CHAPTER 6: TESTING OF ELECTRICAL INSTALLATION

Unit of learning code: ENG/CU/EI/CR/03/4/A

Related Unit of Competency in Occupational Standard; Perform Testing of Electrical Installation

6.1 Introduction to the unit of learning

This unit covers the competencies required to carry out inspection and testing of an electrical installation. It covers testing activities starting from verifying the installed fittings and accessories, identifying the type of tests, carrying out the tests and issuing test certificates.

6.2 Summary of Learning Outcomes

1. Conduct physical inspection
2. Identify the test to be carried out and test equipment
3. Perform the test
4. Issue installation test and wiring certificates

6.2.1 Learning Outcome 1: Conduct Physical Inspection

Introduction to the learning outcome

This learning outcome specifies the content of competencies required to carry out Visual inspection, checking of physical condition, Firmness, Fitting points of the installation as per the established procedures and standards, and identified as per as-built drawings.

6.2.1.1 Performance Standard

Visual inspection is carried out.

Fitting points and equipment are identified as per as-built drawings.

Physical condition of the installation is checked as per established standards.

Firmness of the installation is checked as per the established standards.

6.2.1.2 Information Sheet

Definitions

Inspection. Examination of an electrical installation using all available means to ascertain correct selection and proper installation of electrical equipment.

Inspection and Testing

Periodic inspection and testing of internal wiring installations is necessary. Internal wiring should be checked every year for safe operations.

While carrying out inspection and testing of internal wiring installations, following points should be checked:

Incoming Service Line termination

Check and ensure the following:

1. Service line coming in to the premises is properly terminated and brought in

2. Check for fuse wire rating on each of the phases so as to ensure it is of correct rating

3. Check for wire sizes to be of correct size to carry the required current

4. Check for Earthing to be properly maintained at the service line side

Main Switch Board

A main switch board exists at the point of termination of service line. Supply is provided through this board in to the premises.

a) Ensure that the main switch board is closer to the point of supply in the premises
b) Check for fuses / circuit breakers used of adequate sizes for all phases
c) Check for correct ON/OFF working of Main Switch. A main switch plays a very important role as it helps to switch off the complete supply of the premises in case of emergency / repairs. It should always be in good working condition.
d) Check for any mechanical faults in switching operations that might cause it to remain continuously in ON state. This may be problematic in emergency cases when the electrician wants to switch the supply off
e) Ensure that the Switch board assembly is well covered to protect against rain / weather conditions
f) Inspect to see that you are clearly able to trace the neutral and earthing wires in different color
g) Inspect the electricity meter connections are properly fastened

Internal Wiring Circuits

Internal Wiring Circuits are to be checked for following points:

i. Ensure that each circuit branching out of Main Switch board has a connected load of not more than 800 watts or 10 points
ii. Test for Insulation resistance of conductor and earth to be as per IEC specifications
iii. Electrical resistance from connection with Earth electrode should not be more than one ohm
iv. Ensure metallic covering of iron clad switches, distribution boards are properly earthed
v. Test that that leakage current is less than 1/5,000 of maximum supply current.

General Content Inspection Checklist

1. Connection of conductors: Are terminations electrically and mechanically sound? Is insulation and sheathing removed only to a minimum to allow satisfactory termination?

2. Identification of conductors: Are conductors correctly identified in accordance with the Regulations?
3. Routing of cables: Are cables installed such that account is taken of external influences such as mechanical damage, corrosion, heat, etc.?
4. Conductor selection: Are conductors selected for current carrying capacity and voltage drop in accordance with the design?
5. Connection of single pole devices: Are single pole protective and switching devices connected in the line conductor only?
6. Accessories and equipment: Are all accessories and items of equipment correctly connected?
7. Thermal effects: Are fire barriers present where required and protection against thermal effects provided?
8. Protection against shock: What methods have been used to attain both basic protection and fault protection?
9. Mutual detrimental influence: Are wiring systems installed such that they can have no harmful effect on non-electrical systems, or those systems of different currents or voltages are segregated where necessary?
10. Isolation and switching: Are there appropriate devices for isolation and switching correctly located and installed?
11. Under voltage: Where under voltage may give rise for concern, are there protective devices present?
12. Labeling: Are all protective devices, switches (where necessary) and terminals correctly labeled?
13. External influences: Have all items of equipment and protective measures been selected in accordance with the appropriate external influences?
14. Access: Are all means of access to switchgear and equipment adequate?
15. Notices and signs: Are danger notices and warning signs present?
16. Diagrams: Are diagrams, instructions and similar information relating to the installation available?
17. Erection methods: Have all wiring systems, accessories and Equipment been selected and installed in accordance with the requirements of the Regulations, and are fixings for equipment adequate for the environment?

So, now that we have inspected all relevant items, and provided that there are no defects that may lead to a dangerous situation when testing, we can start the actual testing procedure.

Before testing begins, it is important that a full inspection of the complete installation is carried out.

Reasons for carrying out Electrical installation inspection

1. To ensure the safety of persons and livestock.

2. To ensure protection of property from fire and heat.

3. To ensure that the installation is not damaged so as to impair safety.

4. To ensure that the installation is not defective and complies with the current regulations.

5. Are in compliance with the safety requirements of the relevant equipment standards?

6. Have been correctly selected and erected according to the relevant rules and regulations and to the manufacturer's instructions, in order that performance is not adversely affected

7. Are suitable for the prevailing environmental conditions

Electrical installation inspection is accomplished by checking:

- The method of protection against electric shock
- The protection against thermal effects
- The precautions against propagation of fire
- The selection of the conductors for current-carrying capacity and voltage drop
- The choice and settings of the protective devices, the presence and correct location of suitable isolating and switching devices

- The selection of equipment and protective measures appropriate to external influences the correct identification of the circuits, overcurrent protective devices, switches, terminals, et cetera
- The presence of diagrams, warning notices, or similar information
- The adequacy of the conductor connections
- The presence and adequacy of protective conductors, including equipotential bonding
- The accessibility of the equipment for convenience of operation, identification, and maintenance
- In practice, Electrical installation inspection means checking the following items:
- Firmness of the accessories
- Correct color coding of cables.
- Maintenance points in place
- Good workmanship
- Separate circuits
- Adequate number of circuits
- Adequate number of socket-outlets
- All circuits suitably identified
- A suitable main switch provided
- Main breakers to interrupt all live conductors
- Main earthing terminal provided
- Correct fuses or circuit breakers installed
- All connections secure/loose connections

- Condition of accessories and fitting i.e. whether damaged or not
- The installation earthed in accordance with national standards
- Primary equipotential bonding connects services and other extraneous conductive parts to the primary earth facility
- Supplementary bonding has been provided in all bath and shower rooms
- The following items must be checked concerning protection against direct contact:
- Insulation of live parts
- Enclosures have a suitable degree of protection appropriate to external influences
- Enclosures have unused entries blanked off where necessary

Importance of Electrical installation Inspection

There are many reasons behind the necessity of getting an electrical inspection done. Some of the most common ones are:

- **Protection against possible surges**: This is a common phenomenon in different regions, especially when there is a storm. Electrical surges can not only ruin your appliances, but can also create short circuits in your house. When the inspection is being done, the inspector will check for different points in the wiring that can cause this type of mishap.

- **Fire**: Many a times it has been seen that an electrical short circuit has been the reason behind a fire breakout in a house. These short circuits are caused by different loose wires in the meter or in the cabling itself. During the inspection, the inspector can easily recognize these faults and ask you to rectify them.

- **Shocks**: Imagine touching an electronic appliance and immediately experiencing a surging electric current in your body. Although the impact may not be that disastrous; however, this could lead to other mishaps easily. Apart from this, the body current in an electronic appliance can easily hamper its performance or can render it completely non-workable. An electrical inspector can catch these faults in the wiring in time to rectify them.

6.2.1.4 Learning activities

Learning activity 1

Given an electrical installation premises, Check the Physical condition of the installation as per established standards. Use the following Observation Checklist to check the conditions.

Table 1.1: Observation checklist Learning activity 1

Observation Checklist				
Items to be evaluated	**Available/Done**	**Correct**	**Incorrect**	**Comment**
Connection of Conductors				
Identification of Conductors				
Routing of Cables				
Conductor Selection				
Connection of single pole devices				
Accessories and equipment selection				
Thermal effects considered				
Protection against shock				
Isolation and switching:				
Labeling				
External influences				
Accessibility				

Notices and signs				

Learning activity 2

You are assigned to identify the following electrical protective devices in an electrical installation for an inspection. Perform visual inspection on the devices.

Record your observations against the following checklist in table 1.2

Table 1.2: Observation Checklist activity 2

Observation checklist			
Items	Area of observation	Yes	No
Circuit breaker	Presence breakages		
	Presence of contacts		
	Presence of fasteners		
Double pole switch	Presence of breakages		
	Presence of contacts		
Triple pole switch with neutral	Presence of breakages		
	Presence of contacts		
	Presence of fasteners		
Isolator switch	Presence of breakages		
	Presence of contacts		
	Presence of fasteners		

6.2.1.5 Self-assessment: Learning Outcome 1

1. When a certificate is issued for Initial Verification purposes, for the certificate to be valid it MUST be accompanied by?

   A. inspection tick-sheet

   B. schedules of inspections and test results

   C. test results sheet

   D. Part 'P' certificate

2. Indicate three main areas, about which you would require information, in order correctly to carry out an initial verification of a new installation.
3. State three human senses that could be used during an inspection of an installation.
4. Apart from wear and tear state three areas of investigation that you would consider when carrying out a periodic inspection and test of an installation.
5. An Electrical Installation Certificate should be accompanied by signed documentation regarding three stages of an installation. What are these stages?

6.2.1.6 Tools, Equipment, Supplies and Materials

Tools

Phase Tester

Screw drivers

Equipment

- Test instruments
  - Continuity tester (ohmmeter)
  - Insulation resistance tester
  - Earth loop impedance tester
    - Test lamp

Materials and supplies

- BS 7671
- Guidance Note 3
- The On-site Guide.
- Stationery
- Wiring certificates

Reference materials

- BS 7671
- Guidance Note 3
- The On-site Guide.
- Manufacturers' manuals
- Relevant catalogues
- IEE regulations
- Standards
- County by-laws
- Occupational Safety and Health Act (OSHA)
- National Environmental Management Authority (NEMA) regulations
- National Construction Authority (NCA) regulations

- IEE tables

6.2.1.7 Reference

IEE Wiring Regulations: Inspection, Testing and Certification Sixth Edition Brian Scaddan, IEng, MIET

https://electrical-engineering-portal.com/inspection-electrical-installations-home-1

https://www.dfliq.net/blog/electrical-inspection-a-detailed-overview

6.2.2 Learning Outcome 2: Identify the test to be carried out and test equipment

6.2.2.1 Introduction to the learning outcome

This learning outcome specifies the content of competencies required to identify installation to be tested, test points, test parameters and their expected values as per the established standards, appropriate test equipment as per the tests to carry out. In addition, it also specifies the content of competence required on checking the specifications and functionality of test equipment, preparation and safe storage for easy access in accordance with established procedure.

6.2.2.3 Performance Standard

i. The ***installation*** to be tested is identified per established standards
ii. Test points are identified as per established standards
iii. Test parameters and their expected values are identified as per established standards
iv. Appropriate ***Test equipment*** are identified as per the tests to carried out
v. Test equipment are checked for appropriate specifications and functionality
vi. Test equipment are prepared and stored for safe and easy access in accordance with established procedure

6.2.2.4 Information Sheet

Testing

Implementation of measures in an electrical installation by which its effectiveness is proved.

Reasons of electrical installation testing

1. To ensure that people and goods are kept safe and are protected in the event of a fault.
2. Facilitates preventive maintenance of installations, preventing serious faults which might prove expensive (production shutdown, etc.).
3. To guarantee people's safety with regard to these installations and the electrical
4. Equipment connected to them, standards have naturally been developed and updated to take changes into account.

Purpose of Electrical Installation Testing

All new completed electrical installation should be tested before connection to the supply. The purpose of the electrical installation condition report and testing is to provide, as far as is reasonably practicable:

i. To ensure that the installation is technically sound and free from any possible short circuits, etc.
ii. To know the cause of failure of a particular circuit or circuits or equipment and to locate the exact position of break down.
iii. To ensure that it is free from faults and is as per electricity rules.
iv. These tests will receive the attention of the owner before any possible undue damage occurs. i.e. to confirm that the installation is not damaged or deteriorated.
v. For the safety of persons and livestock.
vi. Protection against damage by fire and heat.

Types of tests

The IEE Regulations indicate a preferred sequence of tests and state that if, due to a defect, compliance cannot be achieved, the defect should be rectified and the test sequence started from the beginning. The tests for 'Site applied insulation', 'Protection by separation', and 'Insulation of non-conducting floors and walls' all require specialist high voltage equipment and in consequence will not be discussed here.

The sequence of tests for an initial inspection and test is as follows:

1. Continuity of protective conductor's tests.
2. Continuity of ring final circuit conductor's tests.
3. Insulation resistance tests.
4. Protection by barriers or enclosures.
5. Polarity tests.
6. Earth electrode resistance.
7. Earth fault loop impedance.
8. Additional protection (RCDs).

9. Prospective fault current (PFC) between live conductors and to earth.

10. Functional testing.

11. Voltage drop

12. Phase sequence.

One other test not included in Part 7 of the IEE Regulations but which nevertheless has to be carried out is external earth fault loop impedance (Ze).

Continuity of protective conductors

These include the cpcs (circuit protective conductor) of radial circuits, main and supplementary Protective bonding conductors. Two methods are available: either can be used for cpcs, but bonding can only be tested by the second.

Method 1

At the distribution board, join together the line conductor and its associated cpc. Using a low resistance ohmmeter, test between line and cpc at all the outlets in the circuit. The reading at the farthest point will be (R1+R2) for that circuit. Record this value; after correction for temperature it may be compared with the designer's value (more about this later).

Method 2

Connect one test instrument lead to the main earthing terminal and a long test lead to the earth connection at all the outlets in the circuit.

Record the value after deducting the lead resistance. An idea of the length of conductor is valuable, as the resistance can be calculated and compared with the test reading.

Table 1.3 gives resistance values already calculated for a range of lengths and sizes.

It should be noted that these tests are applicable only to 'all insulated' systems, as installations using metallic conduit and trunking, MICC and SWA cables will produce spurious values due to the probable parallel paths in existence. This is an example of where testing needs to be carried out during the erection process and before final connections and bonding are in place.

Table 1.2: Resistance (Ω) of Copper Conductors at 20°C

CSA(mm^2)	Lenth (m)									
	5	10	15	20	25	30	35	40	45	50
1.0	0.09	0.18	0.27	0.36	0.45	0.54	0.63	0.72	0.82	0.90
1.5	0.06	0.12	0.18	0.24	0.30	0.36	0.42	0.48	0.55	0.61
2.5	0.04	0.07	0.11	0.15	0.19	0.22	0.26	0.30	0.33	0.37
4.0	0.023	0.05	0.07	0.09	0.12	0.14	0.16	0.18	0.21	0.23
6.0	0.02	0.03	0.05	0.06	0.08	0.09	0.11	0.13	0.14	0.16
10.0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10
16.0	0.006	0.01	0.02	0.023	0.03	0.034	0.04	0.05	0.051	0.06
25.0	0.004	0.007	0.01	0.015	0.02	0.022	0.026	0.03	0.033	0.04
35.0	0.003	0.005	0.008	0.01	0.013	0.016	0.019	0.02	0.024	0.03

If conduit, trunking or SWA is used as the cpc, then the verifier has the option of first inspecting the cpcs (circuit protective conductors) along its length for soundness then conducting the long-lead resistance test.

Continuity of ring final circuit conductors

The requirement of this test is that each conductor of the ring is continuous. It is, however, not sufficient to simply connect an ohmmeter, a bell, etc., to the ends of each conductor and obtain a reading or a sound. So, what is wrong with this procedure? A problem arises if an interconnection exists between sockets on the ring, and there is a break in the ring beyond that interconnection. From Figure 1.2 it will be seen that a simple resistance or bell test will indicate continuity via the interconnection.

However, owing to the break, sockets 4–11 are supplied by the spur from socket 12, not a healthy situation. So how can one test to identify interconnections? There are three methods of conducting such a test.

Two are based on the principle that resistance changes with a change in length or CSA; the other, predominantly used, relies on the fact that the resistance measured across any diameter of a circular loop of conductor is the same. Let us now consider the first two.

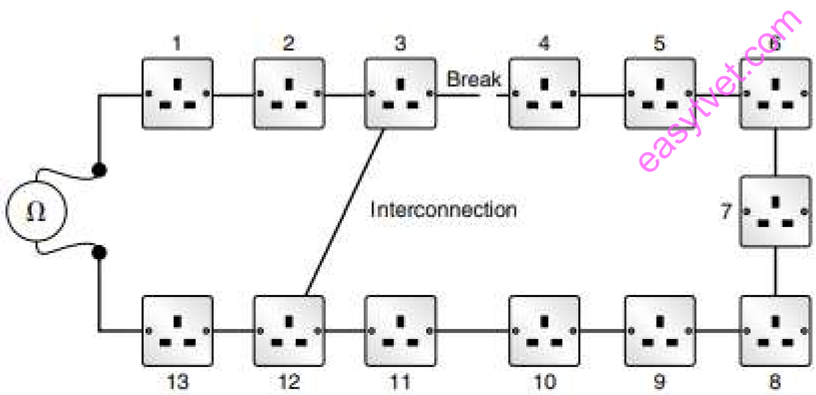

Figure 1.1: Ring circuit with interconnection

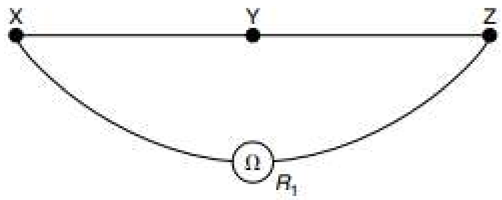

Figure 1.2: End to end conductor resistance.

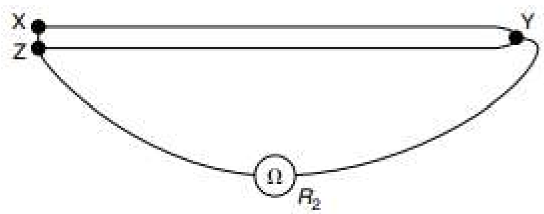

Figure 1.3: Doubled over end to end conductor resistance.

Method 1

If we were to take a length of conductor XYZ and measure the resistance between its ends (Figure 1.3), then double it over at Y, join X and Z, and measure the resistance between XZ and Y (Figure 1.4), we would find that the value was approximately a quarter of the original. This is because the length of the conductor is halved and hence so is the resistance, and the CSA is doubled and so the resistance is halved again.

In order to apply this principle to a ring final circuit, it is necessary to know the position of the socket nearest the mid-point of the ring.

The test procedure is then as follows for each of the conductors of the ring:

1. Measure the resistance of the ring conductor under test between its ends before completing the ring in the fuse board. Record this value, say R1.

2. Complete the ring.

3. Using long test leads, measure between the completed ends and the corresponding terminal at the socket nearest the mid-point of the ring. Record this value, say R2. (The completed ends correspond to point XZ in Figure 2. and the mid-point to Y.)

4. Measure the resistance of the test leads, say R3, and subtract this value from R2, i.e. R2−R3=R4 say.

5. A comparison between R1 and R4 should reveal, if the ring is healthy, that R4 is approximately a quarter of R1.

Method 2

The second method tests two ring circuit conductors at once, and is based on the following. Take two conductors XYZ and ABC and measure their resistances (Figure 1.5). Then double them both over, join the ends XZ and AC and the mid-points YB, and measure the resistance between XZ and AC (Figure 2.6)

This value should be a quarter of that for XYZ plus a quarter of that for ABC. If both conductors are of the same length and CSA, the resultant value would be half that for either of the original resistances. Applied to a ring final circuit, the test procedure is as follows:

1. Measure the resistance of both line and neutral conductors before completion of the ring. They should both be the same value, say R1.

2. Complete the ring for both conductors, and bridge together line and neutral at the mid-point socket (this corresponds to point YB in Figure 1.6).

Now measure between the completed line and neutral ends in the fuse board (points XZ and AC in Figure 1.6).

Record this value, say R2.

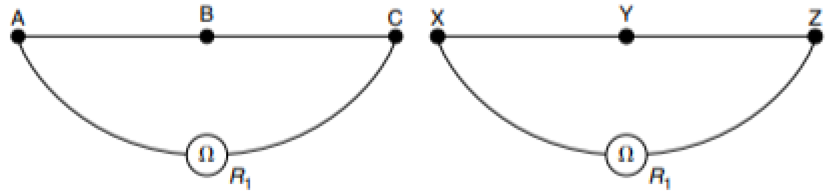

Figure 1.4: End to end conductor resistance.

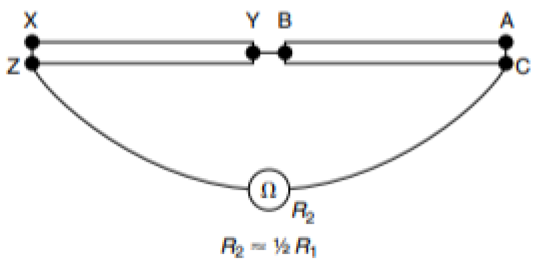

Figure 1.5: Doubled over conductors in parallel

3. R2 should be, for a healthy ring, approximately half of R1 for either line or neutral conductor.

When testing the continuity of a cpc which is a different size from either line or neutral, the resulting value R2 should be a quarter of R1 for line or neutral plus a quarter of R1 for the cpc.

Method 3 (generally used)

The third method is based on the measurement of resistance at any point across the diameter of a circular loop of conductor (Figure 1.7). As long as the measurement is made across the diameter of the ring, all values will be the same. The loop of conductor is formed by crossing over and joining the ends of the ring circuit conductors at the fuse board. The test is conducted as follows: 1. Identify both 'legs' of the ring.

2. Join one line and one neutral conductor of opposite legs of the ring.

3. Obtain a resistance reading between the other line and neutral (Figure 1.8). (A record of this value is important.)

4. Join these last two conductors (Figure 1.9).

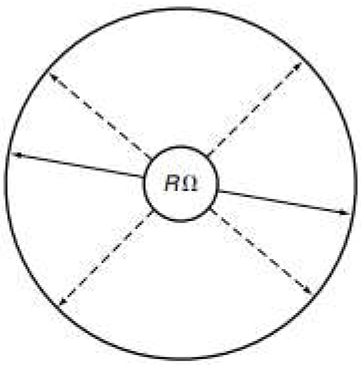

Figure 1.6: Resistance across diameter of circle of conductor.

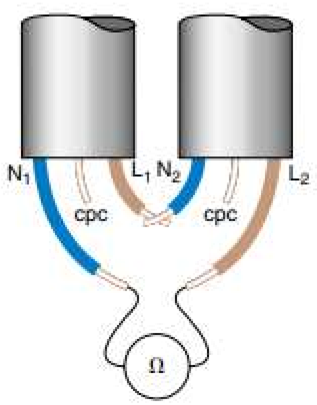

Figure 1.7: End to end double loop resistance.

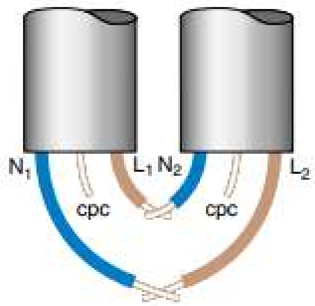

Figure1. 8: Both ends cross connected.

5. Measure the resistance value between L and N at each socket on the ring. All values should be the same, approximately a quarter of the reading in (3) above.

The test is now repeated but the neutral conductors are replaced by the cpcs. If the cable is twin with cpc, the cpc size will be smaller than the line conductor, and although the readings at each socket will be substantially the same, there will be a slight increase in values towards the Centre of the ring, decreasing back towards the start. The highest reading represents R1+R2 for the ring.

The basic principle of this method is that the resistance measured between any two points, equidistant around a closed loop of conductor, will be the same.

Such a loop is formed by the line and neutral conductors of a ring final circuit (Figure 2.0). Let the resistance of conductors be as shown. R measured between L and N on socket A will be:

$$\frac{0.2+0.5+0.3+0.4+0.1+0.3}{2} = \frac{2}{2} = 1\Omega$$

R measured between L and N at B will be :

$$\frac{0.3+0.2+0.5+0.2+0.3+0.4+0.1}{2} = \frac{2}{2} = 1\Omega$$

Hence all sockets on the ring will give a reading of 1Ω between L and N.

If there were a break in the ring in, say, the neutral conductor, all measurements would have been 2, incorrectly indicating to the tester that the ring was continuous. Hence the relevance of step 3 in the test procedure, which at least indicates that there is a continuous L–N loop, even if an interconnection exists.

Figure 2.1 shows a healthy ring with interconnection. Here is an example that shows the slight difference between measurements on the line/cpc test. Consider a 30m ring final circuit wired in 2.5mm2 with a 1.5mm2 cpc. Figure 2.2 illustrates this arrangement when cross-connected for test purposes.

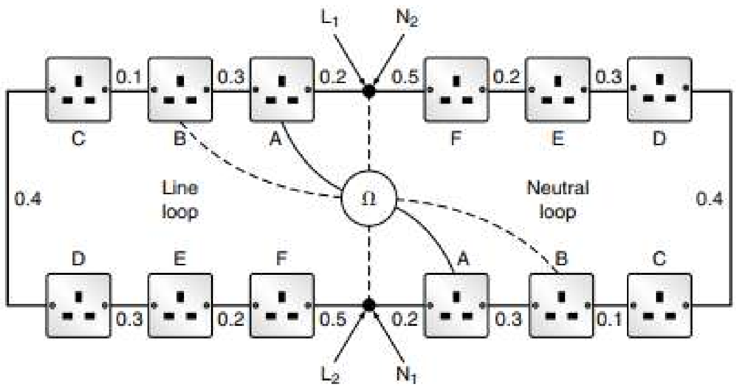

Figure 9: Equidistant loop measurements.

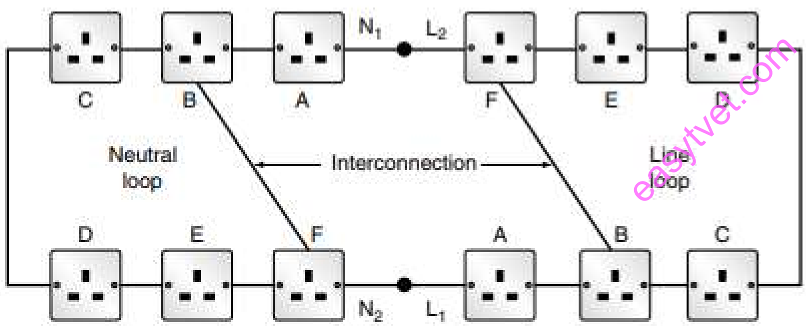

Figure 10: Healthy ring circuits with an interconnection.

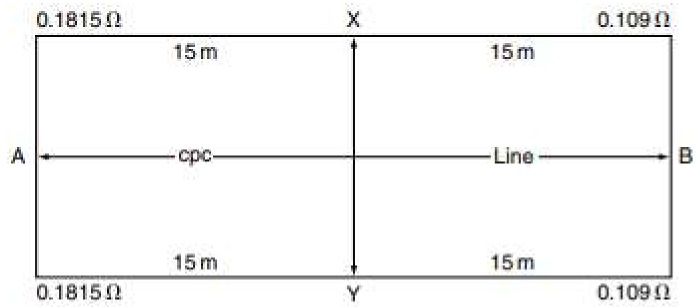

Figure 11: Ring with 2.5mm2 line and 1.5mm2 cpc.

From the resistance tables, 1.5mm2 conductor is seen to have a resistance of 12.1mΩ/m, and 2.5mm2, 7.27mΩ/m. This gives the resistance from X to A as 15×12.1/1000=0.1815Ω and from X to B as 15×7.27/1000=0.109.

The same values apply from Y to A and Y to B. So measuring across X and Y we have 2×0.1815=0.363, in parallel with 2×0.109= [(0.363×0.218)/(0.363+0.218)]Ω (product over sum)=0.137Ω. Measuring across A and B (the mid-point) gives 0.1815+0.109=0.29Ω, in parallel with the same value, i.e. 0.29Ω, which gives 0.29/2=0.145Ω. While there is a difference of 0.008Ω the amount is too small to suggest any faults on the ring. Note: If the line–neutral and line–cpc tests prove satisfactory this is also an indication that the polarity at each socket outlet is correct.

Protection by barriers or enclosures

If an enclosure/barrier is used to house or obscure live parts, and is not a factory-built assembly, it must be ascertained whether or not it complies with the requirements of the IP codes IP2X or IPXXB, or IP4X or IPXXD. For IP2X or IPXXB, the test is made using the British Standard Finger, which is connected in series with a lamp and a supply of not less than 40V and not more than 50V. The test finger is pushed into or behind the enclosure/barrier and the lamp should not light (Figure 2.3).

The test for IP4X or IPXXD is made with a 1.0mm diameter wire with its end cut at right angles to its length. The wire should not enter the enclosure to conform to IP4X. It may enter for 100 mm without touching live parts to conform to IPXXD.

Insulation resistance

An insulation resistance tester, which is a high resistance ohmmeter, is used for this test.

Clearly with voltages of these levels, there are certain precautions to be taken prior to the test being carried out.

Persons should be warned, and sensitive electronic equipment disconnected or unplugged.

A common example of this is the dimmer switch. Also, as many accessories have indicator lamps, and items of equipment such as fluorescent fittings have capacitors fitted, these should be disconnected as they will give rise to false readings. The test procedure is as follows: Poles to earth (Figure 2.4)

1. Isolate supply.

2. Ensure that all protective devices are in place and all switches are closed.

3. Link all poles of the supply together (where appropriate).

4. Test between the linked poles and earth.

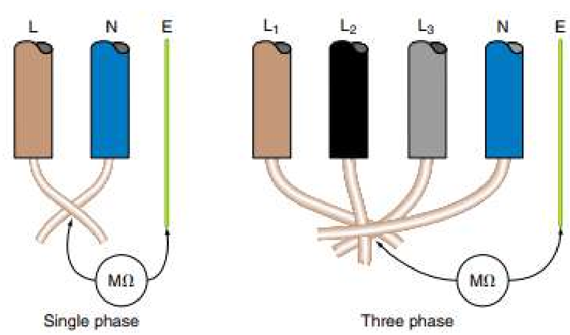

Figure2.4:Test between live conductors and earth

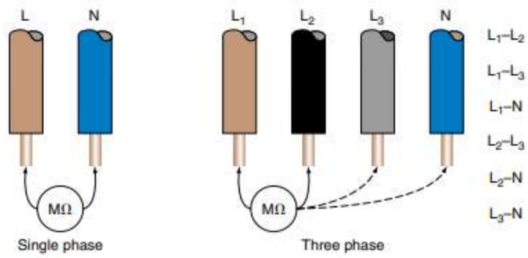

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Figure 12: Test between live conductors.

Between poles (Figure 2.5)

1. As previous test.

2. As previous test.

3. Remove all lamps, equipment, etc.

4. Test between poles.

Test results on disconnected equipment should conform to the relevant British Standard for that equipment. In the absence of a British Standard, the minimum value is 0.5MΩ. For small installations, the tests are performed on the whole system, whereas for larger complex types, the installation may be sub-divided into sections and tests performed on each section.

The reason for this is that as conductor insulation and the circuits they supply are all in parallel, a test on the whole of a large installation would produce pessimistically low readings even though no faults exist. Although for standard 400V/230V installations the minimum value of insulation resistance is 1MΩ, a reading of less than 2MΩ should give rise to some concern. Circuits should be tested individually to locate the source/s of such a low reading.

Polarity

It is required that all fuses and single-pole devices such as single-pole circuit breakers and switches are connected in the line conductor only. It is further required that the center contact of Edison screw lamp holders be connected to the line conductor (BS EN 60298 E14 and E27 ES types are exempt as the screwed part is insulated) and that socket outlets and similar accessories are correctly connected.

Ring final circuits

If method 3 for testing ring circuit conductor continuity was performed, then any cross-polarity would have shown itself and been rectified. Hence no further test is necessary. However, if method 1 or 2 were used, and the mid-point socket was correct, reversals elsewhere in the ring would not be detected and therefore two tests are needed:

1. Link completed line and cpc loops together at the fuse board and test between L and E at each socket. A no reading result will indicate a reversed polarity (Figure 2.6).

2. Repeat as in 1, but with L and N linked. RADIAL CIRCUITS For radial circuits, the test method 1 for continuity of protective conductors will have already proved correct polarity.

It just remains to check the integrity of the neutral conductor for socket outlet circuits, and that switch wires and neutrals are not mixed at lighting points.

This is done by linking L and N at the fuse board and testing between L and N at each outlet and between N and switch wire at each lighting point.

Also, for lighting circuits, to test for switches in line conductors, etc., link L and E at the fuse board and test as shown in Figure 2.7.

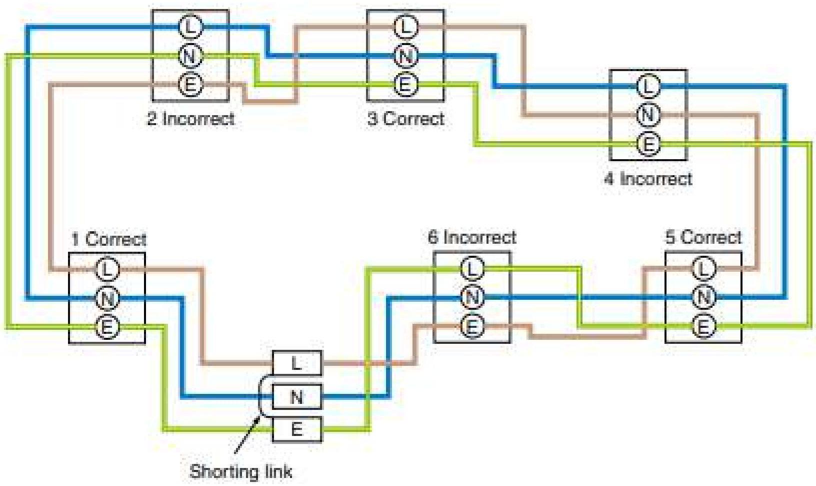

Figure 13: Polarity test if done separately to method 3 ring tests.

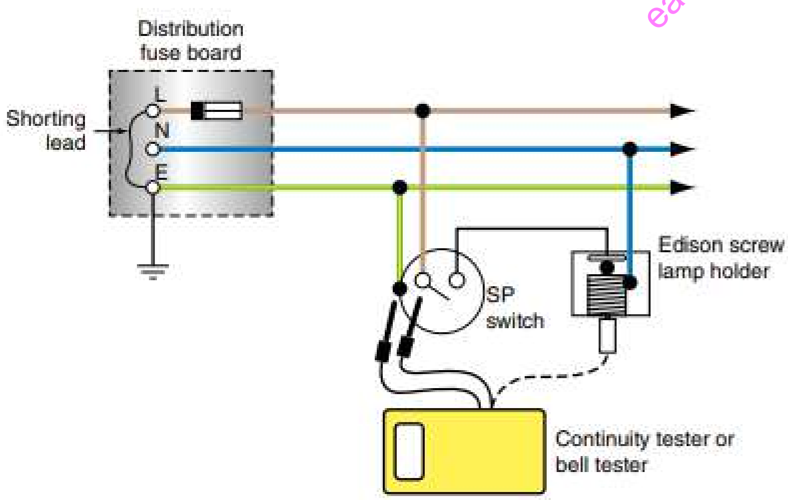

Figure 14: Polarity on ES lamp holder.

Earth electrode resistance

If we were to place an electrode in the earth and measure the resistance between the electrode and points at increasingly larger distances from it, we would notice that the resistance increased with distance until a point was reached (usually around 2.5m) beyond which no increase in resistance was noticed (Figure 2.8).

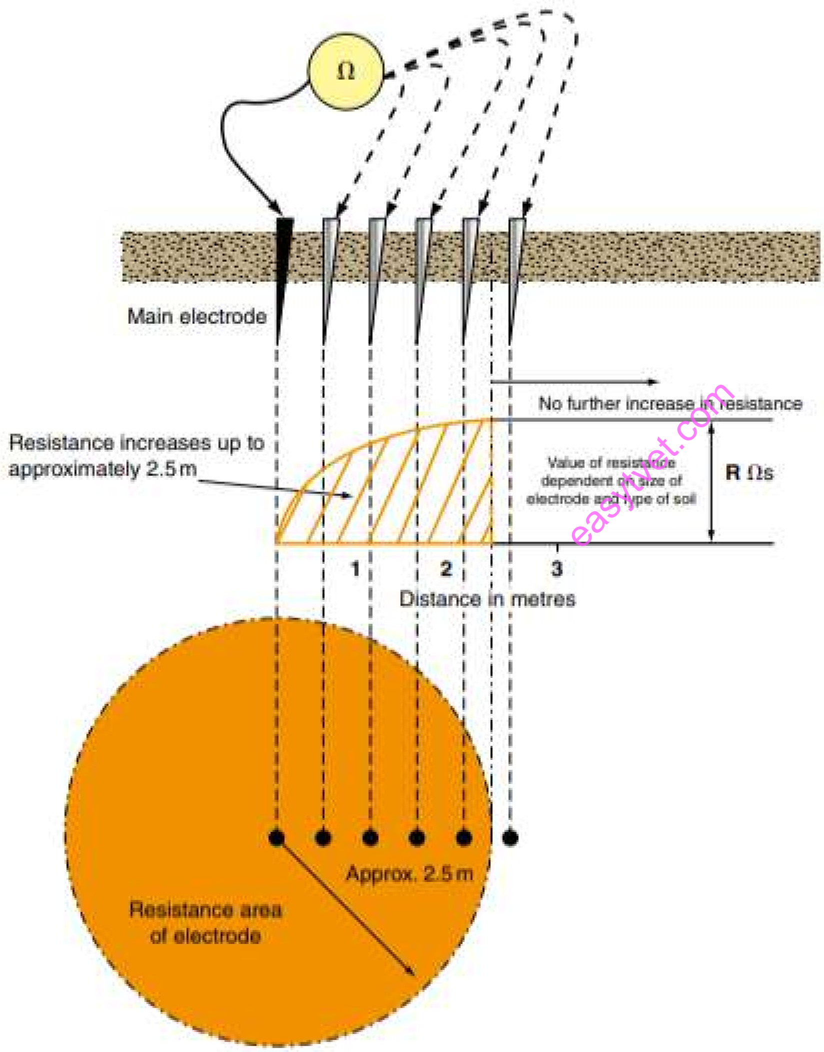

Figure 15: Electrode resistance areas

It is a requirement of the Regulations that for a TT system, exposed conductive parts must be connected via protective conductors to an earth electrode, and that the protection is by either an RCD or an overcurrent device, the RCD being preferred. Conditional on this is the requirement that the product of the sum of the resistances of the earth electrode and protective conductors, and the operating current of the protective device, shall not exceed 50V, i.e. $Ra \times Ia \leq 50V$. (Ra is the sum of the resistances of the earth electrode and the protective conductors connecting it to the exposed conductive part.) Clearly then, there is a need to measure the resistance of the earth electrode. This may be done in either of two ways.

Method 1

Based on the principle of the potential divider (Figure 2.9,), an earth resistance tester is used together with test and auxiliary electrodes spaced as shown in Figure 3.0. This spacing ensures that resistance areas do not overlap.

The method of test is as follows:

1. Place the current electrode (C2) away from the electrode under test, approximately 10 times its length, i.e. 30m for a 3m rod.

2. Place the potential electrode mid-way.

3. Connect test instrument as shown.

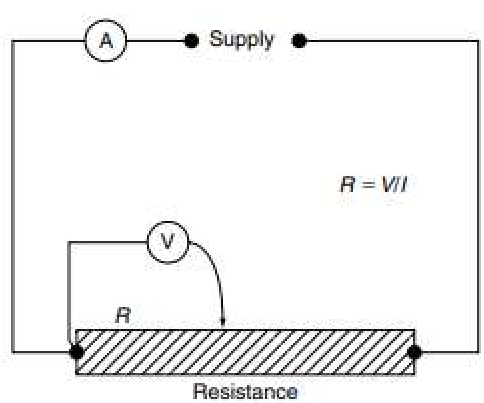

Figure 16: Potential divider.

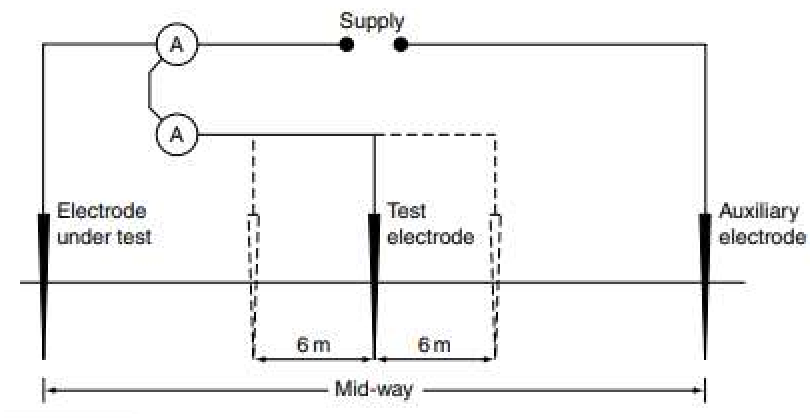

Figure 17: Positions of test electrodes.

4. Record resistance value.

5. Move the potential electrode approximately 6m either side of the mid-position, and record these two readings.

6. Take an average of these three readings (this is the earth electrode resistance). Three readings obtained from an earth electrode resistance test were 181Ω, 185Ω and 179Ω. What is the value of the electrode resistance?

$$Average\ value = \frac{181+185+179}{3} = 181.67\Omega$$

For TT systems the result of this test will indicate compliance if the product of the electrode resistance and the operating current of the overcurrent device does not exceed 50V.

Method 2

On TT systems protected by an RCD, a loop impedance tester is used and effectively measures Ze, which is taken as the earth electrode resistance.

External loop impedance Ze

This is carried out by connecting an earth fault loop impedance tester between the supply line conductor and the earthing conductor at the intake position with the earthing conductors disconnected.

This ensures that parallel resistance paths will not affect the reading. Wherever possible the installation should be isolated from the supply during the test. If this is not possible then all circuits should be isolated. When the test is completed reconnect the earthing conductor.

Earth fault loop impedance Zs

This has to be measured in order to ensure that protective devices will operate in the specified time under fault conditions. As the value of (R1+R2) Ω for a particular circuit will have already been established, Zs may be found by simply adding the R1+R2 value to Ze.

Alternatively, it may be measured directly at the extremity of a particular circuit. Whichever method is used, the value obtained will need to be corrected to compensate for ambient and conductor operating temperatures before a comparison is made with the tabulated values of Zs in the Regulations.

Note: All main protective and supplementary bonding must be in place during this test.

Additional protection

Residual current devices

Only the basic type of RCD will be considered here. Clearly, such devices must operate to their specification; an RCD tester will establish this. As with loop impedance testing, care must be taken when conducting this test as an intentional earth fault is created in the installation.

In consequence, a loop impedance test must be conducted first to confirm that an earth path exists or the RCD test could prove dangerous. It is important to know why an RCD has been installed as this has direct effect on the tests performed. The tests are as follows:

1. With the tester set to the RCD rating, half the rated current is passed through the device. It should not trip.
2. With full rated current passed through the device, it should trip within 200ms (300ms for RCBOs).

3. For RCDs having a residual current rating of 30mA or less, a test current of $5 \times I\Delta n$ should be applied and the device should operate in 40ms or less.

4. All RCDs have a test button which should be operated to ensure the integrity of the tripping mechanism. It does not check any part of the earthing arrangements or the device's sensitivity. As part of the visual inspection, it should be verified that a notice, indicating that the device should be tested via the test button quarterly, is on or adjacent to the RCD.

There seems to be a popular misconception regarding the ratings and uses of RCDs in that they are the panacea for all electrical ills and the only useful rating is 30mA!

Firstly, RCDs are not fail-safe devices; they are electromechanical in operation and can malfunction. Secondly, general purpose RCDs are manufactured in ratings from 5mA to 1000mA (30mA, 100mA, 300mA and 500mA being the most popular) and have many uses. The following list indicates residual current ratings and uses as mentioned in BS 7671.

Requirements for RCD protection

30mA

- All socket outlets rated at not more than 20A and for un-supervised general use.
- Mobile equipment rated at not more than 32A for use outdoors.
- All circuits in a bath/shower room.
- Preferred for all circuits in a TT system.
- All cables installed less than 50mm from the surface of a wall or partition (in the safe zones) if the installation is un-supervised, and also at any depth if the construction of the wall or partition includes metallic parts.
- In zones 0, 1 and 2 of swimming pool locations.
- All circuits in a location containing saunas, etc.
- Socket outlet final circuits not exceeding 32A in agricultural locations.

- Circuits supplying Class II equipment in restrictive conductive locations.
- Each socket outlet in caravan parks and marinas and final circuit for houseboats.
- All socket outlet circuits rated not more than 32A for show stands, etc.
- All socket outlet circuits rated not more than 32A for construction sites (where reduced low voltage, etc. is not used).
- All socket outlets supplying equipment outside mobile or transportable units.
- All circuits in caravans.
- All circuits in circuses, etc.
- A circuit supplying Class II heating equipment for floor and ceiling heating systems.

500mA

- Any circuit supplying one or more socket outlets of rating exceeding
- 32A, on a construction site.

300mA

- At the origin of a temporary supply to circuses, etc.
- Where there is a risk of fire due to storage of combustible materials.
- All circuits (except socket outlets) in agricultural locations.

100mA

- Socket outlets of rating exceeding 32A in agricultural locations.

Where loop impedance values cannot be met, RCDs of an appropriate

rating can be installed. Their rating can be determined from

$I\Delta n = 50 / Zs$ where $I\Delta n$ is the rated operating current of the device, 50 is the touch voltage and Zs is the measured loop impedance.

Prospective fault current

A PFC tester, usually incorporated with a loop impedance tester, is used for this. When testing at the intake position, probes and/or clips will be needed and hence great care needs to be taken when connecting to live terminals, etc. Measurements are taken between L and N, and L and E and the highest value recorded. For three phase supplies, the line to line.

PFC is determined from multiplying the L to N reading by $\sqrt{3}$ (1.732) or more simply by 2.

Phase sequence

For multi-phase circuits, e.g. supplies to three-phase motors, etc., it is important to check that the phase sequence is correct to ensure correct direction of rotation. A phase sequence instrument is used which is basically a small three-phase motor.

Functional testing

Tests on assemblies

These are carried out on a switchgear, interlock, control gear, etc., to ensure that they are mounted and installed according to the Requirements of the 17th Edition.

Voltage drop

There may be occasions when verification of voltage drop is required.

This would be achieved by calculation or by reference to charts or tables.

Periodic inspection and testing

After an installation has had an initial verification and been put into service, there is a requirement for regular periodic verification to take place. In some cases where, for example, a Local Authority is involved, the interval between tests is mandatory. In other cases, the interval is only a recommendation. For example, the recommended time between tests on domestic installations is 10 years, whereas places of public entertainment have a mandatory interval of one year.

Clearly, periodic tests may prove difficult, as premises are usually occupied and in full service, and hence careful planning and consultation are needed in order to minimize any disruption. A thorough visual inspection should be undertaken first, as this will indicate to the experienced inspector the depth to which he or she needs to go with the instrument tests, and an even more rigorous investigation may be required if drawings/design data are not available.

The visual inspection will need to take into account such items as safety, wear and tear, corrosion, signs of overloading, mechanical damage, etc.

In many instances, a sample of items inspected may be taken, for example a minimum of 10% of switching devices may be taken. If, however, the sample indicates considerable deterioration then all items must be inspected.

The test sequence where relevant and where possible should be the same as that for an initial verification. This is not essential: As with visual inspection, sample tests may be made, usually 10%, with the proviso that this is increased in the event of faults being found.

In the light of previous comments regarding sampling, it is clear that periodic verification is subjective, varying from installation to installation. It is also more dangerous and difficult and hence requires the inspector to have considerable experience. Accurate and coherent records must be made and given to the person/s ordering the work. Such records/reports must indicate any departures from or non-compliances with the Regulations, any restrictions in the testing procedure, any dangerous situations, etc.; if the installation was erected according to an earlier edition of the Regulations, it should be tested as far as possible to the requirements of the 17th Edition, and a note made to this effect on the test report.

It should be noted that if an installation is effectively supervised in normal use, then Periodic Inspection and Testing can be replaced by regular maintenance by skilled persons. This would only apply to, say, factory installations where there are permanent maintenance staff.

6

Identification and specification of test equipment

Testing instruments

In order to fulfill the basic requirements for testing to BS 7671, the following instruments are needed:

1. A low-resistance ohmmeter (continuity tester).

2. An insulation resistance tester.

3. A loop impedance tester.

4. A residual current device (RCD) tester.

5. A prospective fault current (PFC) tester.

6. An approved test lamp or voltage indicator.

7. A proving unit.

8. An earth electrode resistance tester.

Many instrument manufacturers have developed dual or multifunction instruments; hence it is quite common to have continuity and insulation resistance in one unit, loop impedance and PFC in one unit, loop impedance, PFC and RCD tests in one unit, etc.

However, regardless of the various combinations, let us take a closer look at the individual test instrument requirements.

Low-resistance ohmmeters/continuity testers

Bells, buzzers, simple multimeters, etc., will all indicate whether or not a circuit is continuous, but will not show the difference between the resistance of, say, a 10 m length of 10 mm^2conductor and a 10 m length of 1 mm^2 conductor.

I use this example as an illustration, as it is based on a real experience of testing the continuity of a 10 mm^2main protective bonding conductor between gas and water services. The services, some 10 m apart, were at either ends of a domestic premise.

The 10 mm^2 conductor, connected to both services, disappeared under the floor and a measurement between both ends indicated a resistance higher than expected.

Further investigation revealed that just under the floor at each end, the 10 mm^2 conductor had been terminated in a connector block and the joint between the two, about 8 m, had been wired with a 1 mm^2 conductor. Only a milli-ohmmeter would have detected such a fault.

Insulation resistance testers

An insulation resistance test is the correct term for this form of testing, not a megger test as megger is a manufacturer's trade name, not the name of the test.

A low-resistance ohmmeter should have a no-load source voltage of between 4 and

24 V, and be capable of delivering an A.C or D.C short circuit voltage of not less than 200 mA. It should have a resolution (i.e. a detectable difference in resistance) of at least 0.01 m **Ω**.

An insulation resistance tester must be capable of delivering 1 mA when the required test voltage is applied across the minimum acceptable value of insulation resistance.

Hence, an instrument selected for use on a low-voltage (50 V ac–1000 V ac) system should be capable of delivering 1 mA at 500 V across a resistance of 1 M Ω.

Loop impedance tester

This instrument functions by creating, in effect, an earth fault for a brief moment, and is connected to the circuit via a plug or by 'flying leads 'connected separately to line, neutral and earth.

The instrument should only allow an earth fault to exist for a maximum of 40 ms, and a resolution of 0.01 Ω is adequate for circuits up to 50 A. Above this circuit rating, the ohmic values become too small to give such accuracy using a standard instrument, and more specialized equipment may be required.

RCD tester

Usually connected by the use of a plug, although ‘ flying leads ’are needed for non-socket outlet circuits, this instrument allows a range of out-of-balance currents to flow through the RCD to cause its operation within specified time limits.

The test instrument should not be operated for longer than 2 s, and it should have a 10 per cent accuracy across the full range of test currents.

The instrument should only allow an earth fault to exist for a maximum of 40 ms, and a resolution of 0.01 Ω is adequate for circuits up to 50 A. Above this circuit rating, the ohmic values become too small to give such accuracy using a standard instrument, and more specialized equipment may be required.

Earth electrode resistance tester

This is a 3 or 4 terminal, battery powered, resistance tester.

PFC tester

Normally one half of a dual loop impedance/PFC tester, this instrument measures the prospective line-neutral fault current at the point of measurement using the same leads as for loop impedance.

Approved test lamp or voltage indicator

A flexible cord with a lamp attached is not an approved device, nor for that matter is the ubiquitous ‘testascope ’or ‘neon screwdriver’, which encourages the passage of current, at low voltage, through the body!

A typical approved test lamp is as shown in Figure 3.1.

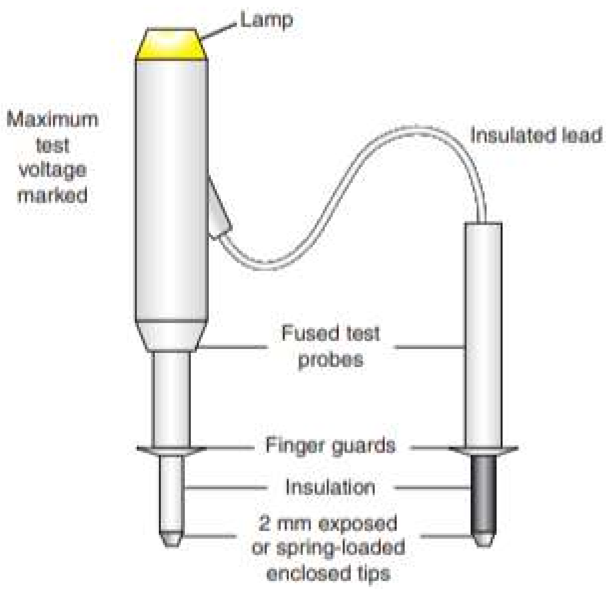

Figure 18: Approved test lamp

Note: Test lamps must be proved against a voltage similar to that to be tested. Hence, proving test lamps that incorporate an internal check, that is shorting out the probes to make a buzzer sound is not acceptable if the voltage to be tested is higher than that delivered by the test lamp.

Characteristics leads and probes associated with test equipment

The Health and Safety Executive, Guidance Note GS 38, recommend that the leads and probes associated with test lamps, voltage indicators, voltmeters, etc., have the following characteristics:

1. The leads should be adequately insulated and, ideally, fused.

2. The leads should be easily distinguished from each other by color.

3. The leads should be flexible and sufficiently long for their purpose.

4. The probes should incorporate finger barriers, to prevent accidental contact with live parts.

5. The probes should be insulated and have a maximum of 2 mm of exposed metal, but preferably have spring loaded enclosed tips.

Calibration of test equipment

Calibration for test equipment is done to ensure that your instruments always perform as expected.

Calibration of measuring test equipment or electrical test equipment such as data loggers, multimeters, oscilloscopes, power supplies or tachometers is required to ensure that your measuring instruments always perform according to expected specifications and standards.

Purpose of Calibration

To ensure readings from an instrument are consistent with other instruments and to determine the accuracy of the instrument i.e. that it can be trusted for its observed/displayed measured value.

Importance of calibration for industry

- To ensure that products are manufactured to specifications.
- To demonstrate that the industry operates a quality system and technically competent and are able to generate technically valid results.
- To increase quality & value of product.
- The calibrated measuring instruments (working standards) have the assurance of an unbroken chain of national/international measuring standards

A standard preventative maintenance service on all instruments

- Pre-service calibration checks are taken
- The equipment is checked internally for any damage, loose electrical connections or foreign material. The cover/s are refitted after all practical foreign material is removed.
- The instrument is then checked externally for damage, inoperative switches, frozen leveling feet or poorly adjusted tare bars. Any old and excess stickers are removed and the housing is cleaned as necessary Corner load, linearity and calibration errors are corrected to obtain optimum performance
- A service sticker is attached to the Instruments which includes the Service and Calibration Report numbers, date the instrument was serviced and when the next preventative maintenance service is recommended

http://nunesinstruments.com/calibration.htm https://www.intertek.com/testing-analysis/calibration/

Test equipment care, storage and maintenance

Care of test instruments The EAWR (1989) require that all electrical systems, this includes test instruments, be maintained to prevent danger.

This does not restrict such maintenance to just a yearly calibration, but requires equipment to be kept in good condition in order that it is safe to use at all times.

In consequence it is important to ensure the continual accuracy of instruments by comparing test readings against known values.

This is most conveniently achieved by the use of 'checkboxes 'which are readily available. Whilst test instruments and associated leads, probes and clips, etc., used in the electrical contracting industry are robust in design and manufacture, they still need treating with care and protecting from mechanical damage.

Keep test gear in a separate box or case away from tools and sharp objects and always check the general condition of a tester and leads before they are used.

6.2.2.5 Reference

IEE Wiring Regulations: Inspection, Testing and Certification Sixth Edition Brian Scaddan, IEng, MIET

https://electrical-engineering-portal.com/inspection-electrical-installations-home-1

https://www.dfliq.net/blog/electrical-inspection-a-detailed-overview/

http://nunesinstruments.com/calibration.htm

https://www.intertek.com/testing-analysis/calibration/

6.2.2.6 learning activities

Learning activity 1

In an electrical installation equipment store, identify measuring instruments that are used to test the presence of voltage in a circuit and perform the voltage test using each of the equipment you identified.

Learning activity 2

Identify the testing instrument found in an electrical installation workshop to test for ring continuity and perform the testing on an existing power circuit.

6.2.2.7 Self-assessment: Learning Outcome 2

1. Identify the type of instrument that would be used to measure leakage current in a circuit.

   A. voltmeter

   B. test lamp

   C. Voltage tester

   D. clamp meter

2. Before carrying out an Insulation Resistance test on a lighting circuit, its essential to...

   A. ensure all light switches are in the off position

   B. link the line and cpc in the CCU

   C. disconnect the earthing conductor

   D. remove all loads from the circuit

3. Continuity of protective conductors (R2) tests are carried out using

   A. a volt meter

   B. a low ohms meter

   C. an insulation resistance tester

   D. a continuity tester

4. State the overall effect on Insulation Resistance if twice as many circuits are added to an existing consumers unit (CCU).

   A. Insulation Resistance would remain the same

   B. Insulation Resistance would increase

   C. Insulation Resistance would decrease

   D. Insulation Resistance would be be 200M Ohms

5. Where is a live polarity check carried out to verify that the supply to an installation is correct?

A. at the end of any installed circuit

B. at the end of every circuit

C. at the mains intake position

D. at any socket outlet

6. During a test on an installation, the following readings were obtained: 20 MΩ; 8 kA; 22 ms. List the instruments which gave these readings.
7. List the first three tests that should be carried out during an initial verification on a new domestic installation.
8. The test for the continuity of a cpc in a radial circuit feeding one socket outlet uses a temporary link and a milliohmmeter, state:

a) where the temporary link is connected.

b) Where the milli-ohmmeter is connected.

c) What the meter reading represents.

9. List three precautions to be taken prior to commencing an insulation resistance test on an installation.
10. List three reasons for conducting a dead polarity test on an installation.
11. Figure 2 shows the layout of the electrical installation in a new detached garage. You are to carry out an initial verification of that installation.

(a) What documentation/information will you require in order to carry out the verification?

(b) Where should it be located?

(c) What particularly important details regarding this installation should have been included on such documentation?

(d) What consideration should be given to the existing installation from which this new installation is fed?

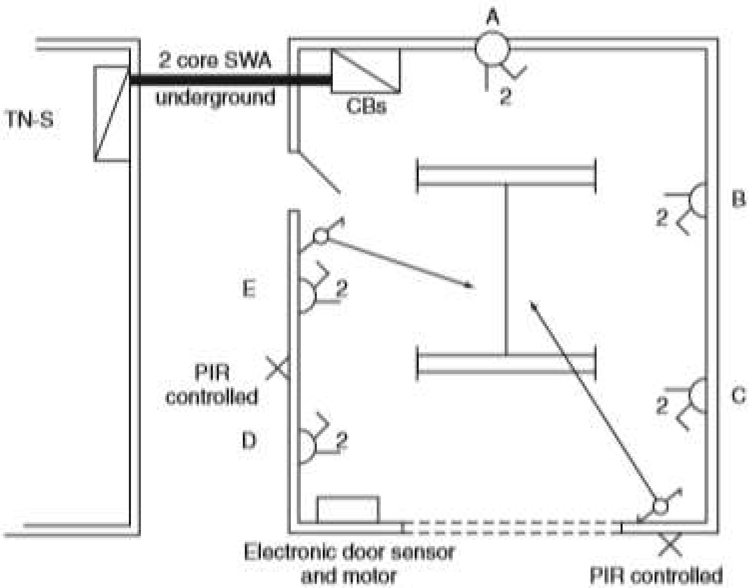

Figure 3.1: Shows the layout of the electrical installation in a new detached garage

(**Source:** IEE Wiring Regulations: Inspection, Testing and Certification Sixth Edition Brian Scaddan, IEng, MIET)

Tools, Equipment, Supplies and Materials

Tools

Phase Tester

Screw drivers

Equipment

- Test instruments
  - Continuity tester (ohmmeter)
  - Insulation resistance tester
  - Earth loop impedance tester
  - Test lamp

Materials and supplies materials

- BS 7671
- Guidance Note 3
- The On-site Guide.
- Stationery
- Wiring certificates

References

- Manufacturers' manuals
- Relevant catalogues
- IEE regulations
- Standards
- County by-laws
- Occupational Safety and Health Act (OSHA)
- National Environmental Management Authority (NEMA) regulations
- National Construction Authority (NCA) regulations
- IEE tables

7

6.2.3 Learning outcome 3: Perform Testing of Electrical Installation

6.2.3.1 Introduction to the learning outcome

This learning outcome specifies the content of competencies required to carry out **Visual inspection** and tests as per test standards and procedures as guided by IEE Regulation, OSHA and EHS.

6.2.3.2 Performance Standard

1. Test sequence procedure is decided based on the test standards
2. Safety precautions are adhered to as per OSHA
3. Additional precaution is observed on the installation in hazardous environment as per EHS standard
4. **Tests** are carried out in line with the IEE regulations
5. Test results are recorded and compared with standards values
6. Test report is compiled and shared with relevant parties

6.2.3.3 Information Sheet

Purpose of Electrical Installation Testing

All new completed electrical installation should be tested before connection to the supply. The purpose of the electrical installation condition report and testing is to provide, as far as is reasonably practicable:

- To ensure that the installation is technically sound and free from any possible short circuits, etc.
- To know the cause of failure of a particular circuit or circuits or equipment and to locate the exact position of break down.
- To ensure that it is free from faults and is as per electricity rules.
- These tests will receive the attention of the owner before any possible undue damage occurs. i.e. to Confirm that the installation is not damaged or deteriorated.
- For the safety of persons and livestock.
- Protection against damage by fire and heat.

Reasons of electrical installation testing

- To ensure that people and goods are kept safe and are protected in the event of a fault.

- Facilitates preventive maintenance of installations, preventing serious faults which might prove expensive (production shutdown, etc.).
- To guarantee people's safety with regard to these installations and the electrical
- Equipment connected to them, standards have naturally been developed and updated to take changes into account.

The electrical testing is divided into 2 parts:

1. **Visual inspection** to guarantee that the installation complies with the safety requirements (presence of an earth electrode, protective devices, etc.) and does not show any visible evidence of damage.

2. **Measurements/Tests**

Types of Electrical Installation Tests

The tests should be made on a new electrical installation before it is switched on to the mains are as under:

1. Insulation resistance test between installation and earth.
2. Insulation resistance test between conductors.
3. Testing of polarity.
4. Testing of earth continuity paths.
5. Earth resistance test.
6. Continuity test
7. Earth loop impedance test

Insulation Resistance Test between Installation and Earth

This test is performed to know the standard of insulation of wires and cables used in the installation.

It also ensures that the insulation is sufficient enough to avoid any possible leakage of current to earth.

The leakage of the current to earth should not exceed 0.02% of the full load current.

Before performing insulation resistance test between installation and earth the conditions to be fulfilled for the position of the main switch, fuses, switches, and other points should be as under:-

- Main switch in OFF position, fuses beyond the main switch should be in position, all switches in ON position.
- All lamps and other equipment should be in their position.

For testing the whole installation, the test is conducted on the main switch. A testing set known as megger is used for the test. It is a special form of the ohmmeter**.**

To perform this test, the **phase and the neutral is short-circuited** temporarily at any suitable point as shown in Figure below;

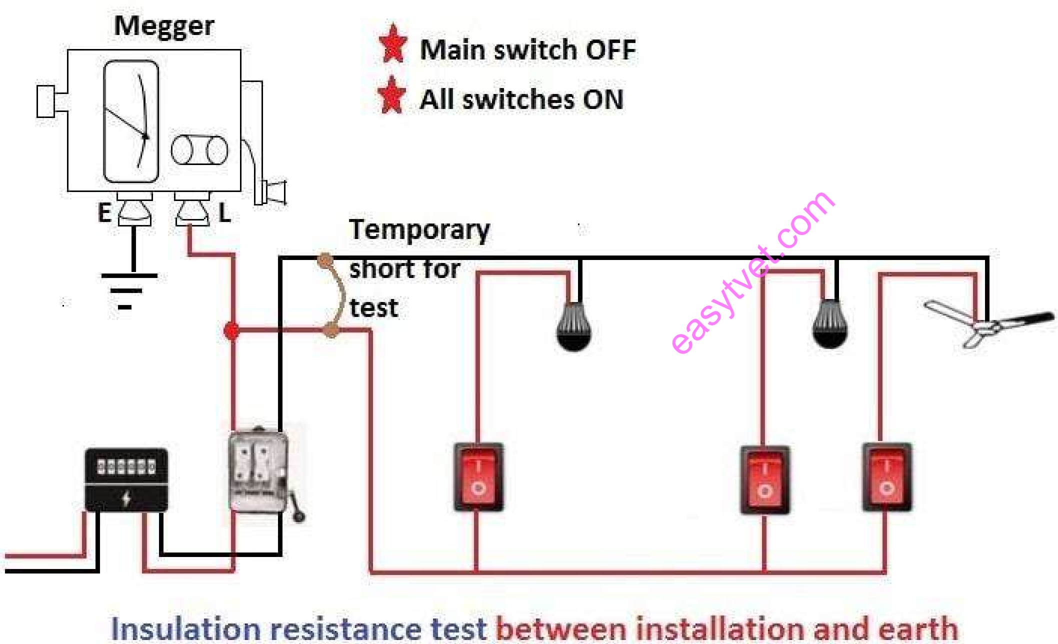

Figure 3.2: Insulation Resistance Test between Installation and Earth

- The 'L' (line terminal) of the megger is connected to the short circuit point in the main switch and the earth terminal marked (E) is connected to earth continuity conductor or some good earth point near-by.

The handle of the tester is turned at a high speed so that sufficient testing voltage is produced. The reading on the dial of the megger is noted.

The **insulation resistance thus measured should not be less than 0.5 MΩ** on a firm, sound and fixed wiring. If the insulation resistance is below this value, the wiring section giving that value should be rewired or checked thoroughly until the required value is obtained.

Insulation Resistance Test between Wiring Conductors

To ensure that the insulation of the cables or wires is not damaged and there is no leakage between them, this test is performed.

Before performing this test, the position of the main switch, fuses, switches, etc. should be as follows:

- ***Main switch in OFF position,***
- ***All switches in ON position,***
- ***All lamps and other appliances should be removed,***
- ***Fuses beyond the main switch should be in position***.

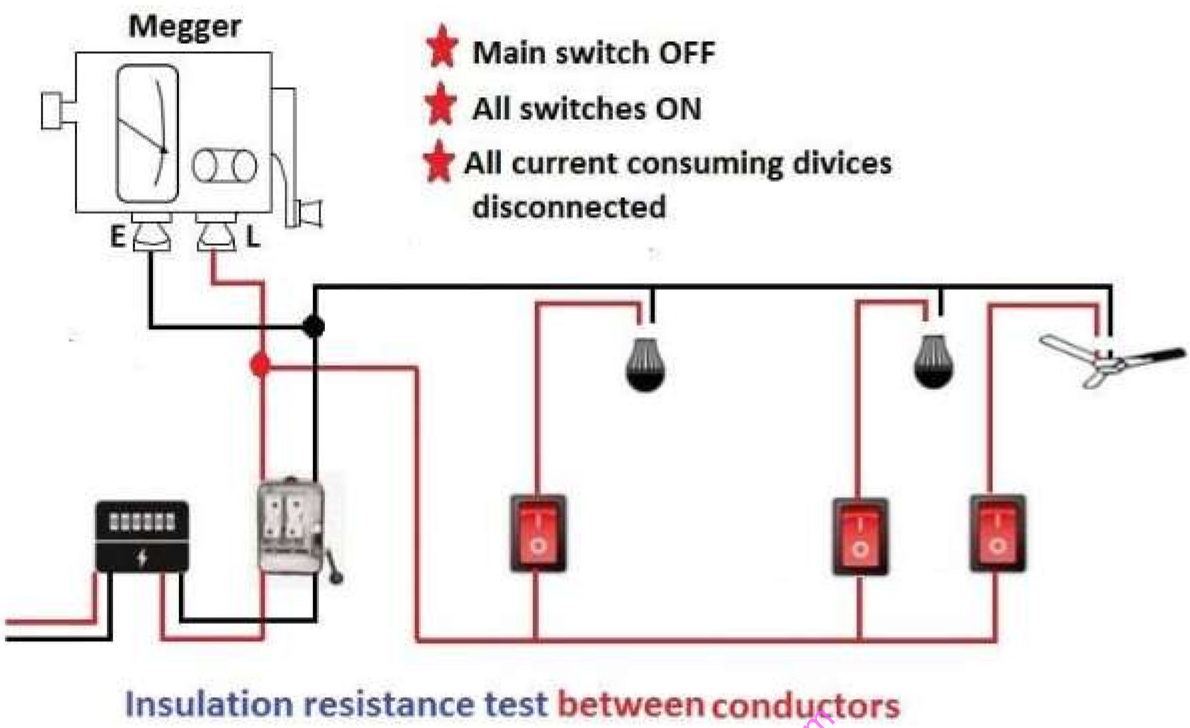

Figure 3.3: Insulation Resistance Test between Wiring Conductors

The line terminal of the megger is connected to phase terminal of the installation and the earth terminal of megger is connected to neutral wire.

The insulation resistance so measured should not be less than 1MΩ, for an installion and 0.5 MΩ for an appliance,

Refer from IEE Regulations

Polarity Test in House Wiring

In a low voltage installation, this test is performed to verify that all single pole switches have been connected to phase wire throughout the installation.

It is very necessary to place all switches on phase so that when a switch is made OFF, the connected appliance is quite dead.

If the switch is connected to the neutral wire then the connected appliance will get phase even if the switch is in OFF position and remain alive.

There is absolutely no difference in the functioning of the switch in either case, but from the safety point of view to avoid shock, etc. the phase should always be given through the switch and neutral direct to the point.

The simple method of conducting the polarity test is by using a test lamp.

Before performing this test the position of the main switch, fuses, switches, etc. should be as under main switch in ON position, all switches in OFF position, all lamps and other appliances should be removed.

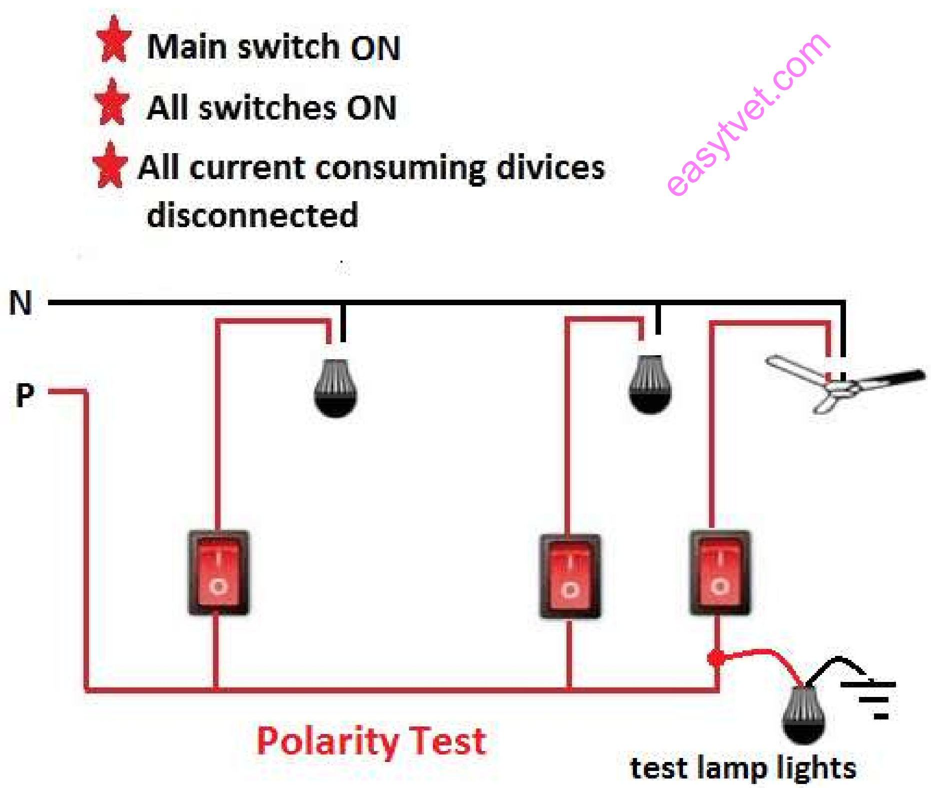

Figure 3.4: Polarity Test in House Wiring

One end of the test lamp is connected to earth wire and the other end to the incoming terminal of the switch.

If the lamp lights, it indicates that the switch is connected to phase wire, otherwise to neutral wire.

Earth Continuity Test of Electrical Installation

To perform this test with the help of megger, the main switch is opened, the main fuses are withdrawn, all the switches are made ON and all the lamps are put in position.

The 'L' (line terminal) of the megger is connected to the phase conductor in the main switch and 'E' (earth terminal) of the megger is connected to an earth point.

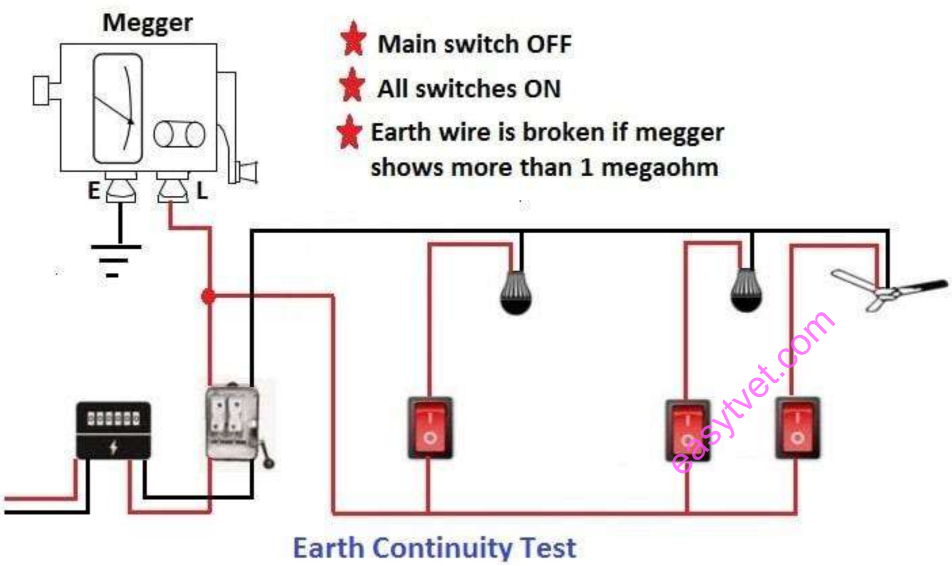

Figure 3.5: Earth Continuity Test of Electrical Installation

In this test, megger should indicate a resistance value between 0.5 and 1 mega ohm.

In this case, if earthing of all the metallic parts and the earth wire will be in good condition, a sufficient amount of current will flow through test circuit and megger will show a reading up to 1 MΩ.

If it will be in bad condition then it will offer high resistance to the current. As a result, a very low quantity of current will flow and megger will show a reading more than 1 MΩ.

Therefore, **if the megger shows a high reading (more than 1 MΩ), it means that the main switch or conduit is not**

properly earthed or the earth wire is broken somewhere requiring correction.

Earth Resistance Test

Resistance of earth is the resistance between infinite earth and earth electrode. This depends upon mainly three factors

1. The resistance of the electrode itself,
2. The contact resistance between electrode surface and soil,
3. The resistivity of soil between the electrode and infinite earth.

https://www.electrical4u.com/resistance-of-earth/#:~:text=%20Resistance%20of%20Earth%20%201%20The%20resistance,between%20the%20electrode%20and%20infinite%20earth.%20More%20

Test Methods for Measuring Earth Resistance

There are six basic test methods to measure earth resistance

1. Four Point Method (Wenner Method)
2. Three-terminal Method (Fall-of-potential Method / 68.1% Method))
3. Two-point Method (Dead Earth Method)
4. Clamp-on test method
5. Slope Method

(1) Four Point Method (Wenner Method):

- This method is the most commonly used for measuring soil resistivity,

Required Equipment:

- Earth Tester (4 Terminal)
- 4 No's of Electrodes (Spike)
- 4 No's of Insulated Wires
- Hammer
- Measuring Tap

Connections:

First, isolate the grounding electrode under measurement by disconnecting it from the rest of the system.

Earth tester set has four terminals, two current terminals marked C1 and C2 and two potential terminals marked P1 and P2.

P1 = Green lead, C1 = Black lead, P2 = Yellow lead, C2 = Red lead

In this method, **four small-sized electrodes** are driven into the soil at the **same depth and equal distance from one another** in a straight line.

The distance between earth electrodes should be at least **20 times greater** than the electrode depth in ground.

Example, if the depth of each earth electrode is 1 foot then the distance between electrodes is greater than 20 feet.

The earth electrode under measurement is connected to **C1** Terminal of Earth Tester.

Drive another potential Earth terminal **(P1)** at depth of 6 to 12 inches from some distance at **C1** Earth Electrode and connect to **P1** Terminal of Earth Tester by insulted wire.

Drive another potential Earth terminal **(P2)** at depth of 6 to 12 inches from some distance at **P1** Earth Electrode and connect to **P2** Terminal of Earth Tester by insulted wire.

Drive another Current Electrode **(C2)** at depth of 6 to 12 inches from some distance at **P2** Earth Electrode and connect to **C2** Terminal of Earth Tester by insulted wire.

Connect the ground tester as shown in the picture.

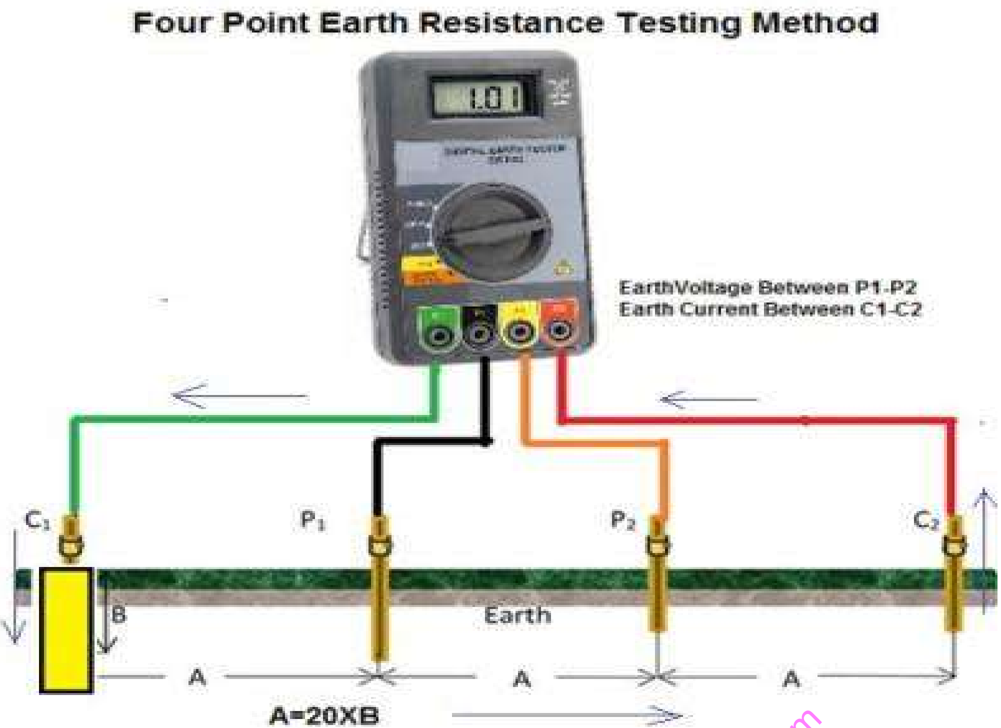

Figure 3.6: Four-point earth resistance testing method

Testing Procedure:

Press START and read out the resistance value. This is the actual value of the ground Resistance of the electrode under test.

Record the reading on the Field Sheet at the appropriate location. If the reading is not stable or displays an error indication, double check the connections. For some meters, the RANGE and TEST CURRENT settings may be changed until a combination that provides a stable reading without error indications is reached.

The Earthing Tester has basically Constant Current generator which injects current into the earth between the two current terminals C1 (E) and C2 (H).

The potential probes P1 & P2 detect the voltage ΔV (a function of the resistance) due to the current injected in the earth by the current terminals C1 & C2.

The test set measures both the current and the voltage and internally calculates and then displays the resistance. R=V/I

If this ground electrode is in parallel or series with other ground rods, the resistance value is the total value of all resistances.

Ground resistance measurements are often corrupted by the existence of ground currents and their harmonics. To prevent this, it is advisable to use Automatic Frequency Control (AFC) System. This automatically selects the testing frequency with the least amount of noise enabling you to get a clear reading.

Repeat above steps by increasing spacing between each electrode at equal distance and measure earth resistance value.

Average the all readings

An effective way of decreasing the electrode resistance to ground is by pouring water around it. The addition of moisture is insignificant for the reading; it will only achieve a better electrical connection and will not influence the overall results. Also, a longer probe or multiple probes (within a short distance) may help.

Application:

It is advisable for Medium or Large electrode System.

It is use for Multiple Depth Testing

Advantage:

This is most accurate Method.

It is Quick, easy method.

Extremely reliable conforms to IEEE 81;

Disadvantage:

There need to turn off the equipment power or disconnect the earth electrode.

One major drawback to this method is that it requires a large distance for measurement.

This distance can range up to 2,000 feet or more for ground systems covering a large area or of very low resistance.

Time consuming and labor intensive

2) Three Point (Fall-of-potential) Method.

The Fall-of-Potential method or Three-Terminal method is the most common way to measure earth electrode system resistance, but it requires special procedures when used to measure large electrode systems

There are three basic fall-of-potential test method.

Full fall-of-Potential: A number of tests are made at different spaces of Potential Probe “P” and the resistance curve is plotted.

Simplified Fall-of-Potential: Three measurements are made at defined distance of Potential Probe”P” and mathematical calculations are used to determine the resistance.

8% Rule: A single measurement is made with Potential Probe "P" at a distance 61.8% (62%) of the distance between the electrode under test and "C".

Required Equipment:

- Earth Tester (4 Terminal or 3 Terminal)
- 4 No's of Electrodes (Spike)
- 4 No's of Insulated Wires
- Hammer
- Measuring Tap

Connections:

First, isolate the grounding electrode under measurement by disconnecting it from the rest of the system.

For Small System:

For 4 Terminal Earth Tester Short Current Terminal (C1) and Potential Terminal (P1) together with a short jumper on the earth tester and connect it to earthing electrode under test.

For 3 Terminal Earth Tester Connect current terminal (C1) to the earth electrode under measurement.

Drive another Current Electrode (C2) into the earth 100 to 200 feet at depth of 6 to 12 inches from the center of the electrode and connect to C2 Terminal of earth tester.

Drive another potential terminal (P2) at depth of 6 to 12 inches into the earth midway between the Current Electrode (C1) and Current Electrode (C2) and connect to Earth Tester on P2

For Large System

Place the current electrode (C2) 400 to 600 feet from the measuring Earth Current Electrode (C1)

Place the potential electrode (P1)8% of the distance from the Earth Current Electrode (C1)

Measure the resistance

Move the current electrode (C2) farther 50 to 100 Feet away from its present position.

Place the potential electrode (P2) 61.8% of the distance from the Earth Current Electrode (C1).

Spike length in the earth should not be more than 1/20th distance between two spikes.

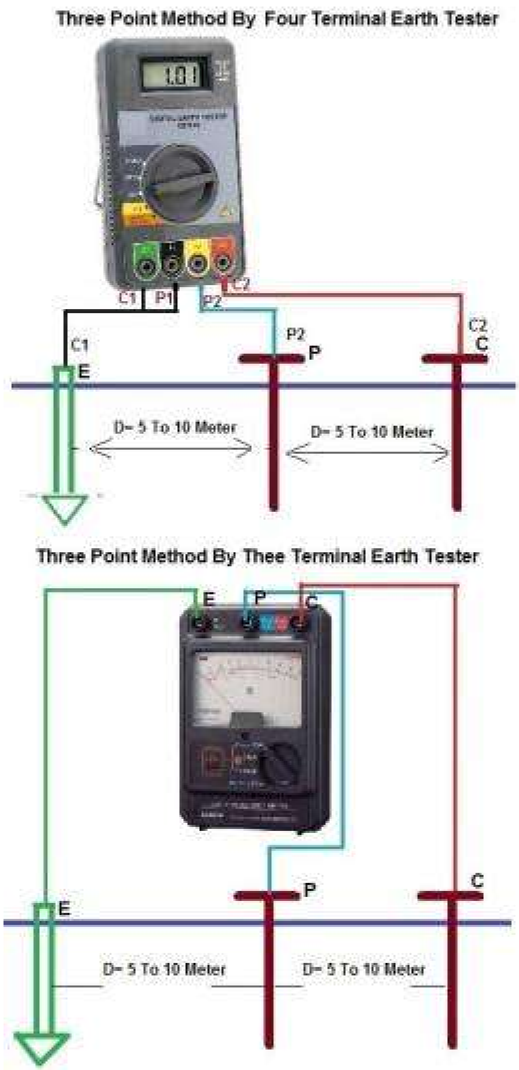

Figure 3.7: Three Point (Fall-of-potential) Method

Testing Procedure:

- Press START and read out the resistance value. This is the actual value of the ground electrode under test.
- Move the potential electrode 10 feet farther away from the electrode and make a second Measurement.
- Move the potential probe 10 feet closer to the electrode and make a third measurement.
- If the three measurements agree with each other within a few percent of their average, then the average of the three measurements may be used as the electrode resistance.
- If the three measurements disagree by more than a few percent from their average, then additional measurement procedures are required.

- The electrode center location seldom is known. In this case, at least three sets of measurements are made, each with the current probe a different distance from the electrode, preferably in different directions.
- When space is not available and it prevent measurements in different directions, suitable measurements can be made by moving the current probe in a line away from or closer to the electrode.
- For example, the measurement may be made with the current probe located 200, 300 and 400 feet along a line from the electrode.
- Each set of measurements involves placing the current probe and then moving the potential probe in 10 feet increments toward or away from the electrode.
- The starting point is not critical but should be 20 to 30 feet from the electrode connection point, in which case the potential probe is moved in 10 feet increments toward the current probe, or 20 to 30 feet from the current probe, in which case the potential probe is moved in 10 feet increments back toward the electrode.
- The spacing between successive potential probe locations is not particularly critical, and does not have to be 10 feet, as long as the measurements are taken at equal intervals along a line between the electrode connection and the current probe.
- Larger spacing means quicker measurements with fewer data points. Smaller spacing means more data points with slower measurements.
- Once all measurements have been made, the data is plotted with the distance from the electrode on the horizontal scale and the measured resistance on the vertical scale.

Importance of Position of Current Electrode (C2):

- Fall-of-Potential measurements are based on the distance of the current and potential probes from the center of the electrode under test.
- For highest degree of accuracy, it is necessary that the probe is placed outside the sphere of influence of the ground electrode under test and the auxiliary earth.
- If we Place Current Electrode (C2) too near to Earth Electrode (C1) then the sphere of influence, the effective areas of resistance will overlap and invalidate measurements taken.
- For the accurate results and to ensure that the ground stakes are outside the spheres of influence.
- Reposition the inner Potation Electrode (P1) 1meter in either direction and take a fresh measurement. If there is a significant change in the reading (30 %), we need to increase the distance between the ground rod under test, the inner

stake (probe) and the outer stake (auxiliary ground) until the measured values remain fairly constant when repositioning the inner stake (probe).

- **The best distance for the current probe is at least 10 to 20 times the largest dimension of the electrode.**
  - Because measurement results are often distorted by underground pieces of metal, underground aquifers, etc. so re measurements are done by changing axis of earth spike by 90 degrees, by changing the depth and distance several times, these results can be a suitable ground resistance system.

    The table is a guide for appropriately setting the probe (inner stake) and auxiliary ground (outer stake).

Table 3: Appropriately setting the probe (inner stake) and auxiliary ground (outer stake).

Distance of Probe Depth of the ground electrode	**Distance to the inner stake**	**Distance to the outer stake**
2 m	15 m	25 m
3 m	20 m	30 m
6 m	25 m	40 m
10 m	**30 m**	50 m

Application:

- It is advisable for High Electrical Load.
- It is suitable for small and medium electrodes system (1 or 2 rods/plates).
- It is useful for homogeneous Soil

Advantage:

- The three-point method is the most reliable test method;
- This test is the most suitable test for large grounding systems.
- Three-terminal is the quicker and simpler, with one less lead to string Spacing for Current Probe

Disadvantage:

- Individual ground electrodes must be disconnected from the system to be measured.
- It is extremely time consuming and labor intensive.
- There are situations where disconnection is not possible.
- Knowledge of location of center probe is necessary
- Time consuming and labor intensive Ineffective if the electrical center is unknown.
- If less measurements are being made then less accurate than full Fall of Potential

61.8% Rule:

- It is proven that the actual electrode resistance is measured when the potential probe is located 61.8% of the distance between the center of the electrode and the current probe. For example, if the current probe is located 400 feet from the electrode center, then the resistance can be measured with the potential probe located 61.8% x 400 = 247 feet from the electrode center.
- The 61.8% measurement point assumes the current and potential probes are located in a straight line and the soil is homogeneous (same type of soil surrounding the electrode area and to a depth equal to 10 times the largest electrode dimension).
- The 61.8% measurement point still provides suitable accuracy for most measurements.

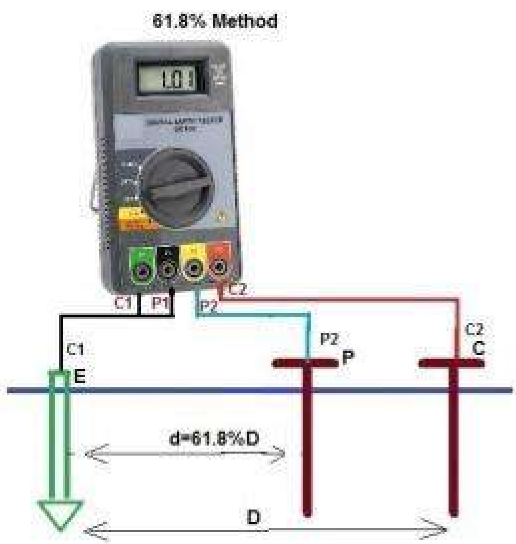

Figure 3.8: 61.8% method

- Suppose, the distance of Current Spike from Earth Electrode D = 60 ft, Then, distance of Potential Spike would be 62 % of D = 0.62D i.e. 0.62 x 60 ft = 37 ft.

Application:

- It is suitable for small and medium electrodes system.
- It is useful for homogeneous Soil

Advantage:

- Simplest to carry out.
- Required minimum calculation;
- Fewest number of test probe moves.

Disadvantage:

- Soil must be homogeneous.
- Less accurate
- Susceptible for non-homogeneous soil

Tests of protective devices

- Fuses / Circuit-breakers

  To check the specifications of the protective devices such as fuses or circuit breakers, a fault loop impedance measurement is carried out to calculate the corresponding short-circuit current. A visual inspection can then be used to check that the sizing is correct.

- Residual current devices (RCDs)

  RCDs, which detect earth leakage currents, can be tested using two methods:

- The basic test, also called a pulse test, which determines the trip time (in milliseconds)
- The step test, which determines the trip time and trip current, thus detecting any RCD ageing.

Fault finding

This is not an exact science as faults in electrical systems can be many, varied and difficult to locate. What we can state however, are the main symptoms of electrical faults, these are:

- Loss of Supply
- Fire
- Shock.

Table 1.4 indicates such symptoms, their possible common causes and the action to be taken. Column 2 illustrates, in general terms, the possible causes of faults. Table 1.5 summarizes these in more detail. Many faults are easily located, many are not, in all cases observe the following general procedure whenever possible:

1. Determine the nature/symptom of the problem.
2. Ask client/personnel for their recollections: how, when and where the problem occurred (this can save so much time).
3. Carry out relevant visual and instrument checks to locate the fault.
4. Rectify if possible.
5. Re-test.

6 Re-instate system.

Table 4: Indicates Symptoms, possible common causes and the action to be taken

Symptom	Possible common Cause	Diagnosis	Action
Complete loss of supply	1. Fault on suppliers(REC) main cable/equipment 2. Fault on service cable 3. Main fuse or CB operated 4. Main DB switch OFF 5. Main RCD operated	1. Check adjacent properties are also OFF 2. Check adjacent properties are ON 3. Check adjacent properties are ON 4. Visual check 5. Visual check	1. Contact REC 2. Contact REC 3. Contact REC 4. Switch back on 5. Re- set, if it trips, then switch off all CB's re-set and turn on each CB until one causes the main RCD to operate. This is likely faulty circuit
Loss of supply to a circuit	1. Circuit fuse or CB operated 2. Conduct broken or out of terminal	1. Visual check 2. Check fuse/CB are OK	1. Replace OR re-set as operation may be due to an overload. If protection still operates, do NOT reset until fault has been found, usually

			by carrying out insulation test 2. Locate faulty out visual check/ continuity
Fire/ burning	1. Overloaded cable 2. Damaged insulation 3. Water in fitting/accessories	1. 1,2 &3 visual check and smell	3. 1,2 &3 turn off supply, to circuit(s) investigate fuse and cable sizes, check for water ingress, damaged insulation, visually and using an insulation resistance tester
Electric shock	1. Exposed live part 2. Insulation breakdown 3. Earthing and bonding inadequate 4. Appliances incorrectly wired or damaged and with inappropriate fusing 5. Incorrect polarity in accessories	1. Use of an approved voltage indicator between exposed and/or extraneous conductive parts	1. Turn off supply to circuit(s) check visually for covers missing etc. 2. Carry out insulation resistance and polarity tests on circuit and

			cables, and establish that all Earthing and bonding is in place and all protective devices are suitable for disconnection times

Table 5: Summary of table 1.4 in more detail.

General cause	Detail
Insulation breakdown	**1.** Damage by installer **2.** Damage by other trades **3.** Damage by user (misuse, nails in walls, etc. **4.** 4. overloading
Fuse, circuit breaker or Residual Current Device operating instantly circuit is switched on	**1.** Short circuit caused by: a) Damaged insulation b) Crossed polarity at terminations c) Water penetration in joint box's seal, gland etc. **2.** Faulty appliances

Fuse or Circuit breaker operating regularly after a period of time.	**1.** Overload caused by too many loads on a circuit, or machinery stalling or with too much mechanical load **2.** Slight water penetration or general dampness
Fuse or Circuit breaker operates with no apparent fault	Transient over voltage caused by switching surges, motor starting etc

6.2.3.4 Learning activities

Learning Activity 1

Do the activity at home or during vacant time

1. Perform an insulation resistance test on an electrical installation in your institution

Learning Activity 2

By the guidance of your trainer, perform the following tests on an existing electrical installation circuit:

i. Polarity test
ii. Earth test
iii. Insulation resistance test
iv. Ring continuity test
v. Earth loop impedance test

6.2.3.5 Self-assessment learning outcome 3

1. Identify the unit of measure for an insulation resistance test

   A. ohms

   B. killo - ohms

   C. Mega - ohms

   D. Milli - ohms

2. On a continuity of ring circuit conductors test, state the purpose of taking test readings at socket outlets once the incoming and outgoing lines and cpcs have been cross-linked in the CCU.

   A. to record the (R1+R2) value

   B. to ensure the cpc is continuous

   C. to prove the circuit is a ring

   D. to ensure that the live is continuous

3. The following readings were obtained during the initial tests on a healthy ring final circuit:

   L1 - L2 -0.8 Ω; N1-N2- 0.8 Ω; cpc1-cpc2-0.8 Ω

   (a) What readings would you expect?

   (i) Between L and N Conductors at Each Socket Outlet?

   (ii) Between L and cpc At Each Socket Outlet?

   (iii) What the L to cpc reading represents?

4. What happens to:

   (a) Conductor resistance when conductor length increases?

   (b) Insulation resistance when cable length increases?

   (c) Conductor resistance when conductor area increases?

6.2.3.6 Tools, Equipment, Supplies and Materials

Tools

Phase Tester

Screw drivers

Equipment

- Test instruments
  - Continuity tester (ohmmeter)
  - Insulation resistance tester
  - Earth loop impedance tester
  - Test lamp

Materials and supplies materials

- BS 7671
- Guidance Note 3
- The On-site Guide.
- Stationery
- Wiring certificates

References

- Manufacturers' manuals
- Relevant catalogues
- IEE regulations
- Standards
- County by-laws
- Occupational Safety and Health Act (OSHA)
- National Environmental Management Authority (NEMA) regulations
- National Construction Authority (NCA) regulations
- IEE tables

Reference materials

- Standards
- County by-laws
- Occupational Safety and Health Act (OSHA)
- National Environmental Management Authority (NEMA) regulations
- National Construction Authority (NCA) regulations
- IEE tables

6.2.3.7 Reference

IEE Wiring Regulations: Inspection, Testing and Certification Sixth Edition Brian Scaddan, IEng, MIET

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6.2.4 Learning outcome 4: Issue installation test results and wiring completion Certificates

6.2.4.1 Introduction to the learning outcome

This learning outcome specifies the content of competencies required in issuing test and wiring certificate as per test standards and procedures as guided by IEE Regulation, OSHA and EHS.

6.2.4.2 Performance Standard

Test certificate is issued to the relevant parties

Wiring certificate is issued to the relevant parties

6.2.4.3 Information Sheet

Having completed all the inspection checks and carried out all the relevant tests, it remains to document all this information. This is done on;

- Electrical Installation Certificates (EICs),
- Periodic Inspection Reports (PIRs),
- schedules of inspections, schedules,
- test results,
- Minor Electrical Installation Works Certificates (MEIWCs) and any other documentation you wish to append to the foregoing.

Examples of such documentation are shown in BS 7671 and the
IEE Guidance Note 3 on inspection and testing.

This documentation is vitally important. It has to be correct and signed or authenticated by a competent person.

EICs and PIRs must be accompanied by a schedule of test results and a schedule of inspections for them to be valid.

It should be noted that three signatures are required on an EIC, one in respect of the design, one in respect of the construction and one in respect of the inspection and test.

(For larger installations there may be more than one designer, hence the certificate has space for two signatures, i.e. designer 1 and designer 2.) It could be, of course, that for a very small company, one person signs all three parts.

Whatever the case, the original must be given to the person ordering the work, and a duplicate retained by the contractor.

One important aspect of an EIC is the recommended interval between inspections.

This should be evaluated by the designer and will depend on the type of installation and its usage. In some cases, the time interval is mandatory, especially where environments are subject to use by the public.

The IEE Guidance Note 3 give recommended maximum frequencies between inspections.

A PIR is very similar in part to an EIC in respect of details of the installation, i.e. maximum demand, type of earthing system, Ze, etc.

The rest of the form deals with the extent and limitations of the inspection and test, recommendations, and a summary of the installation.

The record of the extent and limitations of the inspection is very important. It must be agreed with the client or other third party exactly what parts of the installation will be covered by the report and those that will not. The interval until the next test is determined by the inspector.

With regard to the schedule of test results, test values should be recorded unadjusted, any compensation for temperature, etc., being made after the testing is completed.

Any alterations or additions to an installation will be subject to the issue of an EIC, except where the addition is, say, a single point added to an existing circuit, and then the work is subject to the issue of an MEIWC.

Summary

1. The addition of points to existing circuits requires an MEIWC.
2. A new installation or an addition or alteration that comprises new circuits requires an EIC.
3. An existing installation requires a PIR.

Note

Points (2) and (3) must be accompanied by a schedule of test results and a schedule of inspections.

As the client/customer is to receive the originals of any certification, it is important that all relevant details are completed correctly

This ensures that future inspectors are aware of the installation details and test results which may indicate a slow progressive deterioration in some or all of the installation.

These certificates, etc., could also form part of a 'sellers pack' when a client wishes to sell a property.

The following is a general guide to completing the necessary documentation and should be read in conjunction with the examples given in BS 7671 and the IEE Guidance Note 3.

Types of electrical wiring certificates

1. Electrical Installation Completion Certificate
2. Minor Electrical Installation Works Certificate

Minor Electrical Installation Works Certificate

This certificate should be made out and signed or otherwise authenticated by a skilled person in respect of the design, construction, and inspection and testing of the minor Electrical Installation work.

A Minor Electrical Installation Works Certificate will indicate the responsibility for design, construction, inspection and testing of the work described on the certificate.

The Minor Electrical Installation Works Certificate is intended to be used for additions and alterations to an installation that do not extend to the provision of a new circuit.

Examples include the addition of socket-outlets or lighting points to an existing circuit, the relocation of a light switch etc.

This Certificate may also be used for the replacement of equipment such as accessories or luminaires, but not for the replacement of distribution boards or similar items.

Appropriate inspection and testing, however, should always be carried out irrespective of the extent of the work undertaken.

Issuance of the Minor Electrical Installation Works Certificate

This Certificate is normally issued to confirm that the electrical installation work to which it relates has been designed, constructed, inspected and tested in accordance with British Standard 7671 (the IET Wiring Regulations).

The person ordering the work receives and the contractor retains a duplicate.

An 'original' Certificate or a copy of it, you should be passed, to the owner.

A separate Certificate should be issued for each existing circuit on which minor works have been carried out.

This Certificate is not appropriate if the contractor requested, undertakes more extensive installation work, for which you should be issued an Electrical Installation Certificate.

The Certificate should be retained in a safe place and be shown to any person inspecting or undertaking further work on the electrical installation in the future.

If you later vacate the property, this Certificate will demonstrate to the new owner that the minor electrical installation work carried out complied with the requirements of British Standard 7671 at the time the Certificate was issued

Electrical installation completion certificate

This certificate should be made out and signed or otherwise authenticated by a skilled person or persons in respect of the design, construction, inspection and testing of the work.

Electrical Installation Certificates indicates the responsibility for design, construction, inspection and testing, whether in relation to new work or further work on an existing installation.

Issuance of electrical installation certificate

The Electrical Installation Certificate is to be used only for the initial certification of a new installation or for an addition or alteration to an existing installation where new circuits have been introduced, or the replacement of a consumer unit/distribution board.

It is not to be used for a Periodic Inspection, for which an Electrical Installation Condition Report form should be used.

For an addition or alteration which does not extend to the introduction of new circuits, a Minor Electrical Installation Works Certificate may be used.

The 'original' Certificate is to be issued to the person ordering the work (Regulation 644.4). A duplicate should be retained by the contractor.

1. This Certificate is only valid if accompanied by the Schedule of Inspections and the Schedule(s) of Test Results.
2. The signatures appended are those of the persons authorized by the companies executing the work of design, construction, inspection and testing respectively. A signatory authorized to certify more than one category of work should sign in each of the appropriate places.
3. The time interval recommended before the first periodic inspection must be inserted. The proposed date for the next inspection should take into consideration the frequency and quality of maintenance that the installation can reasonably be expected to receive during its intended life, and the period should be agreed between the designer, installer and other relevant parties.
4. The page numbers for each of the Schedule of Inspections and the Schedule(s) of Test Results should be indicated, together with the total number of sheets involved.
5. The maximum prospective value of fault current recorded should be the greater of either the prospective value of short-circuit current or the prospective value of earth fault current.

Electrical installation certificate

This safety Certificate is issued to confirm that the electrical installation work to which it relates has been designed, constructed, inspected and tested in accordance with British Standard 7671 (the IET Wiring Regulations).

The person ordering the work receives and the contractor retains a duplicate.

An 'original' Certificate or a copy of it, you should be passed, to the owner.

The “original” Certificate should be retained in a safe place and be shown to any person inspecting or undertaking further work on the electrical installation in the future.

If you later vacate the property, this Certificate will demonstrate to the new owner that the electrical installation complied with the requirements of British Standard 7671 at the time the Certificate was issued.

The Construction (Design and Management) Regulations require that, for a project covered by those Regulations, a copy of this Certificate, together with schedules, is included in the project health and safety documentation.

For safety reasons, the electrical installation needs to be inspected at appropriate intervals by a skilled person or persons, competent in such work. The maximum time interval recommended before the next inspection is stated under 'NEXT INSPECTION'.

This Certificate is intended to be issued only for a new electrical installation or for new work associated with an addition or alteration to an existing installation.

It should not be issued for the inspection and testing of an existing electrical installation. An 'Electrical Installation Condition Report' should be issued for such an inspection.

This Certificate is only valid if accompanied by the Schedule of Inspections and the Schedule(s) of Test Results.

6.2.4.4 Learning activities

Learning Activity 1

Imagine you are an electrical technician in an Electrical Contractor's Company. Design and plan the schedule of inspection for the ongoing projects of the company.

Learning Activity 2

Exercise

Objective: To be able to understand the checklist items when doing initial installation inspection and perform the inspection for a communication facility.

With the guidance given by the trainer, Perform initial installation inspection on the installation and complete the following form.

Materials: An **installation inspection checklist** template, and a pen

Template

INSTALLATION INSPECTION CHECKLIST

Client: ………………………………………………Contractor: …………………..………………

Physical Address: ………………………………………………………………………………

Make: ………………… Model: …………………. No. of Ports: ………..………

Visited by certification committee: Date: …………………….. Time: …………………………

Serial No.	PARTICULARS OF THE INSTALLATION	YES	NO
	MANDATORY REQUIREMENTS		
	(A) The Main Terminal Equipment		
1.	The main terminal equipment has been Type approved		
2.	The main terminal equipment has been properly accommodated in a spacious easily accessible area with proper ventilation		
3.	The main equipment has been properly mounted or fixed		
4.	The main terminal equipment cabinet has been properly closed except during maintenance		
5.	The main terminal equipment earth wire has been properly connected with the correct colour code.		
6.	The main terminal equipment earth has not been commoned to commercial power earth		
	(B) Power provision and facilities		
1.	Power cable properly clipped, trunked or cleated		
2.	Power cable has not been jointed		
3.	Power fail facility has been provided		
4.	Power fail facility extensions have been installed and are functional		
5.	The equipment room has been provided with at least one 13 amps socket.		
6.	Power has not been supplied through a multi socket extension cable		
7.	Power socket has been reserved for the terminal equipment only		
8.	All power connections needing protection have been fitted with the correct fuses		
9.	Power fail back-up (Generator or Battery has been provided and is functional		
10.	Correct separation between the power and communications cables has been observed to avoid power infringement		
	(c) Internal Wiring		
1.	The main discase has been provided and well fixed on the wall		
2.	The main discase has been properly closed		
3.	The main discase has been properly earthed		
4.	Terminated pairs on discases have been well done and soldered where necessary		
3.	All Line Jack Units (LJUs) have been properly fixed on the wall		
4.	All LJUs have been properly closed		

5.	LJUs are accessible for maintenance purposes		
6.	Trunkings have been provided for all Telecommunications Cables		
7.	Telecommunications Cables and wires with no trunking have been properly fixed and stapled		
8.	Trunking has been provided between the main equipment and discase		
9.	There are no dry or open joints on the PVC internal cables		
10.	Dropwires have not been used for internal wiring		
	(d) Block Wiring		

Serial No.	PARTICULARS OF THE INSTALLATION	YES
1.	The local internal distribution point or the main distribution frame (MDF) is accommodated in a spacious easily accessible room.	
2.	The room has adequate natural or electrical lighting	
3.	The lead in cable ducts at the MDF have been well sealed to stop water and rodents from entering the room	
4.	The distribution cables are well formed and laced inside the MDF room	
5.	The terminations at the MDF have been properly done and soldered	
6.	The terminations at the discases have been properly done and soldered	
7.	Lockable access to risers is provided for every floor with adequate electrical lighting	
8.	Conduits leaving for various rooms, flats and offices are as per specifications and originate from the local MDF/DP room	
9.	The cables are well formed, laced and well-fixed along the cable risers	
10.	Labeling and sign writing has been done where necessary	
11.	Discases, block terminals or box connections are fitted at suitable accessible areas on every floor	
12.	All discases and sub-discases have been properly earthed	
13.	The main MDF earth has been well provided at the correct value of 0-2 ohms	
14.	The current wiring distribution diagrams are kept securely in DP/MDF room.	
(e) General Issues		
1.	Installation and Commissioning manuals for the installation have been provided	
2.	The installation work has been provided according to the submitted drawings and approved drawings	
3.	Access to the premises has been allowed	
4.	Access to the equipment and the wiring has been allowed	
5.	The client has moved from the premises where the equipment was initially installed	
6.	The equipment has been recovered or interchanged after an operational problem	
7.	The certification team was able to locate the premises	
8.	The maintenance contractor is prompt after calls in case of any problem	

9.	The equipment is giving the client proper and an interrupted service	
10.	The installation is neat, organized and well laid out.	
(f) Any other findings by the Certification Committee		
	RESULTS (ACCEPTED / REJECTED/CANCELLED/DEFFERED) **Certification Committee Team Members** Name: ....Signature: .... Name: .... Signature: .... Name ....Signature: .... **Contractor's Representative** Name: ....Signature.. **Client or Representative** Name: ....Signature..............................	

6.2.4.5 Self-Assessment learning outcome 4

1. An electrical installation certificate for a new installation will require THREE signatories, Identify one of these signatories.

   A. the clerk-of-works

   B. the customer

   C. building control

   D. the inspector/tester

2. An electrical installation completion certificate for a new installation will require THREE signatories, Identify one of these signatories.

   A. the constructor

B. the clerk-of-works

C. the owner

D. the local council

3. When a certificate is issued for Initial Verification purposes, for the certificate to be valid it MUST be accompanied by?

A. test results sheet

B. schedules of inspections and test results

C. inspection tick-sheet

D. Part 'P' certificate

4. An electrical installation certificate for a new installation will require THREE signatories, Identify one of these signatories.

A. the owner

B. the designer

C. the local authority

D. the site manager

6. When the installation of a new circuit to an existing installation has been completed, the inspector will issue?

A. a condition report

B. a schedule of the tests completed

C. a minor-works certificate

D. an initial verification certificate

7. Identify the non-statutory document that details the construction and safe use of electrical test instruments and equipment.

A. HSE guidance note GS38

B. Electricity at Work regulations

C. BS7671 On-site guide

D. Electrical Regulations book

5. __________ document deals with inspection, testing and certification

6. For an addition or alteration of Electrical Installation Works. Which Certificate may be used?

7. Who issues the certificate of a new electrical installation?

8. Which certificate is normally issued after an inspection and testing of a new installation?

6.2.4.6 Tools, Equipment, Supplies and Materials

- Continuity tester (ohmmeter)
- Insulation resistance tester
- Earth loop impedance tester
- Test lamp

Materials and supplies

- A template form for periodic inspection courtesy of IET
- A Template form of model Electrical Installation Certificate courtesy of IET
- A Template form of A Model Minor Electrical Installation Works Certificate Courtesy of IET
- BS7671

Get the template forms from:

1. https://electrical.theiet.org/media/2209/bs-76712018-model-forms-minor-electrical-installation-works-certificate.pdf

2. https://electrical.theiet.org/media/2387/bs-767122018-model-forms-electrical-installation-certificate.pdf

Reference materials

- Standards
- County by-laws
- Occupational Safety and Health Act (OSHA)
- National Environmental Management Authority (NEMA) regulations
- National Construction Authority (NCA) regulations
- IEE tables

6.2.4.7 Reference

IEE Wiring Regulations: Inspection, Testing and Certification Sixth Edition Brian Scaddan, IEng, MIET

https://electrical-engineering-portal.com/inspection-electrical-installations-home-1

https://www.dfliq.net/blog/electrical-inspection-a-detailed-overview/

6.2.5 Sample Response to Self-Assessment

6.2.5.1 Responses for Self-assessment: Learning Outcome 1

1. B
2. **Visual**

   Touch

   Smell

3. **To ensure safety of persons and livestock**

   To ensure protection from fire and heat

   To ensure that the installation is not damaged so as to impair safety

   To ensure that the installation is not defective and complies with current regulations

4. **Design**

   Construction

Inspection and testing

6.2.5.2 Responses for Self-assessment: Learning Outcome 2

1. D
2. D
3. B
4. C
5. C
6. **Insulation Resistance Tester**
   Prospective Short Circuit Current Tester
   RCD Tester

7. **Continuity Of Protective Conductors**

   Continuity Of Ring Final Circuit Conductors

   Insulation Resistance

8.

a) **Between L and E at the consumer unit**

b) **Between L and E at the socket outlet**

c) **This value is (R 1+ R 2) for the circuit.**

9. **check on existence of electronic equipment**

- **check there are no neon's, capacitors, etc., in circuit**
- **all switches closed and accessories equipment removed**
- **no danger to persons or livestock by conducting the test**

10. **all single pole devices in line conductor only**

    center contact of Edison screw lamp holders in line conductor

- **All accessories correctly connected.**

11.

(a) The results of the assessment of general characteristics sections 311, 312 and 313, and diagrams, charts and similar information regarding the installation (5 marks)

(b) In or adjacent to the distribution board (3 marks)

(c) Reference to the electronic door sensor and the PIR controlled external luminaires as these could be vulnerable to a typical test (3 marks)

(d) Maximum demand, rating of consumer unit, earthing and bonding arrangements, capacity of main protective device, etc. (4 marks)

6.2.5.3 Responses for Self-assessment: Learning Outcome 3

1. C
2. A
3. (a)

    (i) **0.4 Ω**

    (ii) **0.4 Ω**

    (iii) **(R 1+ R 2) for the ring**

4.

    (a) **Increase**s

    (b) **Increase**s

    (c) **Decrease**s

6.2.5.4 Responses for Self-assessment: Learning Outcome 4

1. D
2. A
3. B
4. B
5. D
6. A
7. **To ensure accessories, etc., to relevant standard**
   To ensure compliance with BS 7671
   To ensure no damage that may cause danger

4.

(a) The Electricity at Work Regulations

(b) **BS 7671**

Guidance Note 3

The On-site Guide.

8. ***BS7671***
9. **Minor Electrical Installation Works Certificate**
10. **Contractor**
11. **Electrical Installation Certificate**