.4: Test earthing resistance in accordance with standards

- **Topic 1: Continuity test**

This is a quick audible alarm test using a digital multi meter to determine whether an electrical circuit or wire is complete or broken.

This test can be applied to a circuit as a whole or in sections—on individual components or sections of wiring. A break in continuity can be caused by mechanical damage, corrosion of components, or simply a switch being left open.

Follow these steps to complete the continuity test procedure with an auto range digital meter:

1. Make sure all power is off in the circuit you are testing.
2. Set the selector dial to Ω (audible alarm symbol).
3. Connect the test lead and probes on the load terminals as shown (Figure 5). The audible alarm will indicate continuity without a need for taking your eyes off the work.
4. Touch the probes together to check the leads, connections, and battery life. The audible alarm should sound. With the leads apart the meter should display OL or I, depending on the manufacturer.
5. If this is the last test you are doing, turn the meter to "off" and store it in a safe place.

- **Topic 2: Testing electrode**

To connect the metallic (conductive) Parts of an Electric appliance or installations to the earth (ground) is called Earthing or Grounding.
In other words, to connect the metallic parts of electric machinery and devices to the earth plate or earth electrode (which is buried in the moisture earth) through a thick conductor wire (which has very low resistance) for safety purpose is known as *Earthing or grounding.*
To earth or earthing rather, means to connect the part of electrical apparatus such as metallic covering of metals, earth terminal of socket cables, stay wires that do not carry current to the earth. Earthing can be said as the connection of the neutral point of a power supply system to the earth so as to avoid or minimize danger during discharge of electrical energy.

LO 3.5: Perform polarity test in outlet socket in accordance with regulations

- **Topic 1: Visual inspection of outlets sockets**

Things to consider while making visual inspection:

1. Are accessories fixed to the wall properly? Are they missing or damaged?
2. Are the accessories old with wooden back plates?
3. Are the socket outlets round pin or square? Is there a mixture of both?
4. Have cables been installed in vulnerable situations?
5. Have cables, enclosures and accessories been fixed securely?
6. Are any socket outlets likely to be used outside? If they are then they should be RCD protected
7. Are earthing clamps standards and correctly labelled?
8. Is the correct equipment for the correct zones in bath/shower room?
9. Has the bedroom had a shower installed? If so, are the socket outlets 3 metres from the shower and RCD protected?
10. Is there any evidence of mutual detrimental influence; are there any cables fixed to water, gas or any other non-electrical services? (The cables need to be far enough away to avoid damage if the non-electrical services are worked on.)
11. Are the cables of different voltage bands segregated? Low voltage, separated extra low voltage (SELV), telephone cables or television aerials should not be fixed together (although they are permitted to cross).

Whilst these items are being checked, look in any cupboards for sockets or lights. If your customer is uncomfortable with this it is vitally important that you document any areas that cannot be investigated in the extent and limitation section on the Periodic Inspection Report

- **Topic 2: Polarity test in outlet sockets**

Voltage is a difference in energy level between two different points in a circuit. Voltage has not only a value, but also a polarity. One of the points will have a higher energy level (or a higher voltage) than the other.

The voltage polarity must be accounted for when making a measurement. When you connect your DMM to a circuit, you will be *assuming* a particular polarity. The sign of the reading displayed on the DMM reflects this assumption. If the actual and assumed polarities are the same, the displayed number will be positive. Conversely, if the number displayed is negative, the actual polarity is opposite to your assumption

LU 4: Check consumer control unit

LO 4.1: Identify consumer control according to manufacturer's instruction

- **Topic 1: Function and application of CCU**

The role of a consumer unit is easy enough to grasp – as stated above, it controls the electrical supply throughout a single residential property. To understand how it performs that role, you really need to explore the individual roles of its three major components: the main switch, residual current devices, and circuit breakers.

Main Switch

The main switch is just what it sounds like – the central switch controlling the supply of mains electricity from the meter to the consumer unit and subsequently through to the rest of your home. While RCDs and circuits are usually tripped automatically, a mains switch is going to be switched on and off manually. If you want to conduct a piece of electrical repair or are going through an emergency situation, you'll be turning off the consumer unit's main switch.

When you turn the mains switch off, both the incoming live and the incoming neutral power will be separated from the rest of the unit – essentially, you'll have isolated your consumer unit, and therefore the property itself, from the mains electricity supply.

Residual Current Devices (RCD)

RCDs are switches that constantly monitor the electrical currents in your home. As a general rule of thumb, you'll find your circuits split into two sets, with one RCD controlling each one; when one of those RCDs is tripped, all the circuits that it controls will be turned off. In the ever-popular Wylex consumer unit, the first RCD is next to the main switches and the second is about halfway between all the circuits. Most other consumer unit manufacturers follow that layout, although it isn't written in stone.

When an RCD does switch itself off, it's usually to prevent any electric shock or personal injury. As such, most RCDs are quite sensitive, rated at 30 milliamps – above that level, the electric current becomes dangerous to humans.

Let's say you touch a live wire. The electricity will flow through an unintended path – namely your body. That change will be detected by the RCD, which will then trip and turn off the circuit, dramatically reducing the risk of serious injury or death. An RCD also provides protection against electrical fires caused by earth faults. If earth leakage is detected, the RCD will trip before the level of leakage becomes dangerous.

Circuit Breakers

Circuit breakers can be thought of as similar to RCDs since they are safety switches that turn themselves off automatically to protect electrical circuits from damage. However, they are more specialised in that they control specific sections of your home. For example, you may have an individual circuit breaker covering 'spare bathroom', 'downstairs toilet', and 'garage', so your consumer unit will contain quite a number of individual circuits.

In the vast majority of consumer units, each will have its own miniature circuit breaker (MCB), and these will be tripped in case of:

- **Overload:** If you have too many items plugged into the same circuit, the total load can become higher than the MCB's rating, in which case the circuit will be tripped.
- **Overcurrent:** Covers faults with the circuit itself. For example, if a live cable gets loose in the back of a socket and touches the neutral wire, the circuit will be tripped.

If your consumer unit doesn't use those components, it is almost certainly an older model that is no longer up to code. One sure-fire way to know whether you need to upgrade is to check whether you have rewireable fuses – if so, you need a new unit.

Most people will find themselves as acquainted as they need to be with a consumer unit by simply understanding those three main components, but there are a few further parts that could warrant your attention, including:

- **Bus Bar:** Your consumer unit's bus bar will probably look a little bit like a copper comb – it's a section of metal with raised teeth onto which MCBs, RCDs and RCBOs can be mounted for connection to the main Din Rail. Each pole will generally carry up to 120 volts of electricity, and they allow sufficient cooling of each unit by spacing them out.
- **Two-pole RCBO:** An RCBO (Residual Current Circuit Breaker) basically combines the functions of a MCB and a RCD. Two-pole, or double-pole, RCBOs are rated for 20 to 60 amps and supply 240-volt power to larger appliances, such as ovens. They take up two bus bar slots inside your unit.
- **Single Pole Breakers:** Rated at 15, 20, and 30 amps to supply 120-volt power, these are more common in household installations, providing power distribution for smaller appliances, sockets, and light fixtures.
- **Socket Outlet:** A socket is simply an input for a plug that is attached to a wall and connected to your power supply. Every socket outlet in your home will run to one of the circuits in your consumer unit.
- **Main Panel:** The main panel covers all the internal components of your consumer unit. They are usually made from a thin sheet of metal, although they may have transparent plastic sections to let

you view the switches without actually opening the unit. Commercial panels are often lockable, but this is rarely necessary for residential properties. In any case, a panel should be kept closed to prevent dust and moisture getting into the switches. Damaged or dented panels should be replaced since they may be difficult to open during an emergency and could strike against switches when closed.

How to Use a Consumer Unit

You should now have a good working understanding of what consumer units do, how they work, and what components they use in the process. Now you understand that, you need to learn how to use your consumer unit.

It's not a part of your home that will need frequent adjustment, but you should test your consumer unit regularly and understand how to use some of its features. Here's a quick overview to cover the basics needed by the average homeowner.

Timer

Not all consumer units have inbuilt timers, but they're becoming increasingly popular additions. If you don't have a consumer unit with a timer inbuilt, keep in mind that you can simply have one fitted along the DIN rail instead of replacing the entire unit – it's possible to do this yourself, though the exact instructions will vary by unit, and it's generally recommended that you let a professional take care of the task.

Timers allow you to turn off certain circuits at set intervals. If you're going on holiday and want to have your lights turned on and off at set times, a consumer unit timer is a convenient option. Simply set the time and leave your unit to do the rest. When you pick up a timer, make sure you check whether it's a 7-day model or a 24-hour model.

Main Switch

The main switch works manually, turning off the electricity supply to your home in one fell swoop. All you need to do is open the consumer unit, find the main switch, and then turn it off or on – it will not perform either action automatically. One thing to remember is that your home may possibly have one mains switch in a separate consumer unit. This is only likely if you have a larger external unit that consumes a lot of energy, but it's worth keeping in mind. It's just one reason why you should always test that the power has been shut off after you've deactivated the main switch.

RCDs

RCDs will trip automatically, turning off the electricity for all circuits they control. If the electricity in your home goes off, look in the consumer unit and you'll generally find that one of the RCDs has been tripped. You may also find that a MCB has been tripped.

Most of the time, everything will be back to normal after you switch the RCD back on. If it switches straight off again, you should turn off all the MCBs and then reset the RCD. If this doesn't work, turn on each MCB one by one until you find the problem. If the RCD still won't turn on, go around your home turning off all the sockets and lights, then try turning the MCBs on independently once again to isolate the appliance or switch responsible for the problem. If the RCD still turns off automatically, you need to contact a professional.

You'll also need to test the RCD every month to make sure it's working perfectly. Next to the switch will be a simple push button. Pushing it will create an earth leak that should trip the RCD; if it doesn't, you need to contact a professional. Remember to test each RCD independently.

MCB

Like RCDs, a MCB will usually be tripped off automatically. You may overload a light fixture in your bedroom and find that only the electricity in that one room has been turned off – such cases are caused by a single MCB being tripped. You can simply reset the switch to get things back to normal. If that switch turns right back off, contact a professional.

- **Topic 2: Methods of CCU connection**

The essential functions and responsibilities of fuse boards will always remain the same; however, certain aspects will be slightly altered to accommodate different requirements. The types of consumer units include:

- **Main Switch Consumer Unit** – If you choose to go for a Main Switch Consumer Unit, then it will be supplied to you without any of the additional devices used for protection. It will feature only the main switch, but you can install an RCD and MCB if you wish to do so.
- **Dual RCD Consumer Unit** – The next option is a Dual RCD Consumer Unit, which as you can expect from the name will be equipped with two RCD's, as well as the conventional main switch. This remains one of the most popular fuse board types because it is far cheaper than its alternatives.
- **High Integrity Consumer Unit** – Featuring two MCB's, a High Integrity Consumer Unit offers an affordable layer of protection as they allow circuits to be separated. They are created with a simple design, making them more straightforward to install and maintain.
- **RCD Consumer Unit** – These types of units are most commonly used for areas that require a smaller electrical supply; for example, a garage or workshop. Unlike their alternatives, an RCD Consumer Unit does not have a main switch because this function is controlled by a specialist RCD

- **Topic 3: Identification of CCU Protection**

A consumer unit is essentially the main control centre for a home's electrical supply. It's something nearly everyone can recognize but which fewer people can name and far fewer actually work. the consumer unit is found at the point where the electrical supply enters your property from the electricity meter. It distributes that power throughout the property, and its key components – main switches, residual current devices (RCDs), and circuit breakers – can be, according to the component, either manually or automatically shut off to protect you and your property from injury or damage. When something causes a RCD or circuit breaker to turn off automatically, that component will have been said to have 'tripped'.

- **Topic 4: Use of PPE**

PPE are personal protective equipment.
There are well explained in topic 6 of L.O 1.1 in LU1

LO 4.2: Identification of incoming power sources according the work done

- **Topic 1: Checking of power source**

The power source may be Direct current source or Alternating current source depending to the output current

Electricity or "current" is nothing but the movement of electrons through a conductor, like a wire. The difference between AC and DC lies in the direction in which the electrons flow. In DC, the electrons flow steadily in a single direction, or "forward." In AC, electrons keep switching directions, sometimes going "forward" and then going "backward."Alternating current is the best way to transmit electricity over large distances.

- **Topic 2: Purpose of label on cable in electrical circuit.**

Common labelling for electrical applications include wires and cables, circuit breakers, as well as Arc Flash and Safety labels. For an electrical engineer labelling is a crucial aspect in adhering to safe codes of practice in ensuring people are kept safe.

When implemented correctly, proper safety signage and labels help to increase worker safety (and even loss of life in extreme), communicate potentially hazardous situations, and reduce costs associated with lost time from injury.

It is extremely important to select the right label material based on the task at hand.

Cable and wire identification refers to the labels that are typically affixed to a cable or wire for identification purposes. These labels provide a quick and easy way to identify a cable or wire and can be placed in a location that is easy to read even in hard-to-reach areas.

The most common type of cable and wire markers are wraps and heat-shrink tubes. The recommended materials for wire and cable wraps include Vinyl, flexible nylon, and laminated wire/cable wraps.

LO 4.4: Check final installation of Consumer Control Unity (CCU) according work installed

- **Topic 1: Visual inspection**

The visual inspection of any installation is as important as any testing that is carried out on an installation. It helps to know if:

- All accessories fixed to the wall properly
- All cables have been installed in vulnerable situations
- All cables, enclosures and accessories have been fixed securely.
- All earthing wires correctly labeled.

- **Topic 2: Check continuity of circuit breakers.**

This is a quick audible alarm test using a digital multimeter to determine whether an electrical circuit or wire is complete or broken.
This test can be applied to a circuit as a whole or in sections—on individual components or sections of wiring. A break in continuity can be caused by mechanical damage, corrosion of components, or simply a switch being left open

- **Topic 3: Checking circuit breakers termination**

A fuse, as well as a circuit breaker, is part of a system where there are electrical, mechanical and thermal considerations. All three of these are interrelated. If there is too much electrical current for the circuit, the components can overheat. If a conductor termination is not properly torqued, the termination can be a "hot spot" and contribute excess heat. This additional heat is detrimental to the integrity of the termination means, conductor insulation and even the overcurrent protective device. If the conductor size is too small for the circuit load or for how the fuse/termination or circuit breaker/termination has been rated, the undersized conductor will be a source of detrimental excess heat, which bleeds into the devices through the terminals. This excess heat can cause integrity issues.

Some Causes of Loose Terminal Connections Below are some possible causes for loose terminal connections for various termination methods and possible causes of excessive heating of the overcurrent protective device / termination / conductor system: 1. The conductor gauge and type of conductor, copper or aluminum, must be within the connector's specifications 2. The connector is not torqued to the manufacturer's recommendation. 3. The conductor is not crimped appropriately. 4.The quick connect terminal is not seated properly. 5. The quick connect terminal is being used beyond its amp rating 6. The conductor is not properly soldered to a solder terminal 7. The terminal is only rated to accept one conductor, but multiple conductors are being used

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