CHAPTER 7: ELECTRICAL INSTALLATION BREAKDOWN MAINTENANCE

Unit of learning code ENG/CU/EI/CR/03/4/A
Related Unit of Competency in Occupational Standard: Perform Electrical System Breakdown Maintenance

7.1 Introduction

This unit describes the competencies required to enable trainee be able to exhibit competency in the application of health, safety and environmental standards, prepare of working drawings, assemble tools, equipment, materials and drawing instruments, and perform electrical installation

7.2 Summary of Learning Outcomes

1. Identify system failure
2. Troubleshoot cause of failure
3. Repair the installation
4. Test the repaired system

7.2.1 learning outcome 1: Identify System Failure

7.2.1.1 Introduction

To perform breakdown maintenance successfully, one requires the ability to obtain information about the failure from the user, refer to manuals for the system and do visual inspection to identify system failure to identify test points.

7.2.1.2 Information Sheet

Breakdown maintenance

This is a type of maintenance that involves repairing a broken down machine or system after its continued use until it completely breaks down. For example, this type of maintenance would occur if you wait until a machine stops working before fixing it. This is one of several common maintenance types.

Types of Maintenance

The different types of maintenance include:

1. **Corrective**, in which the maintenance department corrects defects that users find.
2. **Preventive**, in which a certain level of service is maintained to identify and to fix potential vulnerabilities. This is done while the machine is still working to prevent the likelihood of an unexpected breakdown. An example would be changing an HVAC filter every six months.
3. **Predictive**, in which physical variables that may indicate a problem with the equipment, such as vibration, temperature, and power consumption, are monitored. This is done to predict potential problems with the equipment. This strategy offers cost savings over time-based and routine maintenance. An example would include installing sensors in an HVAC system that would provide notification when it's time for a filter change.
4. **Zero hours maintenance**, in which equipment is analyzed, as well as scheduling intervals and replacing parts that are worn in advance of a breakdown
5. **Period maintenance**, also called time-based maintenance, consists of basic tasks that users complete, such as cleaning and lubrication.
6. **Breakdown maintenance** as described above, which is usually used for machines of low importance that may have backups in place.

Breakdown maintenance is triggered by either:

1. A planned event, such as run-to-failure maintenance.
2. An unplanned event, such as the need for reactive or corrective maintenance.
3. This type of maintenance is also used as a last-resort attempt to extend the life of equipment that has lost functional abilities. Breakdown maintenance tends to cost more than preventive maintenance.

Maintenance Models

All maintenance models described above include visual inspection and lubrication. For most types of equipment, these steps should be taken at least once a month to find potential problems early. Visual inspections are cost-effective, and applying lubricant will always cost less than fixing the problems associated with a lack of lubricant.

In addition to these common elements, components of each model are as follows:

1. **Corrective model:** Arising breakdown repair applied to the least critical equipment.
2. **Conditional model:** The corrective model plus tests to determine the next action steps, used with equipment that is unlikely to fail.
3. **Systematic model:** Includes tasks done regardless of the condition of the equipment, measurements and tests to determine potential issues, and repair of identified faults. This model is used for equipment that is moderately available and important. These tasks, however, do not need to be done on a fixed schedule.
4. **High-availability model:** Used for equipment for which failure would be catastrophic, including items with above 90 percent of availability and resultant high production costs and demand. Often, no time can be allotted to stop this machine for preventive, corrective, or systematic maintenance. For this reason, it requires predictive maintenance techniques along with an equipment shut down for a complete overhaul at least once a year. This type of model is commonly used for continuously rotating equipment, power production turbines, high-temperature furnaces, and reaction tanks or reactor deposits.

Additional Maintenance Considerations

Maintenance plans must account for both legal regulations about maintenance and specialized knowledge or resources required to perform the maintenance in question. Legal maintenance requirements typically apply to equipment that has the potential to harm people or the environment and outline specific tests, tasks, and inspections that must be included in the maintenance plan. Examples include:

1. Pressurized equipment and devices
2. High- and medium-voltage installations
3. Lifts
4. Fire prevention facilities and equipment
5. Chemical storage tanks.

Maintenance must be a competent electrician.

Breakdown Maintenance:

Breakdown maintenance is maintenance performed on a piece of equipment that has broken down, faulted, or otherwise cannot be operated. The goal of breakdown maintenance is to fix something that has malfunctioned. To the contrary, preventive maintenance is performed in order to keep something running.

Sometimes breakdown maintenance is performed because of an unplanned event. For example, if a critical piece of machinery breaks, the maintenance is performed because of the imminent need for that machine to operate again. However, breakdown maintenance can be planned for in advance, which is what we might call "good" breakdown maintenance.

Breakdown maintenance workflow

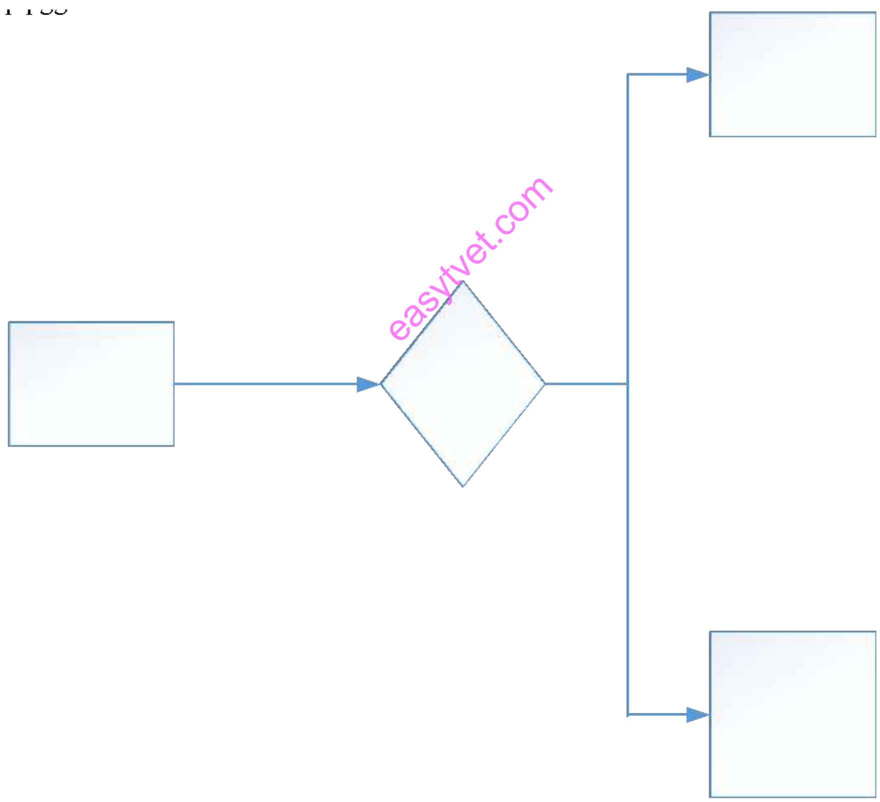


Figure 1 Breakdown maintenance flow chart

There are two types of breakdown maintenance:

1. planned and
2. Unplanned.

Planned breakdown maintenance

Planned breakdown maintenance means that the organization is prepared for a breakdown and even expects it to happen. The equipment runs until it breaks, which initiates a run to failure (RTF) trigger. While RTF triggers can be unplanned, breakdown maintenance plans use RTF as a way of lowering the cost of maintenance.

This kind of plan needs to be rigorously documented and controlled. Employees should be clear on exactly which parts will break down and which parts will be maintained normally via preventive maintenance. Without these checks, a breakdown maintenance plan can be exploited or run awry.

Unplanned breakdown maintenance

Unplanned breakdown maintenance, on the other hand, occurs when a piece of equipment fails or breaks unexpectedly—also called an unplanned downtime event. While some facilities may not utilize a planned breakdown maintenance plan, nearly every facility needs resources in place for unplanned breakdown maintenance. After all, every piece of equipment will break or fault at some point in its life.

Examples of breakdown maintenance

Breakdown maintenance is unique in its applications because it cannot be used with certain industries or products, especially ones that involve health and safety. This means that breakdown maintenance is most frequently used when parts are inexpensive or nonessential.

Here are some examples in which breakdown maintenance is applicable:

1. Equipment can't be repaired at all (inaccessible, designed to not be repaired)
2. Asset consists of inexpensive or easy-to-replace parts
3. Non-critical pieces of equipment (like hand tools)
4. Objects/equipment that are disposable or meant to be replaced at the end of their lifespan
5. Short-life assets (batteries, high flow pumps)

As you can see from these examples, breakdown maintenance becomes viable when there's no inherent safety risk to letting a part or piece of equipment break. As an example, consider a facility's light bulbs. If a light bulb is not linked to a safety feature, it doesn't make financial sense to replace it before it has burned out.

However, breakdown maintenance is absolutely not viable when people's lives can be endangered by a part or product breaking. For example, the aviation industry cannot rely on parts breaking down to fix them because doing so could threaten the personal wellbeing and safety of people on planes. This is also true for tire manufacturers who are responsible for road safety. When it comes to people's lives, preventive and predictive maintenance are the right choice.

Advantages and disadvantages of breakdown maintenance

Advantages

Failed equipment can lead to disastrous consequences, but a clearly-documented breakdown maintenance plan can actually have a few significant benefits for an organization.

1. Minimizes maintenance cost by cutting out unnecessary preventive maintenance
2. Lowers cost of replacing disposable items frequently (light bulbs, tools, fuses)
3. Downtime for repairs is consolidated
4. Low staffing needs
5. Simple and easy to understand when maintenance is required

Disadvantages

1. The downsides of breakdown maintenance are especially important to weigh given the nature of the maintenance plan. For example, breakdown maintenance should never be used with safety equipment because a single lapse can cost one or multiple employees their health or their lives.
2. Form of waste in a manufacturing environment
3. Safety issues can occur with unplanned failures
4. Can be costly depending on parts that fail
5. Requires careful planning and execution
6. Can be difficult to pinpoint source of issues

Machine checks

Various instruments are required to perform checks on machines and equipment, either when the supply is on and they are in operation, or when the supply is off and the machines are at standstill. Instruments required will include an insulation tester, continuity tester, doctor tester, feeler gauge, spring balance, and straight edges and string lines.

Instruments required for supply-off checks

Insulation tester

This is also referred to as a megger. This is an instrument which produces a d.c. output of 500 V which is sufficient test voltage for machines operating on supplies up to 650 V. Tests can be applied to check the insulation values between connections, terminal and windings connected to different poles, or between these and the exposed metalwork of the equipment. Circuit diagrams, or electrical knowledge of the plant is required to ensure that there are no connections which would lead to false values being obtained. The minimum insulation value should be around 1MΩ, although if the machine is damp, it may need drying out to obtain this figure

Continuity tester

This is a meter used to check the actual ohmic values of the windings of a machine, or resistance values of starting or speed control equipment. Again, detailed knowledge is required to ensure that there are no parallel paths when the equipment is fully connected which would lead to false low values being obtained, or is any alternative circuit is connected across (in parallel) with an open circuit winding.

Ductor tester

This is a device for the measure of very low resistance values which are not practical to read on the continuity tester that is, small fractions of an ohm, may be 0.01Ω or so. The tester circulates a heavy current and measures the millivolt (mV) drop across the resistance path. If a doctor is not available, this form of test can be carried out using a heavy current supply, such as a car battery and connecting an ammeter in series with a voltmeter across in parallel with the resistance path to be measured.

$$R = \frac{V}{I}\Omega$$

For example, if on such a test, the current in the circuit is 60A and the millivoltmeter reads 30 mV, the resistance would be 0.0005 Ω, a very difficult value to read directly on an ohmmeter. This instrument is used for the measurement of heavy current armature windings of d.c machines, the copper bars in the rotor of a squirrel-cage motor, or the joints and terminations on busbar and heavy-current cable installations.

Feeler gauges

These are sets of long, parallel blades ranging in thickness from 0.0254 mm, up to around 0.762mm. They are used for checking air gaps between the rotor and stator core of rotating machines, to give an indication of the amount of wear in the bearings. If the bearings are not worn, the readings will be the same all around the circumference. If they are worn, the gap at the top will be higher than that at the bottom. If the difference is large, new bearings will be required to prevent 'fouling' between the cores on rotation.

Note: On machines which are almost enclosed, inspection covers at 90^{o} are positioned on the 'end covers' of the motor frame to enable the air gap to be checked.

Spring balance

This is used to check the tension on contacts and on brush gear of machines and equipment. The brush is hooked to the balance, gently pulled away from the slip ring or commutator and the tension value read on the scale. It can then be compared with the manufacturer's instructions

Straight edge and string lines

These are used to check horizontal and lateral alignments.

Instruments required for supply-on checks

Voltmeter

This is a meter designed to measure voltages at the supply and at different points on the switchgear and the machines. These can be compared with the manufacturer's data or against the readings of similar machines

Approved test lamp

This is another method of testing for the presence of supply or voltage although is does not indicate the actual value.

Test lamps must be of the standard- approved type which contain the necessary safety current-limited device, such as resistors and fuses, so that in the event of a fault, there is no risk of an explosion. They are shrouded with insulation to prevent electric shock while in use.

Ammeter

This meter is used to check the value of the current in the supply conductors and in the various circuits of switchgear and machines, to compare with manufacturer's data, nameplate details, etc. Ordinary ammeter do, of course, need to have the circuit disconnected and then be connected in series. This is where the clip-on type ammeter is of advantage.

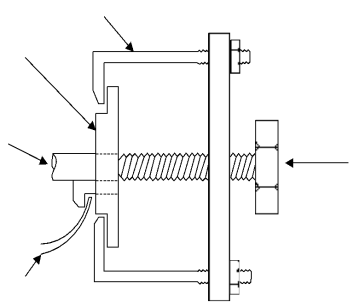
When checking current consumption of machines, in some cases the start current may be up to eight to ten times the full load value, so be sure of the ammeter range and allow the motor to run up to speed.

Multi-test instruments

Current, voltage, insulation and resistance continuity values can all be measured by one instrument which has all the necessary scales and ranges. These are selected as required by the use of a multi-position switch, or a set of outlet sockets. The instrument contains a battery to provide the current flow to measure resistance on the continuity range, plus a power-pack to step the voltage to 500V d.c. for the insulation tests. It is known as the *Electrician's Universal Meter.*

Dismantling of standard electrical machines

1. Clean excess dirt, oil, grease, etc from surfaces.
2. Depending on the weight and size of the machine, place it in a suitable position on floor stand or work bench
3. Any sign of rust on parts to be removed should be sprayed with release fluid
4. Withdraw the key from pinion coupling pulley etc. and then withdraw pinion, etc . See figure 1 for these operations.
5. Undo nuts from end cover bolts and mark the positions of covers relatives to stator frame.
6. Examine for type of bearings, it may need removal of oil rings on the sleeve type.
7. Remove end covers which will leave ball or roller type bearing on the shaft.
8. Remove rotor or armature from stator. On large machines this may heed lifting gear or two people, one at each of the shaft.
9. If the motor is fitted with a commutator or slip rings, try to leave these in position on the shaft.



Note ; when the withdrawal screw is fully tightened and there is no movement of coupling, etc. a sharp (shock) blow with hammer on the screw head will 'shock it 'and should produce movement.

Figure 2 Motor coupling pinion or pulley withdrawal tool.

These operations now leave the machine available for cleaning, inspection and maintenance. To assemble the machine reverse the above steps.

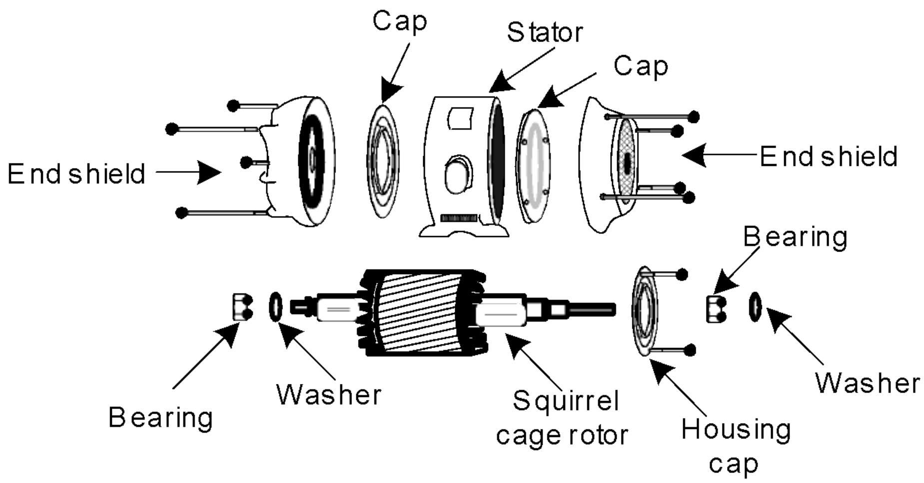


Figure 3 Parts of a disassembled motor.

Inspection of machinery and control gear

All electrical machinery and control gear should be inspected and tested at regular intervals. The frequency of the inspections will depend on the type of equipment and conditions under which it operates. A record of each inspection, together with test results should be kept for future reference.

The inspection of electrical machinery falls into two categories- mechanical and electrical.

Mechanical inspection

1. Visibly check the machine for mechanical damage
2. Check the machine for correct alignment to ensure that no undue stresses are imposed to the bearings
3. Check the air gap (where possible) with feeler gauges.
4. Check the mechanical operation of switchgear and control gear, paying particular attention to contact condition and pressure
5. If starters are fitted with dash-pots, check the grade and level of the oil
6. In the case of any oil-immersed equipment, check that the oil level is correct and the oil is clean

Electrical inspection

1. Check all connections on machinery and control gear, taking note of the condition of the wiring
2. Carry out protective conductor continuity and insulation resistance tests
3. Check fuses for correct rating and also check that any motor-overload current settings are correct
4. Run machinery, listening for knocks, strange noises, etc, and check that all equipment in the circuit is functioning correctly

D.C machines – inspection and maintenance

Owing to their more complex construction, d.c. machines require more frequent maintenance than the common types of a.c. motors. On d.c. machines, the important points to check are the running condition, yoke and field windings, brushes, brush holders, brush springs, armature assembly, bearings, shaft, connection, wiring and insulation.

Running condition

With machine running, check for excessive noise and sparking at the brushes.

Yoke and field windings

With machine isolated from the supply, check that the yoke and field windings are in good condition

Brushes and brush holders

Check that the brushes and brush holders are in good condition and the brushes move freely in their holders. Brushes worn to half their original length should be preplaced, and the new brushes properly bedded in with brush-bedding tape or fine sandpaper.

Brush springs

Check that the brush springs are in good condition that spring pressure is adequate and even on all brushes. A small spring balance may be used for this.

Armature assembly

Check that the coils are in good condition and held securely at the commutator end by their bands. Check the commutator for concentricity, irregularities and cleanliness. Dirt may be removed with a commutator brush, and fine sandpaper will remove slight roughness. Emery cloth must not be used for this purpose as it leaves a greasy film on the commutator. If the commutator is badly worn or eccentric it must be skimmed on a lathe or on a special skimming machine, after which the insulation between the segments may have to be cut back.

Bearings

Check bearings as for as possible for condition and correct lubrication.

Shaft

Check the shaft for concentricity and general condition

Connections and wiring

Check that all connections are tight and that wiring is in good condition with no signs of heat damage.

D.C machine faults

Symptoms	Tests
Starter of the d.c. motor will not hold in 'ON 'position although the motor starts correctly	1. Check that the overload trip is not stuck in the operated position and that remote 'stop' buttons; etc, are not operated 2. Test 'no-volt coil' for short or open circuit 3. In the case of series motors, or starter where the no-volt coil is not in series with a shunt winding, check the no-volts coil circuit for continuity
Excessive sparking at commutator	1. Check brush-gear for correction tension, brushes sticking in holders etc 2. Check polarity of interpoles, if fitted 3. Test the armature windings for short on open-circuits
D.C generator fails to excite	1. May be due to loss of residual magnetism; 'flash' using a suitable battery 2. Check that the rotation of the armature is in the correct direction and that field connections have not been reversed. 3. Check field and armature circuits for open or short -circuits

A.C motor faults

Symptoms	Tests
Motor completely dead	1. Check the voltage at the isolator and motor terminals
Contactor starter does not operate although supply at isolator is correct	1. Check that overload trips limit trips interlocks and remote stop buttons are not operated and that the starter controls are correctly set to the start position

	2. Test continuity of the contactor coil and its associated circuits
Fuses blow or overload trips operate when any attempts is made to start the motor	1. Check that the motor is free to rotate 2. Check that the starter is being operated correctly 3. Test insulation resistance
Single –phase motor hums but refuses to start	1. Check that the motor is free to rotate (particularly for small size motors) 2. Test continuity of main and starting windings and of the centrifugal switch or starting relay 3. Test that the supply is actually reaching the starting winding via the capacitor, if fitted.

7.2.1.3 Learning activities

Field/Visit to an established electrical workshop

Visit Objective/Aim	Indicators	Special Instruction
To establish sources failure	• Failed systems • Methods used to identify failures	• Take notes • Observe keenly methods used to identify failed system

Practical assignment

Visit Objective/Aim	Indicators	Special Instruction
To acquire skills in system failures identification	• Failed systems • Methods used to identify failures	Participate in the process

7.2.1.4 Self - Assessment

1. As an Electrical Installation Technician, what is one rule you should always follow when working on electric or electronic equipment?
   A. Power source
   B. Safety first

C. Location of equipment
D. Required tools

2. As an Electrical Installation Technician, what should you do to the power supply when working on an electrical system?
   A. Close and tag the circuit breakers and main switches
   B. Open and tag the circuit breakers
   C. Open and tag the circuit breakers and main switches
   D. Open and tag the main switches
3. What is failure of equipment?
4. What are the benefits of maintenance?
5. Which human senses that can be used during an inspection of an installation?
6. Apart from wear and tear, what are three other areas of investigation that you would consider when carrying out a periodic inspection and test of an installation?
7. Describe breakdown maintenance
8. What are the two categories of machinery inspection?

7.2.1.5 Tools, Equipment, Supplies and Materials

The following resources are provided

i. An electrical installation company
ii. A functional Safety department.
iii. Computers
iv. Stationery
v. Lecture room
vi. Workshop
vii. Projector
viii. Drawing equipment
ix. Workshop
x. Protective clothing

7.2.1.6 References

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7.2.2 learning outcome 2: Troubleshoot Cause of Failure

7.2.2.1 Introduction

To perform breakdown maintenance successfully, the technician requires the ability to conduct troubleshooting safely, record system failure results and compare parameters against standards values

7.2.2.2 Information Sheet

Trouble shooting electrical installations procedure

Types of fault

The types of faults which may occur in electrical circuit fall into four general groups

1. Open-circuit fault (loss of continuity)
2. Earth fault (flow resistance between live conductor and earthed metalwork)
3. Short circuit fault (low resistance between phase and neutral conductors)
4. High value series resistance fault (bad joint or loose connection in conducting path)

These types fault occur in lighting and power circuits, appliances, apparatus and electric motor. Before any fault can be found and rectified, it is necessary for the electrician to adopt a method or system based on a sound knowledge of circuitry and electrical theory, and on experience. The electrician detailed to repair a faulty circuit is in many ways like a doctor who makes his diagnosis on the basic of the symptoms reveled through a visual inspection or a test using the correct instruments. Haphazard tests carried out at random seldom lead to success in the quick location of faults. The investigation must always be based on an intelligent assessments of the faulty and the probable cause, judged from its effects. In many instances faults arise from installation or circuits which do not in some way or other comply with the requirements of the IEE. Regulations, or else are used in such a manner that the abuse results in a fault. Most faults are easily located by following up reports such as "there was a flash at the lamp; 'the wires got red hot '; the lamp goes dim when it is switched on' or bedroom light will come on only when the bathroom switch is ON'. By careful questioning these reports will enable the electrician to locate the fault quickly and restore the circuit to normal operation again. The following are some common installation defects and omissions which eventually lead to fault;

1. The provision of double-pole fusing on two wire systems with one pole permanently earthed. This frequently occurs with final circuit distribution boards when the main and/or sub main control equipment is single-pole and solid neutral.
2. Fuse protection not related to the current rating of cables to be protected, this is very often due to the equipment manufactures fitting the fuse-carriers with a fuse-element of maximum rating for the fuse-units in the equipment.to locate the fault
3. Connecting boxes for sheathed- wiring systems placed in inaccessible positions in roof voids and beneath floors. Indiscriminate bunching of too many cable using screw-on or inadequate connections
4. Insufficient protection provided for sheathed wiring, e.g. to switch positions and on joints in roof voids
5. Incorrect use of materials, not resistant against corrosion, in damp situations(e.g. enameled conduit and accessories and plain steel fixing screws)
6. Inadequate of complete omission of segregation between cables and/or connections, housed within a common enclosure, supplying systems for extra low voltage; or telecommunication and power and/or lighting operating at a voltage in excess of extra-low voltage.
7. Insufficient attention given in cleaning ends of conduit and/or providing, omission of bushings to prevent abrasion of cables at tapped entries, particularly at switch positions.
8. Insufficient precautions taken against the entry of water to duct and/or trucking systems, particularly where installed within the floor
9. Incorrect use of PVC insulated and/or a sheathed cables and flexible cords, instead of heat-resistant type, for connections to immersion heaters, thermal storage block heaters e.t.c.
10. Incorrect use of braided and twisted flexible cord for bathroom pendant fittings and similar situations subject to damp or condensation.
11. The incorrect use of accessories apparatus or appliances inappropriate for the operating conditions of the situation in which they are require to function. This often applies to agricultural and farm institutions.
12. Installation of cable of insufficient capacity to carry the starting current of motors, causing excessive volt drop.
13. Incorrect rating of fuse element to give protection to the cable supplying this motor.

There are many approaches in trouble shooting Electrical installations. Among them is the procedure outlined below:

Step 1: Observe

Through careful observation and a little bit of reasoning, most faults can be identified as to the actual component with very little testing. When observing malfunctioning equipment, look for visual signs of mechanical damage such as indications of impact, chafed wires or loose components. Don't forget to use your other senses when inspecting equipment e.g. smell, listening, check temperature, etc.

Step 2: Define problem area

Determine the problem area of the malfunctioning equipment. Often times when equipment malfunctions, certain parts of the equipment will work properly while others not. The key is to use your observations (from step 1) to rule out parts of the equipment or circuitry that are operating properly.

Step 3: Identify possible causes

Once the problem area(s) have been defined, it is necessary to identify all the possible causes of the malfunction. It is necessary to list (actually write down) every fault which could cause the problem no matter how remote the possibility of it occurring.

Step 4: Determine most probable cause

Once the list of possible causes has been made, it is then necessary to prioritize each item as to the probability of the cause of the problem.

Step 5: Test and repair

Make sure you follow all your companies' safety precautions, rules and procedures while troubleshooting as faulty equipment may be hazardous. Once you have determined the most probable cause, you must either prove it to be the problem or rule it out.

Fault finding

The location and nature of a fault in an electrical system can usually be quickly determined by systematic tests. The tests to be carried out depends upon the symptoms of the fault. As an example, if a motor shows no sign of life at all, it is advisable to check the supply first.

Most of the tests can be carried out using;

i. Voltage indicator, test lamp, or voltmeter for checking the supply
ii. Continuity tester.
iii. Insulation tester.

Faults in Electrical Appliances

Electrical appliances are electrical machines or equipment which perform household functions

Electric Iron

The electric iron has the following parts:

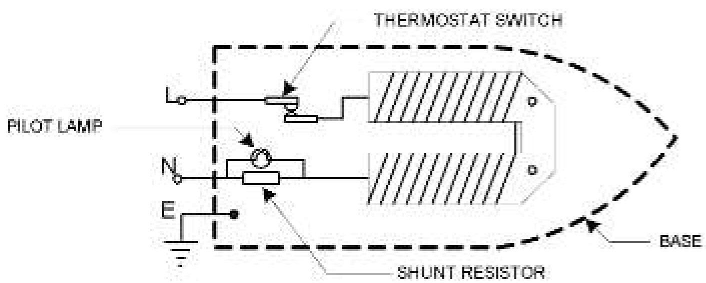

Figure 4 Parts of Iron box

Thermostatic switch

This controls the temperature of the iron by switching it ON and OFF as determined by the setting

Non-inductive coil

It consists of a wire wound in tape form on a mica former. It is insulated with mica and placed on the base plate. The winding is such that no magnetic field is created when the iron is ON. The coil heats up the base plate that is used for ironing

Pilot light

This is used to indicate when the iron is heating. It comes ON when the iron is heating

Common electrical problems in the house

S/N	Problem	Probable cause
1	Loose top plug	i. Defects in manufacture ii. Overheating inside
2	Broken light switch	i. Mechanical blow ii. Defects in manufacture

3	Simple short circuit	i. Breakdown in insulation ii. Poor workmanship
4	Cut or damaged extension cord	i. Mishandling ii. Manufacturers defects
5	Flickering or dimming lights	i. This could be a sign of a poor connection and can lead to eventual arcing ii. Loose/corroded connections making intermittent contact that could result in sparking, overheating, and fire.
6	Light bulbs burn out frequently	You may have a loose connection in the socket or circuit or worn out insulation causing overheating.
7	Dead socket outlets	i. Dead socket outlets can result from a tripped poor connection (and possible arcing) ii. A tripped breaker due to excessive heat buildup resulting in melted wires or outlets.

Common Faults in an Electric Iron

S/N	Fault	Probable causes
1	Iron does not heat up when connected to electrical power	i. Blown fuse ii. Broken conductor iii. Damaged thermostat iv. Broken coil v. Broken shunt resistor
2	Sole plate gives shock when touched	Loose earth connection
3	Pilot light is OFF but iron operates normally	Burnt bulb
4	Iron stuck ON (overheats), no temperature control.	Thermostat stuck ON

Electric Cooker

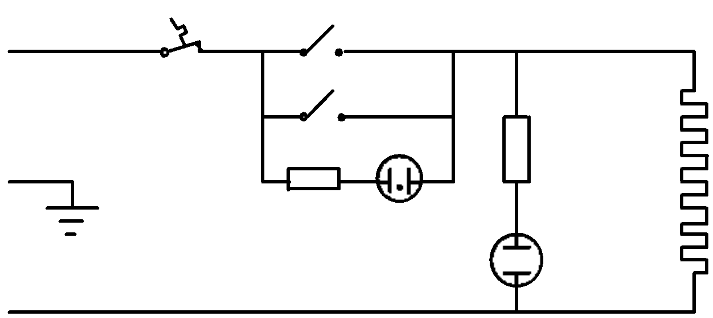

Figure 5. Circuit Diagram of an Electric Cooker

Electric oven

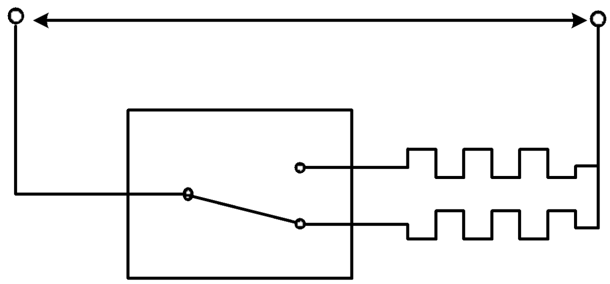

Figure 6. Circuit Diagram of Electric Oven

Common faults in an Electric Cooker and Electric oven

S/N	Fault	Probable causes
1	Coil does not heat up	1. Burnt/broken coil 2. Faulty thermostat 3. Broken cables
2	Temperature control not possible	Thermostat stuck or closed
3	Base plate gives shock	Live wire touching base plate and loose/ broken earth wire

Electric Kettle

An electric kettle has a coil and thermostat as the main components.

Common faults in an Electric Kettle

S/N	Fault	Probable causes
1	Coil does not heat up	1. Burnt/broken coil 2. Faulty thermostat 3. Broken cables
2	Temperature control not possible	Thermostat stuck or closed
3	Kettle gives shock	Live wire touching kettle and loose/ broken earth wire

Motor operated appliances

Many domestic appliances use electric motors for operation. They include:

1. Hand drill
2. Food mixers
3. Fruit blenders
4. Hair driers
5. Refrigerators
6. Air conditioners
7. Washing machines
8. Air fans
9. Vacuum cleaners

The most common motor used is the A.C. series motor (universal motor). This motor runs on both AC and DC.

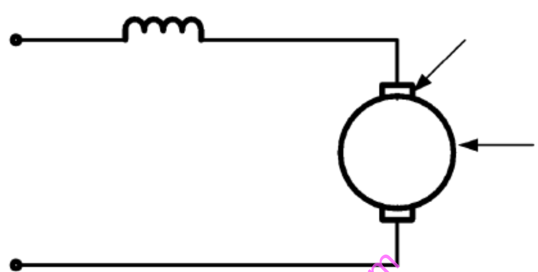

Figure 7. Circuit diagram of Universal motor

Common Faults in Electric Motors

S/N	Fault	Probable causes
1.	Excessive vibration	Uneven foundations defective rotor unbalance
2.	Frame heating	1. Excessive load, foreign matter in the air gap or cooling circuit, excessive ambient temperature. 2. Partial short circuit in windings
3.	Motor is dead	1. Broken wires 2. Blown fuse 3. Field open 4. Brushes disconnected
4.	Heating of bearings	1. Too much grease. 2. Too little grease 3. Incorrect assembly. 4. Bearing overloaded
5	Brushes heating	1. Excessive load 2. Brushes not bedding or sticking in holders 3. Incorrect grade of brushes
6.	No rotation	1. Supply failure (either single phase or complete loss of power) 2. Inefficient torque 3. Reversed phase

7.	Steady electrical hum	1. Running single phase excessive load 2. Reversed phase 3. Uneven airgap
8.	Mechanical noise	1. Foreign matter in airgap or damaged bearings. 2. Misaligned coupling
9.	Pulsating electrical hum	1. Defective rotor 2. Defective wound rotor. Loose connection, partial short circuit e.t.c

Phase Tester

Is used to identify or test a live conductor or the presence or voltage in a circuit

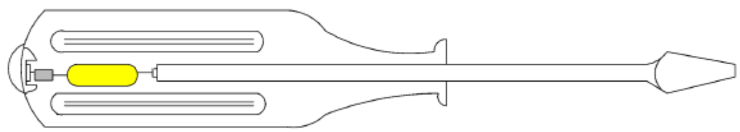

Figure 8. Phase Tester

Ohmmeter

The ohmmeter is used to determine continuity in a circuit. It establishes the whether a conductor is broken or continuous. The circuit must not have power when continuity is being determined by an ohmmeter.

Insulation Resistance Tester

Insulation resistance tester is used to measure the resistance between conductors and resistance is the insulation.

General Procedure for Repair

1. *Carry out visual inspection.*

   The appliance is physically inspected for any breakage or damage or burns. Correct the defect and test to see if the appliance is in good order.

2. *Carry out continuity test and insulation resistance test.*

   Use a circuit diagram to carry out continuity test. If a fault is detected move to step 3.

3. *Dismantle the appliance*

   As you dismantle mark the parts that go together for easier assembly. Clean the parts and trace where the fault is occurred by carrying out electrical measurements.

4. *Repair the appliance*

   Once the fault has been identified, replace or repair the faulty component.

5. *Assemble the appliance*

Assemble the appliance to its original form. Follow the reverse process of dismantling.

6. *Test the appliance*

   Carry out the physical tests to ensure the joints are firm and that there are no loose conductors that can cause short circuit.

Carry out electrical tests to ensure to ensure continuity and good insulation resistance.

Connect the appliance to power to test its working.

7.2.1.5 Learning activities

Field/Visit to an established electrical workshop

Visit Objective/Aim	Indicators	Special Instruction
To establish techniques used in troubleshooting	• Failed systems • Readings	• Take notes • Observe keenly techniques used in troubleshooting

Practical assignment

Visit Objective/Aim	Indicators	Special Instruction
To acquire skills in electrical equipment troubleshooting	• Failed systems • Instruments	Participate in the process

7.2.2.4 Self - Assessment

1. What types of common faults interrupt power through a circuit?
   A. Intact wiring, loose terminals, faulty relays, and faulty switches
   B. Broken wiring, loose terminals, faulty relays, and faulty switches
   C. Broken wiring, tight terminals, faulty relays, and faulty switches
   D. Intact wiring, tight terminals, faulty relays, and faulty switches
2. A piece of equipment must be tested after being repaired, what is the purpose of testing it?
   A. Ensure technician skills are adequate
   B. Ensure future maintenance will not be required
   C. Ensure operators can properly operate equipment

D. Ensure system works properly

3. An electrical circuit needs to be tested for voltage, how would you connect a digital multimeter to that circuit?
   A. Connect in series
   B. Connect in parallel
   C. Connect in parallel-series
   D. Connect in phase
4. As an Electrical Installation Technician, what test do you perform to find an open circuit?
   A. Continuity test
   B. Resistance test
   C. Voltage check
   D. Ohm test
5. As an Electrical Installation Technician, what are the **two** important things to do when faced with equipment which is not functioning properly?
6. During troubleshooting of electrical equipment, what are some of the safety tips to be observed?
7. Explain the following terms used in fault diagnosis.
   i. Replacement time
   ii. Checkout time
8. Outline the general procedure for repair

7.2.2.5 Tools, Equipment, Supplies and Materials

The following resources are provided

i. An electrical installation company
ii. A functional Safety department.
iii. Computers
iv. Stationery
v. Lecture room
vi. Workshop
vii. Projector
viii. Drawing equipment
ix. Workshop

x. Protective clothing

7.2.2.6 References

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7.2.3 learning outcome 3: Prepare List of Tools, Equipment & Materials

7.2.3.1 Introduction

To perform breakdown maintenance successfully, one requires the ability to Identify maintenance tools, equipment and materials while observing safety, check tools, equipment and materials specifications and functionality in accordance with established standards and calibrate equipment as per manufacturer's specifications

7.2.3.2 Information Sheet

Meaning of terms

Repair

This is the restoration of a damaged or broken machine /system to a good working condition.

Replacement

This is the physical replacement of a damaged or broken machine/ system with a working one.

Electrical Installation Tools, Equipment and their use

Hammers

These are tools used in driving or pounding out nails they are made of hard steel, wood, plastic or rubber.

Bending spring

This is a tool used for bending PVC conduits

Stock and die

This is a tool used for making threads on metallic conduits

Side cutter

This is a tool used for medium and big cables.

Combination Pliers

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

Screw driver

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

Long nose pliers

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

Wire stripper

A tool used for removing insulation from insulated cables.

Hacksaw

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

Measuring tools

To measure wire length and other items, the electrician finds considerable use for measuring tools such as the extension or zigzag rule, push-pull rule and a steel tape

Soldering equipment

In doing electric wiring, splices and taps (connections made to wire) should be soldered, unless you use solderless connectors.

Drilling equipment

Drilling equipment is needed to make holes in building structure passages of conduit sand wires

Ladders

The term ladder is generally taken to include step ladders and trestles. The use of ladders for working above ground level is only acceptable for access and work of short duration. It is advisable to inspect the ladder before climbing it. It should be straight and firm. All rungs and tie rods should be in position and there should be no cracks in the stiles. The ladder should not be painted since the paint may be hiding defects. Extension ladders should be erected in the closed position and extended one section at a time. Each section should overlap by at least the number of rungs indicated below:

1. Ladder up to 4.8 m length – 2 rungs overlap
2. Ladder up to 6.0 m length – 3 rungs overlap
3. Ladder over 6.0 m length – 4 rungs overlap

Draw wire/Fish tape

This is a tool used for drawing cables in conduits

Electrical instrument checking and calibration

A digital Multimeter is used to measure voltage, current and resistance and can be used to measure electrical continuity in a circuit. There are two types of Multimeter: digital and analogue. Multimeter should be calibrated or adjusted to a known zero-value prior to use for accurate readings.

Calibration of Multimeter

Electrical calibration refers to the process of verifying the performance of, or adjusting, any instrument that measures or tests electrical parameters to maintain their accuracy. Electrical calibration involves the use of precise devices that evaluate the performance of key properties for other devices called units under test (UUTs).

Equipment that are not calibrated can result in the wrong decision being made which has the potential for further damage to what the instrument was to be used for.

The fragile electronics within Multimeter are protected by a hard casing, which means they can usually be stored in a toolbox.

Multimeter do not require any deep cleaning - just wipe them down with a damp (not wet) cloth, every now and then. Ensure your devices are fully functioning before each use. Change batteries and fuses when necessary and consider removing the batteries if the meter will not be used for an extended period of time.

Many people do a field comparison check of two meters, and call them "calibrated" if they give the same reading. This isn't calibration. It's simply a field check. It can show you if there's a problem, but it can't show you which meter is right. If both meters are out of calibration by the same amount and in the same direction, it won't show you anything. Calibration typically requires a standard that has at least 10 times the accuracy of the instrument under test.

Calibration, in its purest sense, is the comparison of an instrument to a known standard.

Two instruments, A and B, measure 100 V within 1 %. At 480 V, both are within tolerance. At 100 V input, A reads 99.1 V and B reads 100.9 V. But if you use B as your standard, A will appear to be out of tolerance. However, if B is accurate to 0.1 %, then the most B will read at 100

V is 100.1 V. Now if you compare A to B, A is in tolerance. You can also see that A is at the low end of the tolerance range. Modifying A to bring that reading up will presumably keep A from giving a false reading as it experiences normal drift between calibrations.

Why Multimeter is calibrated

A digital Multimeter is one of the most commonly used pieces of test and measurement instrumentation. Quality processes depend on its continual proper operation. However, time, environment, and physical use (or abuses) change a digital multimeter's characteristics. That's why it's important to periodically calibrate or verify the performance of a digital multimeter.

A multimeter should be calibrated or adjusted to a known zero-value prior to use for accurate readings.

How to calibrate a digital multimeter

1. Set the multimeter to the highest resistance range by turning the dial to the highest "ohm" setting.
2. Touch the test probes of your digital multimeter together.
3. Press the calibration knob until the display reads "0" on the digital multimeter if you don't see "0 ohms" initially.

Calibration may be required for the following reasons:

a) a new instrument
b) after an instrument has been repaired or modified
c) when a specified time period has elapsed
d) when a specified usage (operating hours) has elapsed
e) before and/or after a critical measurement
f) after an event, for example:
   i. after an instrument has been exposed to a shock, vibration, or physical damage, which might potentially have compromised the integrity of its calibration
   ii. sudden changes in weather

g) whenever observations appear questionable or instrument indications do not match the output of surrogate instruments
h) As specified by a requirement, e.g., customer specification, instrument manufacturer recommendation.

How to take care of your tools

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

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

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

Basic maintenance of electric tools

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

a) **Clean out the dust:** To make sure that your electric tools are ready for use, keep them clean and free of dust. The housing intake on your electric tools and the exhaust are especially important areas to keep clean. Take some time to clean out the dust every once in a while on your tools while they are sitting in storage.
b) **Check the cords:** Look for wear and tear on the power cords on your electric tools. There can be damage to the insulation and you should keep an eye out for loose wires. This will ensure that your electric tool can get the power that it needs to function without an accident. Wipe the cords down to keep them from becoming damaged from oil and

grease. The prongs on the cords should be examined as well. Make sure that the casing is intact and the prongs are not loose.

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

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

7.2.3.3 Learning activities

Field/Visit to an established electrical workshop

Visit Objective/Aim	Indicators	Special Instruction
To establish tools, equipment and materials preparation techniques	i. Tools ii. Equipment iii. Materials	i. Take notes ii. Keenly observe tools handling iii. Keenly observe tools storage

Practical assignment

Visit Objective/Aim	Indicators	Special Instruction
To acquire skills in tools, equipment and materials preparation techniques	i. Tools ii. Equipment iii. Materials	i. Participate in the process ii. Handle tools properly iii. Store tools properly

4. 7elf - Assessment

1. As an Electrical Installation Technician, what test do you perform to find an open circuit?
   - A. Resistance test
   - B. Continuity test
   - C. Voltage check
   - D. Ohm test
2. One of the following is the most accurate instrument used for testing insulation resistance, which one is it?
   - A. Growler

B. Megohmmeter
C. Ohmmeter
D. Tachometer

3. List any four tools used in break down maintenance
4. Describe safe the usage of ladder during maintenance of an electrical system
5. Explain the basic maintenance procedure of electric tools
6. Explain why a multimeter is calibrated
7. Why is calibration required?

7.2.3.5 Tools, Equipment, Supplies and Materials

The following resources are provided

i. An electrical installation company
ii. A functional Safety department.
iii. Computers
iv. Stationery
v. Lecture room
vi. Workshop
vii. Projector
viii. Drawing equipment
ix. Workshop
x. Protective clothing

7.2.3.6 References

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7.2.4 leaning outcome 4: Repair the Installation

7.2.4.1 Introduction

To repair the system successfully, one requires the ability to observe safety precautions are as per OSHA, repair system in accordance with maintenance manual, use tools and equipment for repair and record repair activities according to the established procedure.

7.2.4.2 Information Sheet

Remedy of common faults in an installation

S/N	Problem	Probable cause	Action to be taken
1	Loose top plug	i. Defects in manufacture ii. Overheating inside	Turn off the breaker. Double check for voltage to the outlet
2	Broken light switch	i. Mechanical blow ii. Defects in manufacture	Turn off the circuit breaker then use a flathead screwdriver to remove the faceplate. Test the two wires connected to the screw for electricity.
3	Simple short circuit	i. Breakdown in insulation ii. Poor workmanship	Reset the breaker. Repeated occurrences with the same appliance indicate it's the appliance – not the electrical system.
4	Cut or damaged extension cord	i. Mishandling ii. Manufacturers defects	Unplug both ends. Cut off the old plug. Gently score and peel back the insulation jacket, twist them and crew them into the back of the plug. Then close the plug and secure the wires.
5	Flickering or dimming lights	i. This could be a sign of a poor connection and can lead to eventual arcing ii. Loose/corroded connections making intermittent contact that could result in sparking, overheating, and fire.	Put off the light and troubleshoot the problem

6	Light bulbs burn out frequently	You may have a loose connection in the socket or circuit or worn out insulation causing overheating.	Open the lamp holder and identify the problem then fix it
7	Dead socket outlets	i. Dead socket outlets can result from a tripped poor connection (and possible arcing) ii. A tripped breaker due to excessive heat buildup resulting in melted wires or outlets.	i. Replace the damaged socket outlet ii. Carry out rewiring if the cables are damaged

Remedy of Faults in an Electric iron

S/N	Fault	Probable causes	Remedy
1	Iron does not heat up when connected to electrical power	i. Blown fuse ii. Broken conductor iii. Damaged thermostat iv. Broken coil v. Broken shunt resistor	i. Replace fuse with the correct size ii. Repair or replace broken conductor iii. Damaged thermostat iv. Replace coil v. Replace broken shunt resistor
2	Sole plate gives shock when touched	Loose earth connection	Tighten earth connection
3	Pilot light is OFF but iron operates normally	Burnt bulb	Replace bulb
4	Iron stuck ON (overheats) - no temperature control.	Thermostat stuck ON	Replace or repair thermostat

Remedy of Faults in Electric cooker and electric oven

S/N	Fault	Probable causes	Remedy
1	Coil does not heat up	i. Burnt/broken coil ii. Faulty thermostat iii. Broken cables	Replace coil Replace thermostat Replace cables
2	Temperature control not possible	Thermostat stuck closed	Service/replace thermostat

3	Base plate gives shock	Live wire touching base plate and loose/ broken earth wire	Check wire and rectify the fault

Remedy of Faults in Electric kettle

S/N	Fault	Probable causes	Remedy
1	Coil does not heat up	i. Burnt/broken coil ii. Faulty thermostat iii. Broken cables	Replace coil Replace thermostat Replace cables
2	Temperature control not possible	Thermostat stuck closed	Service/replace thermostat
3	Kettle gives shock	Live wire touching kettle and loose/ broken earth wire	Check wire and rectify the fault

Remedy of Faults in Electric motors

S/N	Fault	Probable causes	Remedy
1.	Excessive vibration	Uneven foundations defective rotor unbalance	Check level and alignment of base and realign uncouple from driven machine, remove motor pulley or coupling. Run motor between each of these operations to determine whether the unbalance is in the driven machine, pulley or rotor. Rebalance
2.	Frame heating	Excessive load, foreign matter in the air gap or cooling circuit, excessive ambient temperature. Partial short circuit in windings	i. Check airgap, dismantle motor and clean. ii. Check windings with suitable meter. Repair if defective or return to manufacturer.
3.	Motor is dead	i. Broken wires ii. Blown fuse iii. Field open iv. Brushes disconnected	
		i. Too much grease. ii. Too little grease iii. Incorrect assembly. iv. Bearing overloaded	i. Remove surplus grease. ii. Wash bearings. iii. Assemble squarely on shaft

4.	Heating of bearings		iv. This may be due to misalignment of the drive, excessive end thrust imposed on motor or too much belt tension. Take appropriate steps to reduce the load on bearing.
5	Brushes heating	i. Excessive load ii. Brushes not bedding or sticking in holders iii. Incorrect grade of brushes	i. Reduce load ii. Carefully rebend or clean brushes and adjust pressure iii. Ensure brushes used are those specified by the motor manufacturer
6.	No rotation	i. Supply failure (either single phase or complete loss of power) ii. Inefficient torque iii. Reversed phase	i. Disconnect motor immediately with a single-phase fault serious overloading and burnout may rapidly occur. Ensure correct supply is restored to motor terminals. ii. Check starting torque required and compare with motor rating, taking into account type of starter in use. Change to larger motor or to different type of starter. iii. Check and correct connections in turn
7.	Steady electrical hum	i. Running single phase excessive load ii. Reversed phase iii. Uneven airgap	i. Check if all supply lines are live with balanced voltage. Compare line current with that given on motor name plate. Reduce load or change to larger motor. ii. Check and correct connections in turn iii. Check airgap with feelers. If because of worn bearings, fit new ones
8.	Mechanical noise	i. Foreign matter in airgap or damaged bearings. ii. Misaligned coupling	i. Check airgap, dismantle rotor and clean, check with a listening stick. If confirmed, try rotating outer face of bearing 180°. If still unsatisfactory fit new bearing. ii. Check coupling gap and realign
		i. Defective rotor ii. Defective wound rotor. Loose connection, partial short circuit e.t.c	i. Check speed at full load. If it is low and if there is a periodic swing of current when running, a defective rotor is indicated and the matter should be referred to the manufacturer.

9.	Pulsating electrical hum		ii. Checks should be made on a wound rotor machine for rotor resistance and open circuit voltage between slip-rings.

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Remedy of Faults in Fluorescent lamps

		Faulty lamp					Faulty starter					Faulty choke				Faulty p.f capacitor					Faulty wiring or circuit						
	If trouble is encountered, first look below for symptoms	Air leak or cracked tube	Broken electrode or lamp cap	Mercury deficient	Low emission	Life expired	Contacts stuck together	Air leak or open circuit fault	Short-circuited suppressor	Internal fault	Incorrect type	Open-circuited winding	Earth fault	Short-circuited turns	Wrong type or tapping	Open circuits	Earth fault	Short circuit	Wrong capacitance	Fault discharge resistor	Short –circuited lampholder	Component wrongly connected	Loose connection	Earth wiring	Crossed wiring in two-lamp units	Wrong supply voltage	No supply or fuse blown
A	lamp does not attempt to start; no glow from ends	x	0			x		x		x	x	x	x									X	X	X			0
B	Lamp flashes on and off				x	0				X	X				X						X	X			x	x	
C	Lamp ends glow steadily but lamp does not start						0		0	0	x											X		x			

D	Faint glow at one end of lamp		x																				x				
E	Lamp lights but is dim			X		x									x												
F	Lamp takes excessive time to start				x	X				X	x				x						x		x	x		x	
G	Premature end-blackening of lamp										x			x	x						X	X		X	X	x	
H	Choke overheats												X	X	X							X		X		x	
I	Supply fuse blown or lamp electrodes fused												X	X			X	X		X		X		x			
J	Low power factor															X			X							x	
K	Excessive radio interference					o				x												X	x				
When possible faults has been located, make these tests to find which component is faulty		LAMP Check lamp in good circuit and if proved faulty replace with a new lamp; see note below					STARTER Check operation of starter in good circuit and if found faulty, fit new replacement.					CHOKE Check insulation resistance, continuity and, if possible, impedance. Make sure tapping and rating are correct				CAPACITOR Check, is possible ,insulation resistance and capacitance, measure value of discharge resistor					CIRCUIT Check circuit against wiring diagram, examine all connections and terminal. Check fuses supply voltage and, if possible, insulation resistance of complete fitting.						

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7.2.4.3 Learning activities

Field/Visit to an established electrical workshop

Visit Objective/Aim	Indicators	Special Instruction
To establish techniques used in repair of electrical installation	i. Failed systems ii. Tools	• Take notes • Observe keenly techniques used in repair of electrical installation,

Practical assignment

Visit Objective/Aim	Indicators	Special Instruction
To acquire skills in electrical installation repair	i. Failed systems ii. Tools	Participate in the process

7.2.4.4 Self - Assessment

1. As an Electrical Installation Technician, what are the two basic rules you should follow when working with hand tools?
   A. Use the proper tool and ensure it is properly checked out from tool issue
   B. Ensure it is properly checked out from tool issue
   C. Use the proper tool and keep it in working order
   D. Ensure it is properly checked out from tool issue and is the proper tool
2. One of the following steps will make your troubleshooting easier, which one is it?
   A. Review system operation, analyze symptoms, detect and isolate trouble
   B. Review system operation, clean and inspect, detect and isolate trouble
   C. Review system operation, analyze symptom, and perform clean/inspect
   D. Analyze symptoms, clean and inspect, detect and isolate the problem

3. What types of common faults interrupt power through a circuit?
   A. Intact wiring, loose terminals, faulty relays, and faulty switches
   B. Broken wiring, loose terminals, faulty relays, and faulty switches
   C. Broken wiring, tight terminals, faulty relays, and faulty switches
   D. Intact wiring, tight terminals, faulty relays, and faulty switches
4. A piece of equipment must be tested after being repaired, what is the purpose of testing it?
   A. Ensure technician skills are adequate
   B. Ensure future maintenance will not be required
   C. Ensure operators can properly operate equipment
   D. Ensure system works properly

5. State possible remedy for the following faults in an electrical installation
    (a) Dead socket outlets
    (b) Flickering or dimming lights
    (c) Light bulbs burn out frequently

7.2.4.5 Tools, Equipment, Supplies and Materials

The following resources are provided

i. An electrical installation company
ii. A functional Safety department.
iii. Computers
iv. Stationery
v. Lecture room
vi. Workshop
vii. Projector
viii. Drawing equipment
ix. Workshop
x. Protective clothing

7.2.4.6 References

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7.2.5 Learning Outcome 5: Test the Repaired System

7.2.5.1 Introduction

To test repaired system successfully, one requires the ability to identify test points as per established standards, perform tests while observing safety rules and as per established procedure, record test results, compare parameters against standard values and prepare maintenance report according to approved format

7.2.5.2 Information Sheet

Visual inspection

The purpose of inspection is to ensure that all that was specified or intended in the design is in the right place and functioning. Visual inspection will involve;

1. Checking workmanship-that the installation is neat
2. Checking whether cable sizes with proper colour code are used
3. Checking whether proper models and rating of components are used.

Purpose of Testing a repaired Installation

The reason for testing an installation is to detect faults before dangerous situations arise.

Factors which the installation must be protected against are:-

i. Earth leakage and danger of electric shock
ii. Excess current
iii. Moisture and corrosion

The main tests to be carried out on a complete electrical installation are:-

1. Verification of polarity test
2. Effectiveness of earthing test
3. Ring circuit continuity test
4. Insulation resistance test
5. Earth fault loop impedance test

The tests should be carried out on:

a) New installations
b) Additions to existing installations
c) Existing installations periodically

Verification of Polarity Test

The purpose of this test is to check the phase conductor is taken through the fuse and switch to the appliance the reason for this test is to ensure that the neutral wire is earthed at the supply authority's substation.

The Neutral must never be broken by a fuse or switch.

Preparation for the test

1. Supply OFF
2. Lamps and appliances OUT
3. All switches OFF
4. Neutral links IN
5. Fuses OUT

Instrument used: Ohmmeter or Bell set

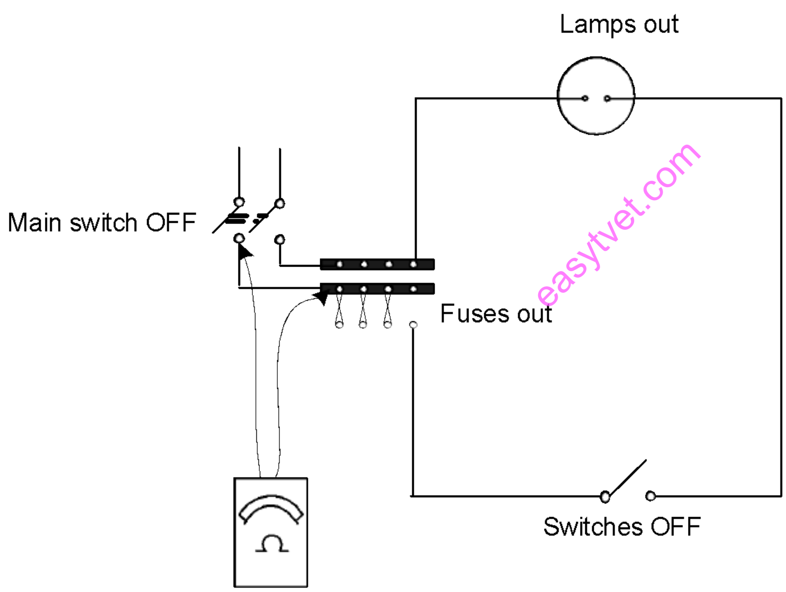

Figure 9 Verification of polarity test

Reading: Zero Ohms on Ohmmeter

NB – This test should not be carried out on a LIVE installation.

Effectiveness of earthing tests

The purpose of this test is:-

i. To measure the resistance of the earth continuity conductor.
ii. To check that the earth continuity heavy leakage currents.
iii. To ensure that the earth electrode is effectively connected to the general mass of earth.

Earth Continuity

Earth continuity is making sure that should there be an electrical fault, all exposed metalwork in a building is bonded together and connected to the earth block in the consumer unit, leaking the current to earth and automatically disconnecting the supply. An earth continuity test will verify that exposed metalwork in a building is bonded together and connected to the earthing block in the consumer unit.

The ohmmeter leads are connected between the points being tested, between simultaneously accessible conductive parts e.g. pipe works, sinks etc. This test will verify that the conductor is sound.

Earth fault loop test

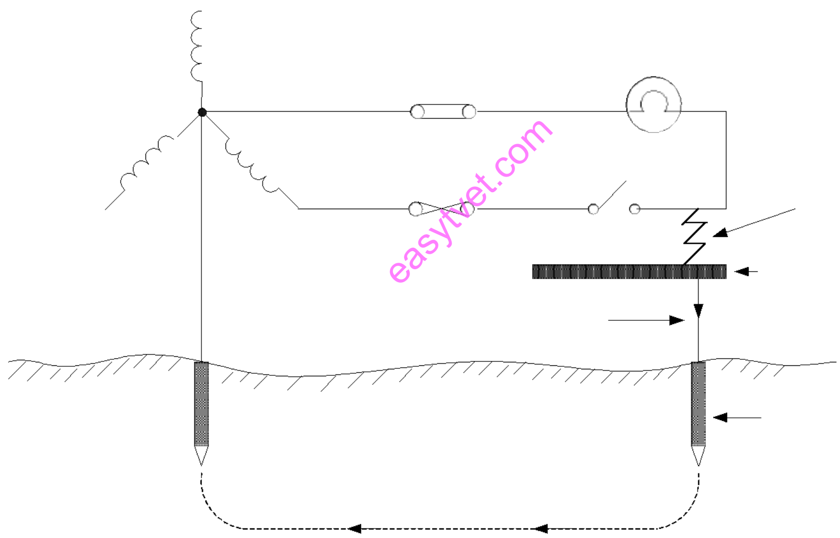

Figure 10 Earth fault loop test

The earth fault loop is the path which the leakage current will take back to the supply transformer when there is an earth leakage in an installation. The path is as shown below.

The test must be carried out on a new or largely modified installations where earth-leakage protection relies on the operation of fuses or excess current circuit – breakers.

1. The leakage current flows from the faulty conductor into the earth continuity conductor.
2. It then flows along the earth continuity conductor to the earthing lead.
3. The earthing lead carries the current to the earth electrode.

4. The leakage current now takes the shortest path back to the earthed neutral of the supply transformer.

The purpose of this test is to show that the earth fault loop is capable of carrying heavy leakage currents so that the protective gear (e.g. fuses) will operate when leakages occur between the line conductor and the earthed metalwork of the installation.

Apparatus: Line-earth loop tester (Megger).

Method

The Line-earth loop tester, operating on fall mains voltage, passes a short duration current of approximately 20A from the line conductor, through the consumer's earth continuity conductor and the earth return path to the neutral of the supply transformer. This instrument measures the value of the loop in Ohms.

Readings

The minimum permissible reading depends on the operating conditions but the two main factors are:-

Operating current of fuse or circuit breaker protecting circuit.

Supply voltage.

Example

If the circuit fuse operated at 50A and the supply voltage is 240V then the resistance of the earth fault loop must not be more than $\frac{240\,V}{60\,A} = 4\Omega$. If the resistance is higher than this value the fuse will not open under serious fault conditions.

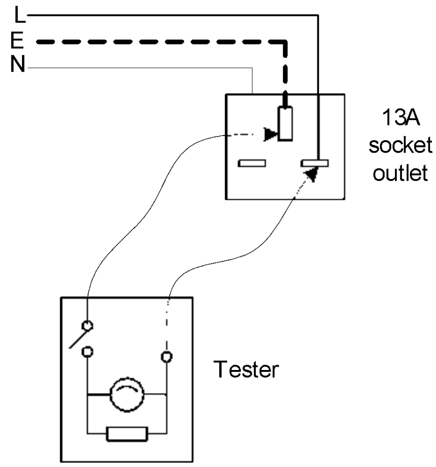

Figure 11 Circuit of megger line-earth loop tester

Factors determining resistance of earth fault loop are as follows.

1. The continuity of the metallic circuit up to the earth electrode (the earth continuity conductor and the earthing lead).
2. The resistance of the body of earth surrounding the earth electrode.

Earthing Lead – The minimum size of copper earthing lead is $1mm^2$. The earthing lead connecting an earth–leakage circuit-breaker to an earth electrode need not exceed $2.5mm^2$. The earthing lead should be protected against mechanical damage and corrosion and the clamp used for connecting the earth lead to the earth electrode should be non-ferrous and should be accessible for inspection.

The resistance area is the name given to the resistance of the body of earth surrounding the earth electrode.

The resistance area is measured using

1. An alternating current (at a maximum pressure of 40V) is connected between the main earth electrode A and an auxiliary electrode B, placed about 30m from A. An ammeter is placed in series with the supply to measure the current through the circuit.
2. A second auxiliary electrode C is placed between A and B and the voltage (potential difference) is measured between A and C. the resistance of the resistance area is found by taking various readings from point A towards point B. Outside the resistance area the resistance is constant .

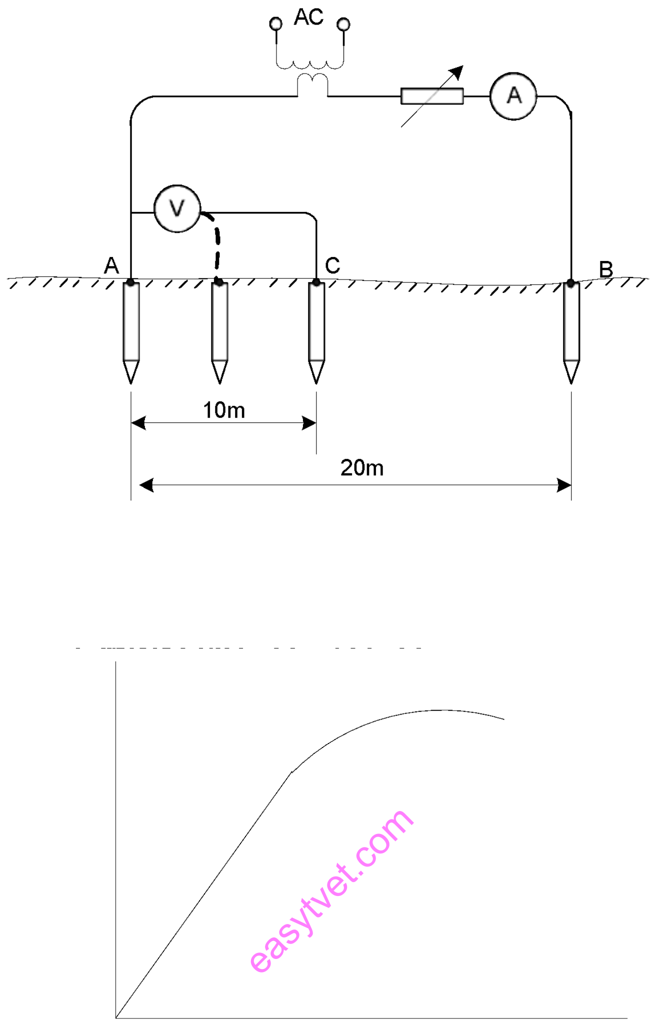

Figure 12 Resistance area measurement

$$R = \frac{Voltage\ between\ \ A\ and\ C}{Current}$$

Insulation Tests

The purpose of the insulation resistance test is to make sure that there is no possibility of leakage currents flowing between insulated conductors and also to make sure that there is no leakage of current between the conductors of the installation and ‘the general mass of earth.

Earth Insulation Resistance Test

The purpose of the earth insulation resistance test is to detect whether there is existence of possible leakages to earth and locate the actual leakage.

Preparation for the test:

The following should be observed.

a) Supply OFF
b) Fuses IN; neutral links IN
c) All switches ON
d) All lamps IN
e) Connect all poles together

Test Instrument

The instrument used for insulation resistance testing is a hand-driven d.c. generator which should be capable of supplying a d.c. voltage more than twice the voltage normally supplied to the circuit. The voltage need not exceed 500V for low-voltage circuits (low-voltage range: 50V to 1000V). The test should be carried out at the nearest possible point to the supply authority's equipment.

Method

1. Connect one wire of insulation tester to earthed metalwork (case of main switch, trunking, and conduit).
2. Connect other wire to phase (or phases) and neutral in turn

Reading

The accepted reading will depend upon the size of the installation but should not be less than one megohm. An outlet, in this instance, includes points and switches but a switch combined with a socket outlet, appliance, or light fitting, is regarded as one outlet. These are the readings when an installation is complete.

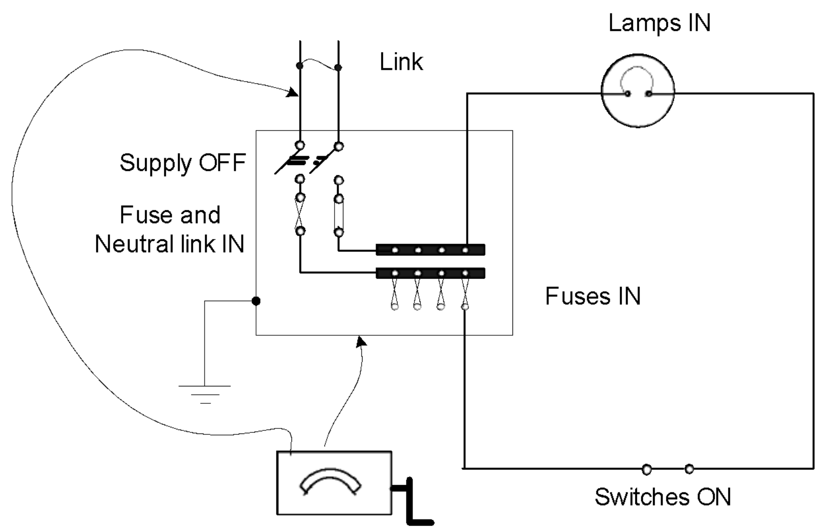

Figure 13 Insulation resistance test.

If the reading obtained is less than the minimum allowed, then the installation must be sub-divided to isolate the faulty circuit.

Between Poles Test

The purpose of the between poles test is to make sure that there are no short circuit or low-resistance connections between the 'live' conductors in the installation.

Preparations for Test

1. Supply OFF
2. Lamps OUT; appliances OFF
3. All switches ON; all fuses and neutral links IN

Test Instrument

Insulation resistance tester (e.g. megger). The test should be carried out at the nearest possible point to the supply Authority's equipment.

Method

Connect insulation resistance tester between phase and neutral

Readings

The minimum readings required are similar to those for the earth insulation resistance test on the same installation.

Test of Ring Circuit Continuity

On completion of a ring circuit installation a test, similar to that carried out to check the verification of polarity, must be carried out to ensure the continuity of all time, neutral and earth continuity conductors throughout the ring circuit. This test is carried at the point of connection in the distribution fuse board prior to the completion and connection of the ring circuit conductors.

Tests to be carried out are given below

1. Verification of polarity – Used to check that phase wire is switched and fused. Reading on ohmmeter or bell set-zero or continuity.
2. Earthing tests – To ensure that the metalwork of the installation is 'effectively connected to the general mass of earth'.

   (a). testing earth continuity conductor. Maximum reading, 0.5 Ω.

   (b). Testing earth fault loop impedance by current injection. Reading determined by setting of protective equipment.

   (c). testing effectiveness of earth electrode. Reading determined by setting of protective equipment.
3. Insulation tests (a) between poles (b). Earth insulation resistance (between all conductors and earth).
4. Ring circuit should be tested with ohmmeter or bell set for continuity of ring.

Commissioning

After completion of the installation, it is the duty of the contractor to now hand over the completed building to the owner. This is achieved by filling in details of the installation on completion certificate and handing it over to owner and a copy to the supply authority.

Completion Certificate.

Upon completion of new installation or a major extension on existing installation and inspection and testing has been carried out. The contractor the contractor should issue out a completion certificate. The certificate gives details of the installation including the name and address of the customer number of appliances, method of earthing and readings of the tests carried out. The certificate states that the installation has been carried out in accordance with the I.E.E regulations and also recommends periodic inspection and testing.

Inspection Certificate.

After an installation has been re-inspected and tested as recommended in the completion certificate on specified date an inspection certificate is completed and handed on to the consumer. The certificate contains more details than the completion certificate since it gives full range of tests of the installation

7.2.5.3 Learning activities

Field/Visit to an established electrical workshop

Visit Objective/Aim	Indicators	Special Instruction
To establish techniques used in testing an installation	● Instruments ● Readings	● Take notes ● Note instruments used ● Note measurement values.

Practical assignment

Visit Objective/Aim	Indicators	Special Instruction
To acquire skills in testing an electrical installation	● Instruments ● Readings	Participate in the process

7.2.5.4 Self -Assessment

1. The picture below shows one of the instruments used by electrical artisans in their daily activities, What is the name of the instrument?

A. Tester
B. Earth loop tester
C. Multimeter
D. Voltmeter

2. What is the test voltage used when performing an insulation resistance test on a 230V system?
    A. 50V
    B. 500V
    C. 24V
    D. 250V
3. Who is supposed to carry out periodic testing on an existing installation?
    A. Energy regulatory commission.
    B. Competent Person
    C. Kenya power
    D. Building inspector
4. What is the purpose of testing a repaired Installation?
5. What are the main tests to be carried out on a complete electrical installation
6. With the aid of a diagram describe verification of polarity test
7. Describe what is an inspection certificate

7.2.5.5 Tools, Equipment, Supplies and Materials

The following resources are provided

i. An electrical installation company
ii. A functional Safety department.
iii. Computers
iv. Stationery
v. Lecture room
vi. Workshop
vii. Projector
viii. Drawing equipment
ix. Workshop
x. Protective clothing

7.2.5.6 References

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7.2.6 Answers to Self-Assessment

7.2.6.1 Identify System Failure

1. B
2. C

   The termination of the ability of an equipment to perform its required function

3. What are the benefits of maintenance?
   - i. *Maximize the useful life of equipment/facilities*
   - ii. *Reduce accidents and fire risks (keeping Equipment safe)*
   - iii. *Minimize the possibility of failure or breakdown because this will result in lost production.*
   - iv. *Minimize operating costs by preventing major repair works from arising*
   - v. *Maximize the production/operation capacity from the given equipment resources*
   - vi. *Improve the morale of operatives*
   - vii. *Reduce the chances of scrap in production*
   - viii. *Enable product or service quality and customer satisfaction to be achieved through correctly adjusted, serviced and operated equipment.*
   - ix. *Give cost records which are helpful when it comes to considering replacement.*
4. Which human senses that can be used during an inspection of an installation?
   - i. *Visual*
   - ii. *Touch*
   - iii. *Smell*
5. Apart from wear and tear, what are three other areas of investigation that you would consider when carrying out a periodic inspection and test of an installation?
   - i. *To ensure safety of persons and livestock*
   - ii. *To ensure protection from fire and heat*
   - iii. *To ensure that the installation is not damaged so as to impair safety*
   - iv. *To ensure that the installation is not defective and complies with current regulations.*
7. Describe breakdown maintenance

   The breakdown maintenance is a type of maintenance that involves using a machine until it completely breaks down and then repairing it to working order. The is a type of maintenance that involves using a machine until it completely breaks down and then repairing it to working order. For example, this type of maintenance would occur if you *wait until a machine stops working before fixing it. This is one of several common maintenance types.*

8. What are the two categories of machinery inspection?

i. *Mechanical inspection*

ii. *Electrical inspection*

7.2.6.2 Troubleshoot Cause of Failure

1. B
2. **D**
3. B
4. A
5. As an Electrical Installation Technician, what are the **two** important things to do when faced with equipment which is not functioning properly?
   - *Be sure you understand how the equipment is designed to operate. It makes it much easier to analyze faulty operation when you know how it should operate.*
   - *Note the condition of the equipment as found. You should look at the state of the relays which lamps are lit. Look for signs of mechanical damage, overheating, unusual sounds smells etc.*
   - *Test the operation of the equipment including all of its features. Make note of any feature that is not operating properly. Make sure you observe these operations very carefully.*

6. During troubleshooting of electrical equipment, what are some of the safety tips to be observed?
   - *Be informed, be aware of the Hazards, Make sure you know and understand all the rules and regulations that apply to the work you are doing.*
   - *Follow all safety rules and procedures, these are designed to protect you. Do not take short cuts.*
   - *Use the troubleshooting simulator in this program to practice your troubleshooting skills in a safe environment.*

- *Wear all required personal protective equipment. In the event of equipment failure or accident contact, your personal protective equipment may save your life.*

7. Explain the following terms used in fault diagnosis.

   Replacement time - *this involves removal of the faulty, followed by connection and wiring, as appropriate of a replacement.*

   Checkout time - *this involves verifying that the fault condition no longer exists and that the system is operational.*

8. Outline the general procedure for repair
   i. *Carry out visual inspection.*
   ii. *Carry out continuity test and insulation resistance test.*
   iii. *Dismantle the appliance*
   iv. *Repair the appliance*
   v. *Assemble the appliance*
   vi. *Test the appliance*

7.2.6.3 Prepare list of tools, Equipment & Materials

1.B

2.B

3. List any four tools used in break down maintenance
   i. *Ladder*
   ii. *Hammer*
   iii. *Pliers*
   iv. *Screw drivers e.t.c*
4. Describe safe the usage of ladder during maintenance of an electrical system

   The term ladder is generally taken to include step ladders and trestles. The use of ladders for working above ground level is only acceptable for access and work of short duration. It is advisable to inspect the ladder before climbing it. It should be straight and firm. All rungs and tie rods should be in position and there should be no cracks in the stiles. The ladder should not be painted since the paint may be hiding defects. Extension ladders should be erected in the closed position and extended one section at a time. Each section should overlap by at least the number of rungs indicated below:

   1. *Ladder up to 4.8 m length – 2 rungs overlap*
   2. *Ladder up to 6.0 m length – 3 rungs overlap*

3. *Ladder over 6.0 m length – 4 rungs overlap*

5. Explain the basic maintenance procedure of electric tools

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

a) *Clean out the dust: To make sure that your electric tools are ready for use, keep them clean and free of dust. The housing intake on your electric tools and the exhaust are especially important areas to keep clean. Take some time to clean out the dust every once in a while on your tools while they are sitting in storage.*
b) *Check the cords: Look for wear and tear on the power cords on your electric tools. There can be damage to the insulation and you should keep an eye out for loose wires. This will ensure that your electric tool can get the power that it needs to function without an accident. Wipe the cords down to keep them from becoming damaged from oil and grease. The prongs on the cords should be examined as well. Make sure that the casing is intact and the prongs are not loose.*
c) *Oil some electric tools: The electric tools in your toolbox that have a cutting surface should be lightly oiled to prevent rust. Examine the cutting surface for rust to make sure that your tools are kept in good condition.*
d) *Storing your tools: Keep your electric tools stored in their original cases and containers. This will keep them free of dust and dirt while they are not being used.*

6. Why Multimeter is calibrated

A digital Multimeter is one of the most commonly used pieces of test and measurement instrumentation. Quality processes depend on its continual proper operation. However, time, environment, and physical use (or abuses) change a digital multimeter's characteristics. That's why it's important to periodically calibrate or verify the performance of a digital multimeter. A multimeter should be calibrated or adjusted to a known zero-value prior to use for accurate readings.

7. Why is calibration required?

Calibration may be required for the following reasons:

a) *a new instrument*

b) after an instrument has been repaired or modified

c) when a specified time period has elapsed

d) when a specified usage (operating hours) has elapsed

e) before and/or after a critical measurement

f) after an event, for example:

iii. after an instrument has been exposed to a shock, vibration, or physical damage, which might potentially have compromised the integrity of its calibration

iv. sudden changes in weather

g) whenever observations appear questionable or instrument indications do not match the output of surrogate instruments

h) As specified by a requirement, e.g., customer specification, instrument manufacturer recommendation.

7.2.6.4 Repair the Installation

1. A
2. A
3. B
4. D
5. State possible cause and remedy for the following faults in an electrical installation
   (a) Dead socket outlets
   (b) Flickering or dimming lights
   (c) Light bulbs burn out frequently

(a) *Dead socket outlets can result from a tripped poor connection (and possible arcing), a tripped breaker due to excessive heat buildup resulting in melted wires or outlets. Replace the damaged socket outlet, carry out rewiring if the cables are damaged*

(b) This could be a sign of a poor connection and can lead to eventual arcing

Loose/corroded connections making intermittent contact that could result in sparking, overheating, and fire. Put off the light and fix these problems

(c) *You may have a loose connection in the socket or circuit or worn out insulation causing overheating. Open the lamp holder and identify the problem then fix it.*

7.2.6.5 Test the Repaired System

1. C
2. B
3. B

4. What is the purpose of testing a repaired Installation?

The reason for testing an installation is to detect faults before dangerous situations arise.

Factors which the installation must be protected against are:-

i. Earth leakage and danger of electric shock

ii. Excess current

iii. Moisture and corrosion

5. What are the main tests to be carried out on a complete electrical installation?
   1. *Verification of polarity test*
   2. *Effectiveness of earthing test*
   3. *Ring circuit continuity test*
   4. *Insulation resistance test*
   5. *Earth fault loop impedance test*

6. With the aid of a diagram describe verification of polarity test

The purpose of this test is to check the phase conductor is taken through the fuse and switch to the appliance the reason for this test is to ensure that the neutral wire is earthed at the supply authority's substation.

The Neutral must never be broken by a fuse or switch.

Preparation for the test

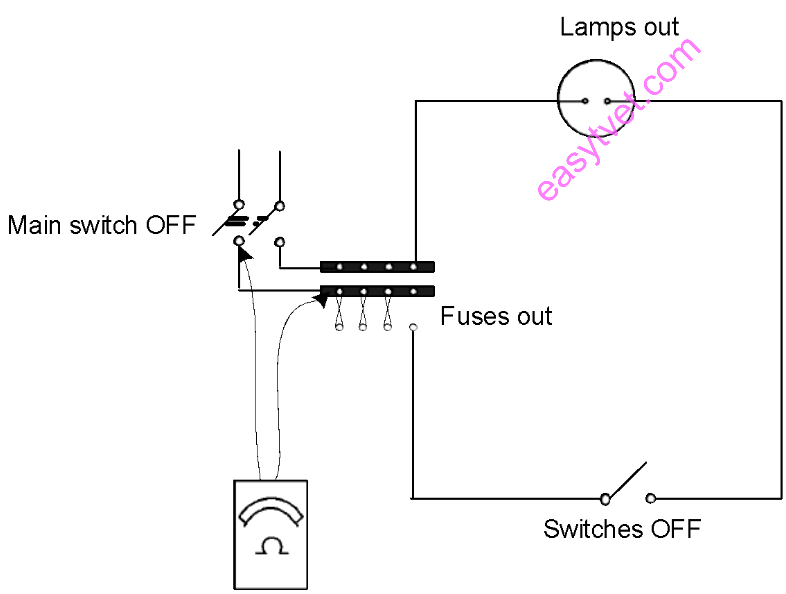
1. *Supply OFF*
2. *Lamps and appliances OUT*

3. *All switches OFF*
4. *Neutral links IN*
5. *Fuses OUT*

Instrument used: Ohmmeter or Bell set

7. Describe what an inspection certificate is.

After an installation has been re-inspected and tested as recommended in the completion certificate on specified date an inspection certificate is completed and handed on to the consumer. The certificate contains more details than the completion certificate since it gives full range of tests of the installation



Reading: Zero Ohms on Ohmmeter

This test should not be carried out on a LIVE installation.