Industrial Electrical Machines and Drives Servicing Level II

Learning Guide -39

Unit of Competence: - Perform Commissioning Of Electrical Equipment/Systems

Module Title: - Performing Commissioning Of Electrical Equipment/Systems

LG Code: - EEL EMD2 M06 0919 LO2- LG39

TTLM code: - EEL EMD2 M06 0919 V1

LO2:- Commission Electrical Equipment/Systems

Instruction Sheet	Learning Guide 24

This learning guide is developed to provide you the necessary information regarding the following Learning out comes and contents.

Module learning out comes and contents:

- Following safety policies and procedures
- Following Electrical testing criteria
- commission Electrical equipment/systems
- Responding Unforeseen events
- Revising Records, electrical plans and schematic diagrams
- Filling-out and submitting test data forms

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Follow safety policies and procedures
- Follow Electrical test criteria
- commission Electrical equipment/systems
- Respond Unforeseen events
- Revise Records, electrical plans and schematic diagrams
- Fill-out and submit test data forms

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to provide the learners with the required knowledge and skill to cast concrete.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the "Information Sheets". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the "Self-checks" for each information sheet.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to "Operation sheets and LAP Tests if any". However, if your rating is unsatisfactory, ask your teacher for further instructions or go back to Learning Activity.
7. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result;
8. Then proceed to the next information sheet.

Information Sheet #1	Following Safety Policies and Procedures

2.1 Following Safety Policies and Procedures

The procedures stated in this T&C (testing and commissioning) Procedure cover the activities in preliminary tests and inspections, functional performance tests and the commissioning of newly completed installations and existing ones after major alteration. They are so compiled to facilitate the work of Project Building Services Engineer (PBSE) and Project Building Services Inspector (PBSI), who are appointed as the Architect's Representatives, in the following aspects with respect to testing and commissioning.

This T&C Procedure is also intended to lay down the minimum testing and commissioning requirements to be carried out by the EE Contractor on a new Low Voltage Cubicle Switchboard Installation upon completion or on an existing Low Voltage Cubicle Switchboard Installation after a major alteration involving modification of the main bus bar such as upgrading, reposition and extension.

One easy way to illustrate the effects of commissioning is to compare a building to a human body. Both have an outer layer of skin that protects the inner functions from the elements. Both have an electrical system, a heating and cooling system, a frame to support their weight, and even a plumbing system- as well as a distinctive personality expressed by their appearance.

Now, imagine a person's body could be commissioned to function at optimal levels. It would have no health problems. It would never get sick. It would have perfect vision and perfect hearing, and it would perform any physical task with athleticism. Cx plays the combined roles of personal trainer and doctor for your building, producing an alpha structure that far outperforms its non-commissioned counterparts.

According to the National Institute of Building Sciences' "Whole Building Design Guide," one of the main benefits of implementing Cx is cost savings. Cx produces a monetary and emotional return on investment with reduced energy costs and peace of mind in the form of reduced change orders, reduced contractor claims, reduced contractor callbacks, avoided project delays, improved project scheduling, improved documentation development and improved communications to keep the project team focused on properly turning over a facility.

Other benefits include a more comfortable environment for building occupants, improved air quality, increased reliability and uptime, reduced maintenance and longer life cycles for building equipment. Cx can be implemented with many systems across a range of projects and at any stage of a facility's life cycle.

Objectives of the Testing and Commissioning (T&C) Works:

(i) To verify proper functioning of the equipment/system after installation; and

(ii) To verify that the performance of the installed equipment/systems meet with the specified design intent through a series of tests and adjustments.

(iii) To capture and record performance data of the whole installation as the baseline for future operation and maintenance.

Types of Commissioning

There are four primary types of commissioning:

New construction commissioning - This begins when the building is just an idea, a drawing or a schematic and is typically just called "commissioning." It is a systematic process of verifying and documenting that a facility and all of its systems and assemblies are planned, designed, installed, tested, operated and maintained to meet the owner's project requirements (OPR). Ideally, the commissioning process begins in predesign, continues into the warranty period for a minimum of one year after construction, and involves the proper preparation of operations personnel.

Re-commissioning -Also known as ongoing Cx, the Cx process is repeated after a project has been commissioned previously. This may be preferred option as system.

Performance drifts and/or technologies change and advance over time, making it Possible to restore the efficiency of a previously commissioned building and potentially Enhance optimization further.

Retro-commissioning -When the Cx process begins after a building has already been built but has not been put through the commissioning process, a building's systems are tested and tuned to perform optimally for the current facility requirements. Low-cost and no-cost improvements such as energy conservation measures or reliability enhancements are also recommended, implemented and then commissioned to ensure proper performance.

Monitoring-based commissioning -Known as MBCX, this process involves innovative commissioning techniques combined with new technology to integrate energy management, utility and building automation data with analytical and diagnostic algorithms that identify actual energy savings and performance enhancement opportunities in real time and ongoing. MBCx seeks to resolve performance issues as they surface and continually refine facilities so that greater than design performance (i.e technical potential) is achieved over time.

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Choose the Best Answer

1. The procedures stated in this testing and commissioning cover:
   A. Preliminary testing & inspection B. Functional performance test
   C. Commissioning of new installation D. Commissioning existing ones
   E. All of these

2. Objectives of the Testing and Commissioning Works:
   A. To verify proper functioning of the equipment/system
   B. To verify performance of the installed equipment/system
   C. To capture and record performance data
   D. All of these
   E. None of these

3. One of the following is not types of commissioning?
   A. New construction commissioning B. Monitoring based commissioning
   C. Retro-Commissioning D. Re-Commissioning
   E. None of these

4. _______________ begins when the building is just an idea, a drawing or a schematic and is typically just called "commissioning."
   A. New construction commissioning B. Monitoring based commissioning
   C. Retro-Commissioning D. Re-Commissioning
   E. None of these

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Score = ____________

Rating: _____________

Name: ___________________________ Date: _______________

ANSWER SHEET

1. E
2. D
3. E
4. A

Information sheet #2	Following Electrical Testing Criteria

2.2 Following Electrical Testing Criteria

2.2.1. CONTINUITY TEST

What is continuity testing?

An electrical continuity test is the checking of an electric circuit to see if the current flows throughout the circuit. Continuity test is performed by applying a small voltage to one end of the circuit and measuring on the other end.

In electronics, a continuity test is the checking of an electric circuit to see if current flows (that it is in fact a complete circuit). A continuity test is performed by placing a small voltage (wired in series with an LED or noise-producing component such as a piezoelectric speaker) across the chosen path.

Continuity testing is a very valuable debugging tool which can used in conjunction with other debugging tools and can be carried out very quickly. It is a way to check if 2 parts of a circuit that should be electrically connected are indeed connected.

You can also use it to check some components are working correctly such as switches and of course for internal breaks in wires etc. As well as a quick check for ground connections and so on (see below).

Using the schematic for your pedal build will show you which parts of the circuit should be connected and conversely which should not. You would simply follow the schematic for the particular part of the circuit you wish to check.

You will need a multimeter with the continuity test facility most digital multi meters will have this, the symbol on the dial may vary slightly from meter to meter here are some examples:
As you can see it is a diode symbol with a radiating wave, some meters will display both and some one or the other.

With continuity testing your meter passes a small current into the circuit to check the resistance between 2 points. You would connect your meter probes at either end, if the current flows from one probe to the other via the part of the circuit you are testing an audible beep will be heard and a very small resistance displayed on the screen telling you there is good continuity and an electrical connection is present.

If there is no connection, no audible beep would be heard and the meter would display infinite resistance for an open circuit again different meters use different measurements usually either displaying a '1' or 'OL' indicating an open circuit in that part of the circuit usually caused by a poor solder joint and although possible very rarely a component problem or break in the wires or PCB traces.

You can also use continuity testing to check if 2 parts of a circuit are connected that should not be connected indicating possible solder bridges etc. You can check to see if switches are good for example here's how you would check a 3pdt switch and a DPDT toggle switch:

To check ground connections you would put one probe on the ground pad or ground connection you wish to check and simply touch a metal part of the enclosure to quickly test for good grounding. So if you suspect a poor grounding point e.g jack socket touch the jack ground lug with one probe and any other ground point with the other to very quickly check if you have a good ground connection.

I always use a bare part of the enclosure for easy one handed testing. So there you have it a brief look at continuity testing and its value to the DIY pedal builder.

Electrical testers are used to check AC and DC voltage, continuity, circuit problems, amperage, shorted and open circuit problems, and to make sure the voltages are correct at the electrical panel.

Electricians use these electrical testers every day to see if a circuit or device is energized. They are crucial safety tools that keep electricians out of harm's way and tell them if there is trouble on a circuit or device.

There are several different types of testers on the market, some with specific purposes only and some with multiple testing features. Here are the top 6 electrical testers used by professional electricians.

A continuity tester is a device that is powered by batteries and has a probe at on end and a cord with either an alligator clip or another probe at the other end. Basically, if you touch the two together, you complete a circuit and a light lights or a sound, like a buzzing sound, goes off to indicate there is a complete circuit. These testers are great for checking to see if something like a single-pole switch is working properly. Beware! Be sure to turn the power off to the circuit or device that you'll be testing!

Continuity testers are also great for checking wire runs for a complete circuit. You may also find short circuits in wiring with this tester; say two wires have melted together inside the outer jacket of NM sheathed cable.

By touching one probe to the white and the other to the black wire, if the light lights and the buzz sound, the wires are identified as shorted together. Once again, be sure the power is off before doing any testing.

One of the easiest ways to check for faulty devices and parts is to use a multi-tester, sometimes called a multi-meter.

Testing continuity by using the ohm setting will tell you if the connection through the device is complete or if it has opened and is no longer usable. For instance, if you place one of the test leads on one side of a fuse and the other lead on the other side of the fuse, you should show a short circuit or 0 ohms. If your meter shows infinite resistance, the fuse is bad and should be replaced.

To test something, turn the dial of the tester to the ohm setting. This portion of the dial has markings like X1, X10, XK1, etc... This simply means that on the X1 setting, the value of ohms shown on the dial is taken times 1 and that is the amount of ohms. Let's say it shows 50 ohms. That means 50x1=50 ohms. with the dial set at x10, if the dial shows 50, 50x10=500 ohms. You can see the theory here. By adjusting the dial to another setting the multiples increase.

With the test leads apart and not touching, the meter needle should be all the way to the right, showing maximum ohms. On a digital meter, the screen will show infinite resistance.

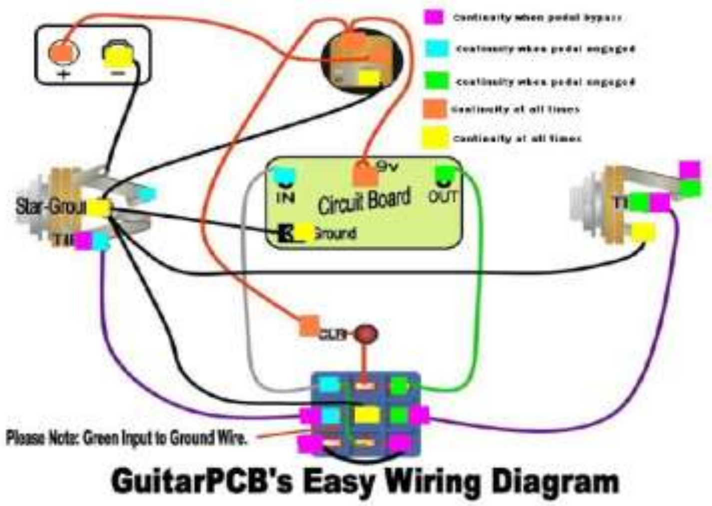

Fig.1. CONTINUITY TEST

By touching the two test leads together, either tester should show a 0 ohms reading. The digital will likely show a 0.00 reading. Sometimes meters have an audible continuity setting that looks like a diode.

With this setting, when the test leads are touched together, the meter will show the reading and an audible alarm will sound. My tester has a constant beep sound.

2.2.2. ELECTRICAL INSULATION TEST

Electric Motor Insulation Resistance Testing

Electric motor insulation exhibits a negative temperature coefficient, meaning as temperature increases, resistance decreases. This would lead you to believe that insulation resistance of a de-energized motor will decrease after starting the motor. However, most often the resistance will initially increase after running due to moisture being evaporated by the increasing temperature of the windings. The governing standard (IEEE43) on insulation resistance testing requires a temperature correction to 40 degrees Celsius, which could quickly turn acceptable measured resistance readings into unacceptably low corrected resistance readings. Before sending a motor to be refurbished, consider space heaters.

Insulation Resistance

The test shall be in accordance with COP Code 21B (5).A suitable direct current (d.c.) in sulation tester should be used tomeasure insulation resistance. Care should be taken to ensure that theinsulation of the equipment under test could withstand the test voltagewithou t damage.

To carry out this test, it is acceptable to divide large installation intosections with groups of o utlets, each group containing not less than 50outlets. The termoutletin this case includes every point andevery switch. A socket outlet or appliance or luminaire incorporating aswitch is regarded as one outlet.

When measured with all fuse links in place, all switches and circuitbreakers (including, if p racticable, the main switch) closed and allpoles or phases of the wiring electrically c onnected together, theinsulation resistance to earth should not be less than the appropriate values given in Table 21 (1) of COP. For best practice, the insulationresistance shall not b e lower than 1.0 mega ohm for low voltageinstallation under a test voltage of d.c. 500V .

When measured between all conductors connected to any one phase orpole of the supply a nd, in turn, all conductors connected to each otherphase or pole, the insulation resistance s hould not be less than theappropriate values in Table 21(1) of COP. For best practice theinsulation resistance shall not be lower than 1.0 mega ohm for lowvoltage installation un der a test voltage of d.c. 500V.

For the sake of enhanced safety, when the value of insulationresistance measured is near the minimum values as required in thisT&C procedure, or at a relatively low valves where consideredabnormal to trade’s practice, the concerned circuit /installation shall be re-checked to improve and re-test shall be conducted afterward.In carrying out the test:

(a)wherever practicable, all lamps should be removed and allcurrent using equipment shoul d be disconnected and all localswitches controlling lamps or other equipment should be closed;

(b)where the removal of lamps and/or the disconnection ofcurrent using equipment is i mpracticable, the local switchescontrolling such lamps and/or equipment should be open;

(c)electronic devices connected in the installation should beisolated or short circuited where appropriate so that they arenot damaged by the test voltage.

(d)where the circuits contain voltage sensitive devices, the testshould measure the insulation resistance to earth with all liveconductors (including the neutral) connected together.

The sequence of test shall be as follows:

(1)Main switch/switchboard and outgoing circuits with sub-main switches being isolated;

(2)Submain switches/switchboards and outgoing circuits withfinal circuits boards being isolated; and

(3)Final circuit boards and final circuits.Where equipment is disconnected for the test and the equipment hasexposed conductive parts require to be connected to protectiveconductors, the insulation resistance between the exposed conductiveparts and all live parts of the equipment should be measured separatelyand should have a minimum insulation resistance not less than 0.5MegaOhm.

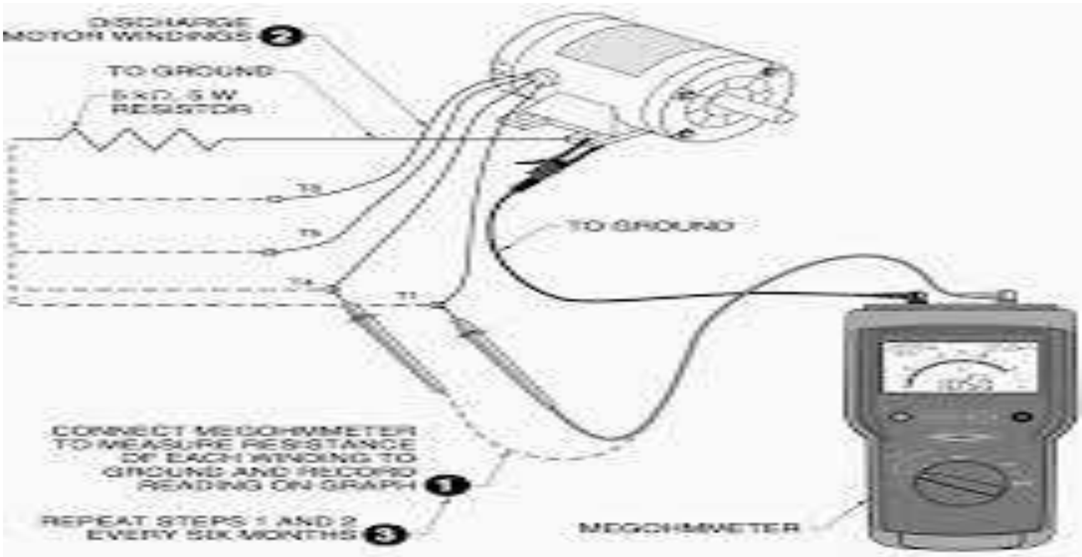

Fig.2. ELECTRICAL INSULATION TEST

How Insulation Resistance is measured?

You have seen that good insulation has high resistance; poor insulation, relatively low resistance. The actual resistance values can be higher or lower, depending upon such factors as the temperature or moisture content of the insulation (resistance decreases in temperature or moisture). With a little record-keeping and common sense, however, you can get a good picture of the insulation condition from values that are only relative. The Megger insulation tester is a small, portable instrument that gives you a direct reading of insulation resistance in ohms or megohms. For good insulation, the resistance usually reads in the megohm range.

The Megger insulation tester is essentially a high-range resistance meter (ohmmeter) with a built-in direct-current generator. This meter is of special construction with both current and voltage coils, enabling true ohms to be read directly, independent of the actual voltage applied. This method is nondestructive; that is, it does not cause deterioration of the insulation.

FACTORS AFFECTING INSULATION RESISTANCE READINGS

Remember that the measured resistance (of the insulation) will be determined by the voltage applied and the resultant current ($R = E/I$). There are a number of things that affect current, including temperature of the insulation and humidity, as mentioned in the previous section. Right now, let's just consider the nature of current through insulation and the effect of how long voltage is applied.

Current through and along insulation is made up partly of a relatively steady current in leakage paths over the insulation surface. Electricity also flows through the volume of the insulation. Actually, as shown in Fig. …, our total current comprises three components:

1. Capacitance Charging Current that starts out high and drops after the insulation has been charged to full voltage (much like water flow in a garden hose when you first turn on the spigot).
2. Absorption Current Also an initially high current which then drops (for reasons discussed under the section Time-Resistance Method).
3. Conduction or Leakage Current A small essentially steady current both through and over the insulation.

2-point (dead earth) method

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

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

3-point (Fall-of-potential) method

The three-point method is the most thorough and reliable test method; used for measuring resistance to earth of an installed grounding electrode. The standard used as a reference for fall-of-potential testing is IEEE Standard 81: Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System With a four terminal tester, P1 and C1 terminals on the instrument are jumpered and connected to the earth electrode under test while the C2 reference rod is driven into the earth straight out as far from the electrode under test as possible. Potential reference P2 is then driven into the earth, at a set number of points, roughly on a straight line between C1 and C2. Resistance readings are logged for each P2 point.

4-point method

This method is the most commonly used for measuring soil resistivity, which is important for designing electrical grounding systems. In this method, four small-sized electrodes are driven into the earth at the same depth and equal distance apart - in a straight line - and a measurement is taken. The amount of moisture and salt content of soil radically affects its resistivity. Soil resistivity measurements will also be affected by existing nearby grounded electrodes. Buried conductive objects in contact with the soil can invalidate readings if they are close enough to alter the test current flow pattern. This is particularly true for large or long objects.

Clamp-on method

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

Photo Credit: AEMC

Measurements are made by "clamping" the tester around the grounding electrode under test, similar to how you would measure current with a multi-meter current clamp. The tester applies a known voltage without a direct electrical connection via a transmit coil and measures the current via a receive coil. The test is carried out at a high frequency to enable the transformers to be as small and practical as possible.

How Insulation Resistance is Measured Using meger

you have seen that good insulation has high resistance; poor insulation,relatively low resi stance. The actual resistance values can be higher or lower,depending upon such factor s as the temperature or moisture content of the insulation (resistance decreases in temperature or moisture). With a little record-keeping and common sense, however, you can get a good picture of the insulation condition from values that are only relative.

The Megger insulation tester is a small, portable instrument that gives you direct reading of insulation resistance in ohms or megohms. For good insulation, the resistance usually reads in the megohm range.

The Megger insulation tester is essentially a high-range resistance meter (ohmmeter) with a built-in direct-current generator. This meter is of special construction with both current and voltage coils, enabling true ohms to be read directly, independent of the actual voltage applied. This method is non-destructive; that is, it does not cause deterioration of the insulation.

The generator can be hand-cranked or line-operated to develop a high dC voltage which causes a small current through and over surfaces of the insulation being tested (Fig. 2). This current (usually at an applied voltage of 500 volts or more) is measured by the ohmmeter, which has an indicating scale. Fig. 3 shows a typical scale, which reads increasing resistance values from left up to infinity, or a resistance too high to be measured.

2.2.3. EARTH RESISTANCE TEST

What is insulation resistance testing?

Basically, you're applying a voltage (specifically a highly regulated, stabilized DC voltage) across a dielectric, measuring the amount of current flowing through that dielectric, and then calculating (using Ohm's Law) a resistance measurement. Let's clarify our use of the term "current." We're talking about leakage current. The resistance measurement is in megohms. You use this resistance measurement to evaluate insulation integrity.

Current flow through a dielectric may seem somewhat contradictory, but remember, no electrical insulation is perfect. So, some current will flow.

What's the purpose of insulation resistance testing?

You can use it as: A quality control measure at the time a piece of electrical equipment is produced; An installation requirement to help ensure specifications are met and to verify proper hookup; A periodic preventive maintenance task; and A troubleshooting tool.

How do you perform an insulation resistance test?

Generally, you connect two leads (positive and negative) across an insulation barrier. A third lead, which connects to a guard terminal, may or may not be available with your tester. If it is, you may or may not have to use it. This guard terminal acts as a shunt to remove the connected element from the measurement. In other words, it allows you to be selective in evaluating certain specific components in a large piece of electrical equipment.

Obviously, it's a good idea to have a basic familiarity with the item you're testing. Basically, you should know what is supposed to be insulated from what. The equipment you're testing will determine how you hook up your Meg ohmmeter.

Fig. 3a. Earth Resistance Test

After you make your connections, you apply the test voltage for 1 min. (This is a standard industry parameter that allows you to make relatively accurate comparisons of readings from past tests done by other technicians.)

During this interval, the resistance reading should drop or remain relatively steady. Larger insulation systems will show a steady decrease; smaller systems will remain steady because the capacitive and absorption currents drop to zero faster than on larger systems. After 1 min, you should read and record the resistance value.

When performing insulation resistance testing, you must maintain consistency. Why? Because electrical insulation will exhibit dynamic behavior during the course of your test; whether the dielectric is "good" or "bad." To evaluate a number of test results on the same piece of equipment, you have to conduct the test the same way and under the relatively same environmental parameters, each and every time.

Your resistance measurement readings will also change with time. This is because electrical insulation materials exhibit capacitance and will charge during the course of the test. This can be somewhat frustrating to a novice. However, it becomes a useful tool to a seasoned technician.

As you gain more skills, you'll become familiar with this behavior and be able to make maximum use of it in evaluating your test results. This is one factor that generates the continued popularity of analog testers.

What affects insulation resistance readings?

Insulation resistance is temperature-sensitive. When temperature increases, insulation resistance decreases, and vice versa. A common rule of thumb is insulation resistance changes by a factor of two for each 10 DegrC change. So, to compare new readings with hprevious ones, you'll have to correct your readings to some base temperature. For example, suppose you measured 100 megohms with an insulation temperature of 30 DegrC. A corrected measurement at 20 DegrC would be 200 megohms (100 megohms times two).

Also, "acceptable" values of insulation resistance depend upon the equipment you're testing. Historically, many field electricians use the somewhat arbitrary standard of 1 megohm per kV. The International Electrical Testing Association (NETA) specification Maintenance Testing Specifications for Electrical Power Distribution Equipment and Systems provides much more realistic and useful values.

Remember; compare your test readings with others taken on similar equipment. Then, investigate any values below the NETS standard minimums or sudden departures from previous values.

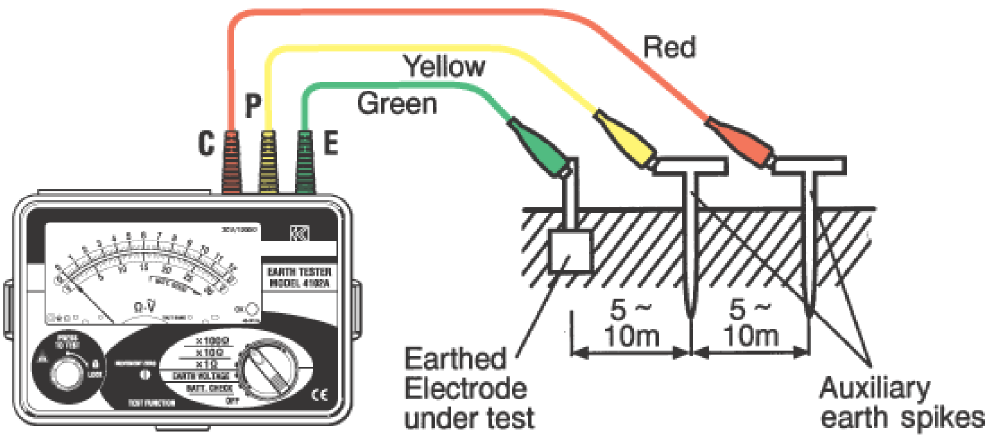

Fig. 3b. Earth Resistance Test

2.2.4 PHASE SEQUENCE TEST

Phase Sequence and Motor Rotation Tester

If you install or connect 3phase motors and systems, you recognize the importance of veri ying the correct motor rotationand wiring phase sequence. Improper connections can caus e motors to rotate in reverse direction, potentially damaging themotor and the equipment it s powering.
The PRM-6 Phase Sequence and Motor Rotation Tester can test the motor rotation of 3-phase systems and verify 3-phasereceptacle wiring and phase sequencing with test leads. An additional advanced feature is wireless motor rotation detection, which senses motor rot ation direction without use oftest leads. This is particularly useful for fastrunning motors wh en the motor rotation cannot be visually determined or whenthe drive shaft is not visible.Du rably constructed with a rubber outer casing, the PRM6 has a bright, backlight LCD display , CAT IV 600 V rating, andconforms to EN 61010 and EN 61557 standards, making it an es sential tool for motor rotation and phase sequence testing incommercial and industrial envi ronments on electrical systems up to 700 V.

Fig.5 Phase Sequence Test

2.2.5. LOAD TEST

A **complete test** uses a number of individual tests. these individual tests include:

locked-rotor test at a rated frequency, speed-torque curve, no-load saturation curve,dual-frequency heat run or coupled heat run Locked-rotor test at rated frequency.

The locked-rotor test at rated frequency is used to determine the locked-rotor torque (lrt) and current (Ira). in order to determine the values at rated voltage, at least three test points of voltage *versus* current, watts, and sometimes torque are taken to as high a voltage as possible and then extrapolated to rated voltage on log-log graph paper to establish the desired values.

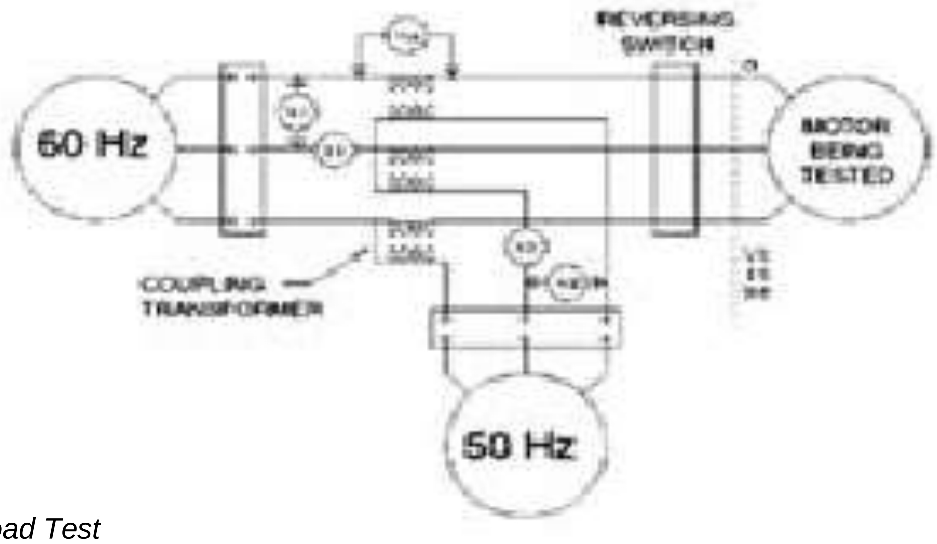

Fig.5 Load Test

2.2.6. VOLTAGE TEST

The threephase squirrelcage induction motor can, and many times does, hav e the samearmature (stator) winding as the threephase synchronous motor. As in the s ynchronous motor, applyingthreephase currents to the armature creates a synchronously-rotating magnetic field.

The induction motor rotor is a completely shortcircuited conductive cage. Figure 6 illustrates the rotor construction.The rotor receives its excitation by induction from th e armature field. Hence, the inductionmachine is a doubly excited machine in the same sense as the synchronous and DC machines.

The basic principle of operation is described by Faraday’s Law. If we assume that the machinerotor is at a standstill and the armature is excited, then the armature-produced rotating field is moving withrespect to the rotor.In fact, the relative speed be tween the rotating field and the rotor is synchronousspeed. For this condition, the rotating field induces a large voltage in the rotor bars. The large voltagecauses a l arge current in the squirrelcase which, in turn, creates a magnetic field in the rotor.

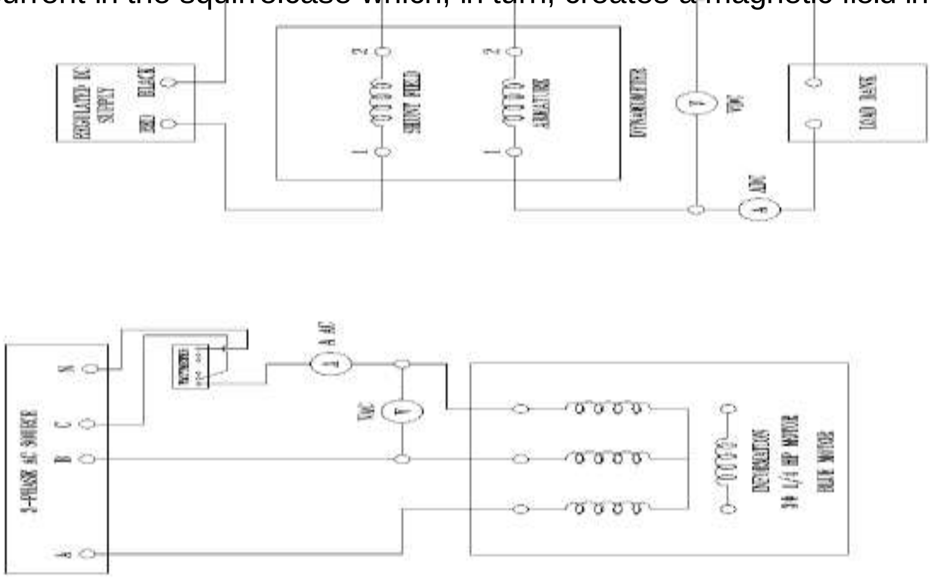

Fig. 6 Voltage Test

The rotormagnetic field interacts with the armature magnetic field, and a torque is produced.If the producedtorque is larger than any load torque, the rotor begins to turn.As the rotor accelerates, the speeddifference between the rotor and the armat ure field is reduced.This reduced speed difference (or slip)causes the induced rotor voltage to be reduced, the rotor current to be reduced, the rotor flux to be reduced, and the torque produced by the machine to be reduced. Eventually, the torque produced by themotor equals the torque demanded by the load, and the motor settles to a n equilibrium rotor speed. Thisequilibrium rotor speed must be less than synchronou s speed since there must be a slip to producetorque.

The frequencydependent nature of the rotor impedances causes the torque v ersus speedcharacteristic of the induction motor to be quite nonlinear. Figure shows a t ypical characteristic.Designers have learned to design rotors for specific torque cha racteristics. The National ElectricalManufacturers Association NEMA has classified and standard designs which satisfy a range of torquespeed characteristics. Figure 4 shows the NEMA designs and the rotor bar geometries that produce the esponses.

2.2.7 WINDING RESISTANCE TEST

How resistance is measured?

You have seen that good insulation has high resistance; poor insulation,relatively low resi stance. The actual resistance values can be higher or lower,depending upon such factor s as the temperature or moisture content of theinsulation (resistance decreases in temper ature or moisture). With a littlerecordkeeping and common sense, however, you can get a good picture ofthe insulation condition from values that are only relative.

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The Megger insulation tester is essentially a high-range resistance meter (ohmmeter) with a built-in direct-current generator. This meter is of special construction with both current and voltage coils, enabling true ohms to be read directly, independent of the actual voltage applied. This method is non-destructive; that is, it does not cause deterioration of the insulation.

The generator can be hand-cranked or line-operated to develop a high dC voltage which causes a small current through and over surfaces of the insulation being tested (Fig. 2). This current (usually at an applied voltage of 500 volts or more) is measured by the ohmmeter, which has an indicating scale. Fig. 3 shows a typical scale, which reads increasing resistance values from left up to infinity, or a resistance too high to be measured.

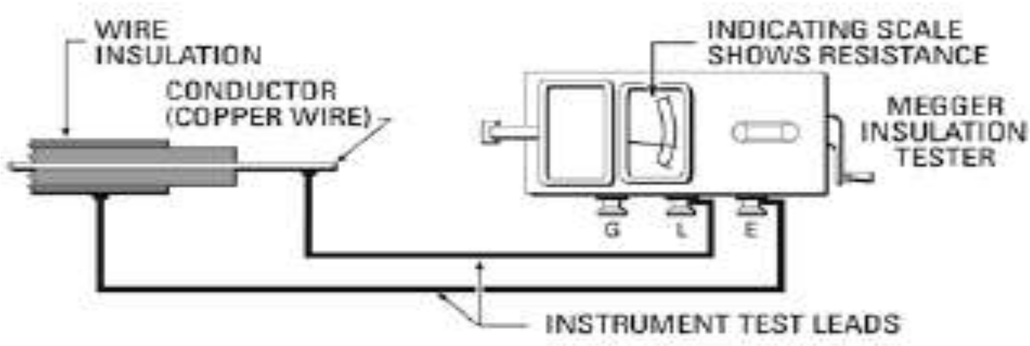

Fig.7. Winding Resistance Test

2.2.8. POLARIZATION INDEX (P.I.) TEST

Don’t second guess three-phase systems

If you install or connect 3phase motors and systems, you recognize the importance of verif ying the correct motor rotationand wiring phase sequence. Improper connections can caus e motors to rotate in reverse direction, potentially damaging themotor and the equipment it s powering.

The PRM-6 Phase Sequence and Motor Rotation Tester can test the motor rotation of 3-phase systems and verify 3-phasereceptacle wiring and phase sequencing with test leads. An additional advanced feature is wireless motor rotation detection, which senses motor rot ation direction without use oftest leads. This is particularly useful for fastrunning motors wh en the motor rotation cannot be visually determined or whenthe drive shaft is not visible.Du rably constructed with a rubber outer casing, the PRM6 has a bright, backlight LCD display , CAT IV 600 V rating, andconforms to EN 61010 and EN 61557 standards, making it an es sential tool for motor rotation and phase sequence testing incommercial and industrial envi ronments on electrical systems up to 700 V.

Fig. 8 POLARIZATION INDEX (P.I.) TEST

2.2.9 LOCK ROTOR TEST

Learning Objectives

After this presentation you will be able to:

- Conduct locked rotor **tests on 3-phase induction motors**
- **Conduct no-load tests on 3**-phase induction motors
- Use measurements from lock rotor and no-load tests to find motor circuit parameters

Locked-Rotor Test Procedure

1.) connect ammeters wattmeters and voltmeters as shown above

2.) mechanically lock the motor rotor

3.) adjust the supply voltage until rated current flows

4.) measure V P and I (line-to-line voltage, line current and total active power)

Recommended practice is to perform test at 25% rated f (15 Hz)Minimizes errors due to sa turation (X's) and skin effects (R's

The locked rotor test, like short circuit test on a transformer,provides the information about le akage impedances and rotorresistance. Rotor is at the stand still, while low voltage is applied to stator windings to circulate rated current. Measure the voltageand power to the phase. Sin ce there is no rotation slip, s=1 whichgives us following equivalent circuit.

2.2.10. FREE RUNNING TEST

DC TACHOMETER

It is sometimes necessary in control systems to feed back a voltage proportional to the sp eed of theshaft. In a d.c. servomechanism this can be achieved by using a d.c. ta chometer which is apermanent magnet d.c. generator.

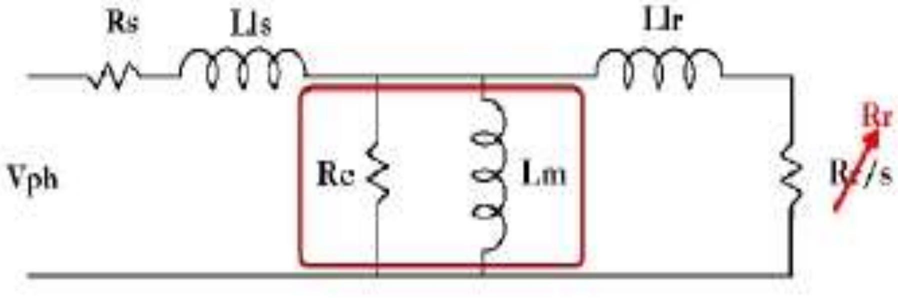

Fig. 9 FREE RUNNING TEST

The field is due to permanent magnet which ensures that thevoltage output will be directl y proportional to the speed.A d.c. tachometer can be used on a.c. servomechanism by co nverting the d.c. output volt-age to an a.c. voltage by using an inverter circuit.

AC TACHOMETER

An a.c. tachometer is used in feedback control system to feedback an a.c. voltage propor tional tothe speed of the shaft. This is basically a twophase induction motor as shown in Fig. 9.13. One ofthe stator windings is used as the reference winding and the other the co ntrol winding. Thereference winding is fed a suitable a.c. voltage of constant frequency a nd magnitude. Therefore, avoltage of the same frequency is induced in the control windin g. This output voltage is fed to thehigh input impedance circuit of an amplifier so that the control winding can be considered as opencircuited. It is essential that the voltage induce d in the control winding is directly proportional tothe shaft speed and phase of this voltage be fixed with respect to voltage supplied to the referencewinding.

The principle of operation of an a.c. tachometer can be explained using double revolving field theory. With reference to reference winding the tachometer can be considered equiv alent toa single phase induction motor. At standstill, the forward and backward fields are equal andhence voltage induced in the control winding is zero.

When the rotor is revolving, the rotor current due to forward rotating field decreases since its effective impedance increases whereas for the backward rotating field the impedance decreases,the difference between them being function of speed. Therefore, the voltage d eveloped across control winding is a function of speed. Reversal of direction of rotation re verses the phase of outputvoltage.

For a constant phase angle of output voltage and linear relationship between output volt-age and speed, a suitable value of ratio of rotor reactance to rotor resistance should be c hosen. Ifit is low, the sensitivity i.e. volts per revolution per minute is sacrificed but linear s peed range iswide. However, if it is high the speed range is limited to a fairly small fractio n of synchronousspeed to meet the condition of linearity of voltage and consistency of ph ase angle. An a.c. tachometer should have low inertia when rapid speed variations are en countered as in automatic controlsystem.

2.2.12 OPEN/SHORT CIRCUIT TEST

The open circuit and short circuit test are performed for determining the parameter of the transformer like their sufficiency, voltage regulation, constant etc. these tests are performed without the actual loading and because of this reason the very less power is required for the test.

Fig:-OPEN/SHORT CIRCUIT TEST

2.2.13 TRANSFORMER TURN RATIO TEST

Transformer Uses

Changing: - Voltage Levels
Current Levels
Impedance values Isolation

Transformer Operation

Primary coil is supplied with a AC voltage.
Current drawn produces a magnetic field
Magnetic field transported to a secondary coil via a magnetic circuit
Magnetic field induces a voltage in secondary

Fig. 10 TRANSFORMER TURN RATIO TEST

2.2.14 .DIELECTRIC STRENGTH TEST

The dielectric strength test is a measurement of isolation. It is measured between each win ding or all other windingsand the core or case. The terminals of the winding under test are strapped together, while all other winding terminalsand the case or core are tied to ground. For an RMS voltage a leakage current can be specified, although this test isgenerally a go nogo test since failure will be determined by a flashover or breakdown. A DC voltage can al so be used,and should be specified in Volts DC. If a sinusoidal voltage is applied, it will alw ays be an appropriate 60Hz root-mean-squared (rms) voltage.(See Insulation resistance test).

2.2.15. VOLTAGE EXCITATION TEST

For this specification the following definitions are considered:

1.Discharge Circuit

This circuit is comprised of devices that allow the insertion of a discharge resista nce in the fieldwinding terminals of the generator during a de-excitation sequence, in a coordinated form with theopening of the field switch. This circuit must consider the use of a varistor as an element ofprotection against overvoltage.

2.Initial Excitation Circuit

The devices that allow the initialization of the excitation of the generator through the exte rnal supplysources.

3.Power Stage

The equipment that supplies field current for the synchronous machine (gene rator) excitation,comprised of an: excitation transformer, rectifying bridge, and power b ars and/or buses, or AC and DC and sectioning elements.

4.On Line Generator

The operative condition of the generator when it is connected to a power electrica l system, and isdelivering active power and/or reactive to the electric network.

5. No load condition

Operative condition of the generator when it is at nominal speed and voltage in terminals, and is notconnected to the electric power system.

6.Field Switch

Allows connecting and disconnecting the output of the excitation system to the fiel d winding of thegenerator.

7.Alarms and Signaling

The devices that contain signal information and indication of the operative state o f the excitationsystem.

8.Protection

The equipment which protects the excitation system devices when abnormal condit ions, failuresand/or incorrect operation are present.

9.Voltage Regulator

An automatic control system that maintains the voltage in the armature terminals at a val ue definedby a reference element.

10.Excitation System

The equipment that contains control and power elements which provide the required field current tomaintain the voltage at the generator terminals under the voltage r egulation or field currentregulation operation. Additionally it contains the prote ction, monitoring, logging and sequencecontrol functions.

2.2.16. ENERGIZING ELECTRICAL TEST

Energy is vital for every industry. So is energy management.Industry's dependence on scarce energy resources, thevolatility of energy costs, the growing environmentalconsciousness an d more stringent legislation are just a fewof the factors influencing the global drive for improv ed energymanagement.The power management system (PMS) prevents blackoutsand distru bances of your operations while at the same timeit controls energy costs, enhances safety a nd mitigates bothenvironmental and health impacts.

ABB's power management system has been specificallydesigned for the most energy-intensive sectors in whichyou operate, such as the oil and gas and the petrochemical industries. In many areas around the world, your operationsface an insufficient or unreliable p ublic power supply. In largepart, you must therefore depend on your own energy genera-tion and distribution capabilities. ABB's PMS manages yourenergy vulnerability and ensures sustainable energy for yourplant operations by reconciling efficiency, economic, health, safety and environmental considerations.

ABB has a track record of successful PMS implementationsaround the world, including:

– offshore platforms
– Floating production, storage and offloading vessels (FPSO)
– refineries
– LNG complexes
– large industrial complexes

Proven power management functions

Industrial plants require a stable and optimized electrical network. To achieve that goal, the PMS controls and supervisespower generation and supply with proven features.
Fast load shedding (40 to 150 ms, depending on the configuration) is based on fast networ k determination and energybalance calculations. The system's protection/control units can also monitor and, if necessary, invoke frequency-basedload shedding. Re-acceleration by the motor control centersare also featured. The extended load shedding re port is foroperator assistance in trouble shooting in case of incidents.In addition to supervis ory control and data acquisition (SCADA), the system offers generator control (including int egration with the governor and excitation controller); transformercontrol (including tap chan ger control); circuit breaker control(including integration with protection); motor control (incl uding integration with motor control centers); and power control(including peak shaving an d load sharing). Manual and automatic synchronization, restarting, and monitoring.

Operational advantages

The PMS also allows for a more critical design of your plants'electrical equipment. It rearra nges generation, importation andloading so that the individual generators, reactors, transfo rmers and tielines operate well within their specification limits.Tight integration and serial c ommunication with motor control centers (MCCs), protection units, governor and excitation controllers, variable speed drives and other subsystems reduce both wiring and maintena nce costs, creating substantialsavings.
Power import, generation and frequency and voltage controlare optimized by means of acti ve and reactive power control. Because of the large number of load shedding groups and priorities that can be set, load shed actions are limitedto the exact minimum required. As a result, critical processunits keep receiving power that would otherwise be shed.The restart ing function ensures safe recovery after loadshedactions. As a further operational benefit, the system providesadvanced control of DLN turbines with low NOx emissionslevels. Operators are also given the tools and access theyneed for better control over the configuration of the e lectricalnetwork, the set points and statuses of all machines (transformers and generators), a nd the startup of big motors fromthe central control room. At the same time they receive a cla roverview of the network configuration (main circuit breakersand substation configurations), t he network loads and thecontrol system health.

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page.

CHOOSE THE BEST ANSWER

1. _______________ test is the checking of an electric circuit to see if the current flows throughout the circuit.

A. Continuity Test B. Insulation Test C. Earth Resistance Test D. Phase Sequence Test

2. To carry_________________test, it is acceptable to divide large installation into sections with groups of outlets.

A. Continuity Test B. Insulation Test C. Earth Resistance Test D. Phase Sequence Test

3. __________________ test saves motor from its damage due to reverse rotation.

A. Continuity Test B. Insulation Test C. Earth Resistance Test D. Phase Sequence Test

4. ______________ test at rated frequency is used to determine the locked rotor torque (lrt) and current (Ira).

A. Load Test B. Insulation Test C. Earth Resistance Test D. Phase Sequence Test

5. __________________tess saves motors from damages Improper connections can cause motors to rotate in reverse direction, potentially damaging the motor and the equipment its powering.

A. Load Test B. Polarization Index (P.I.) Test C. Earth Resistance Test D. Phase Sequence Test

6. ________________________ test, like short circuit test on a transformer,provides the information about leakage impedances and rotorresistance.

A. locked rotor test B. Polarization Index (P.I.) Test C. Earth Resistance Test D. Phase Sequence Test

7. ________________________ test are performed for determining the parameter of the transformer like their sufficiency, voltage regulation, constant etc.

A. locked rotor test B. Polarization Index (P.I.) Test C. Open/Short Circuit Test D. Phase Sequence Test

8. _________________ test is a measurement of isolation.

A. locked rotor test B. Polarization Index (P.I.) Test C. Open/Short Circuit Test D. dielectric strength test

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Score = ____________

Rating: _____________

Name: _________________________ Date: _______________

ANSWER SHEET

1. A
2. B
3. D
4. A
5. B
6. A
7. C
8. D

Information Sheet #3	Commissioning Electrical Equipment/System

2.3 Commissioning Electrical Equipment / System

The commissioning of the electrical and mechanical systems within a building is a part of the ‘handing-over’ process of the new building by the architect and main contractor to the client or customer in readiness for its occupation and intended use. To ‘**commission’** means to give authority to someone to check that everything is in working order. If it is out of commission, it is not in working order. Following the completion, inspection and testing of the new electrical installation, the functional operation of all the electrical systems must be tested before they are handed over to the customer. It is during the commissioning period that any design or equipment failures become apparent, and this testing is one of the few quality controls possible on a building services installation. This is the role of the commissioning engineer, who must assure himself that all the systems are in working order and that they work as they were designed to work. He must also instruct the client’s representative, or the staff who will use the equipment, in the correct operation of the systems, as part of the handover arrangements.

The commissioning engineer must test the operation of all the electrical systems, including the motor controls, the fan and air conditioning systems, the fire alarm and emergency lighting systems. However, before testing the emergency systems, he must first notify everyone in the building of his intentions so that alarms may be ignored during the period of testing.

Commissioning has become one of the most important functions within the building projects completion sequence. The commissioning engineer will therefore have access to all relevant contract documents, including the building specifications and the electrical installation certificates as required by the IEE Regulations (BS 7671), and have a knowledge of the requirements of the Electricity at Work Act and the Health and Safety at Work Act. The building will only be handed over to the client if the commissioning engineer is satisfied that all the building services meet the design specification in the contract documents

Self-Check -3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Say True or False

1. To 'commission' means to give authority to someone to check that everything is in working order.
2. The commission engineer must test the operation of only the electrical systems.
3. Commissioning has become one of the most important functions within the building projects completion sequence.
4. The commissioning engineer shall not have access in electrical installation certificate as required by the IEE regulations.

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Score = ____________

Rating: _____________

Name: ___________________________ Date: ________________

ANSWER SHEET

1. TRUE
2. FALSE
3. TRUE
4. FALSE

Information Sheet #4	Responding Unforeseen Events

2.4 Responding Unforeseen Events

Accidents, Malfunctions and Unplanned Events refers to events or upset conditions that are not part of any activity or normal operation of the Project as has been planned by North cliff. Even with the best planning and the implementation of preventative measures, the potential exists for accidents, malfunctions or unplanned events to occur during any Project phase, and if they occur, for adverse environmental effects to result if these events are not addressed or responded to in an environmentally appropriate manner.

Many accidents, malfunctions and unplanned events are, however, preventable and can be readily addressed or prevented by good planning, design, emergency response planning, and mitigation. By identifying and assessing the potential for these events to occur, North cliff can also identify and put in place prevention and response procedures to minimize or eliminate the potential for significant adverse environmental effects, should an accidental event occur.

As the Project is being designed, and will be constructed and operated, according to best practice for health, safety, and environmental protection to minimize the potential environmental effects that could result from the Project, as well as those that could result from accidents, malfunctions or unplanned events. Prevention and mitigation will be accomplished by the following general principles:

- use best management practices and technology for carrying out the Project while controlling permitted/allowable releases to the environment and consequent environmental effects;
- incorporate safety and reliability by design, and application of principles and practices of process and mine safety management;
- develop and apply procedures and training aimed at safe operation of the facilities that prevent or avoid the potential upsets that might lead to accidents, malfunctions or unplanned events; and

- Implement effective emergency preparedness and response.

Chapter 3 provided a discussion of the features of the Project that will accomplish the safe, reliable, and environmentally responsible implementation of the Project, as well as how it will be carefully constructed, operated, and ultimately decommissioned in a manner that minimizes the potential for Accidents, Malfunctions and Unplanned Events to occur.

The Project design, mitigation, and response procedures implemented as part of the planning stage of the Project and as adapted throughout the Project life are intended to minimize the potential for accidents, malfunctions and unplanned events to occur, and with their development and implementation, the potential for such events to occur will be greatly reduced. In the unlikely event of an accident, malfunction or unplanned event, emergency response plans and corrective action procedures will be implemented to minimize the resulting environmental effects. The Project will have safety measures built in to mitigate or manage potential upsets, should they occur. Employees will be trained in operational procedures and environmental emergency response procedures, including safety measures to prevent and respond to Accidents, Malfunctions and Unplanned Events.

Self-Check -4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Say True or False

1. Accidents, malfunctions and unplanned events refer to unforeseen events or upset conditions.
2. Many accidents, malfunctions and unplanned events are not preventable and cannot be readily addressed.
3. Implementing effective emergency preparedness and response is one of the principles of prevention and mitigation of unforeseen events.
4. Employees should be trained in operational procedures and environmental emergency response procedures.
5. Emergency response plans and corrective action procedures must not be implemented to minimize the resulting environmental effects.

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Score = ____________

Rating: _____________

Name: ___________________________ Date: ________________

ANSWER SHEET

1. TRUE
2. FALSE
3. TRUE
4. TRUE
5. FALSE

Information Sheet #5	Revising Records, Electrical Plans and Schematic Diagrams

2.5 Revising Records, Electrical Plans and Schematic Diagrams

Any modified or additional drawings, information or instructions necessary for the satisfactory completion of the work shall be revised and recorded. "As Installed" detail shall be provided to EE in electronic form as well as hard copy. Electronic documentation is required in the following formats:

All documentation - Adobe Acrobat "pdf".

Drawings – Micro station "dgn" or compatible.

During the installation a system of records shall be maintained which provides objective evidence that requirements have been met, including construction in accordance with applicable standards, construction drawings/plans and specifications.

All records shall be available for audit and review by EE during the installation. The records should provide full traceability of all quality characteristics and activities. During construction activities QA mechanisms such as check sheets, checklists, inspection & test plans (ITPs) shall be utilized for an EE representative to witness and sign off.

EE's QCC auditor shall be present to witness the installation at hold points, as required by EE, and work shall not proceed past a hold point without EE consent.

Accredited organization and have a current test sticker affixed. The ASP is responsible for ensuring that test equipment and instrumentation is traceable.

Self-Check -5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page.

Fill the Blank Spaces with Appropriate Word(s) or Phrase(s)

1. Any modified or additional drawings, information or instructions necessary for the satisfactory completion of the work shall be _________________________.
2. During the installation a system of records shall be maintained to meet the requirements accordance with______________,___________&________________.
3. All records shall be available for audit and review by _________________________.
4. During construction activities mechanisms such as ________, ________, _______ & __________ shall be utilized for an EE representative to witness and sign off.

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

ANSWER SHEET

1. revised and recorded
2. applicable standards, construction plans and specifications
3. IEE during installation
4. Check sheets, check lists, inspection and test plans

Information Sheet #6	Filling–Out and Submitting Test Data Forms

2.6 Filling–Out and Submitting Test Data Forms

The commissioning agent schedules functional tests through the general contractor and subcontractors. Under the supervision of the commissioning agent, the installing subcontractor performs the hardware and/or software manipulations required for the testing. Owner maintenance staff may also be present in order to assist in system observations. The commissioning agent witnesses and records the results of functional performance testing.

Any deficiencies found from functional performance testing will be documented in a Deficiency Report. The report will include all details of the components or systems found to be non-compliant with the parameters of the functional performance test plans and design documents. The deficiency report will become part of the punch list. The report will detail the adjustments or alterations required to correct the system operation, and identify the responsible party. The deficiency report will be continuously updated. The commissioning agent schedules any required retesting through the general contractor. Decisions regarding deficiencies and corrections are made at as low a level as possible, preferably between commissioning agent, sub-contractor and general contractor.

Self-Check #6	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page.

Fill the Blank Spaces with Appropriate Word(s) or Phrase(s)

1. The commissioning agent schedules functional tests through the _____________ and ________________________.
2. The installing subcontractor performs the _____________ and/or ___________ manipulations required for the testing.
3. Owner maintenance staff present in order to assist in system____________________.
4. Any deficiencies found from functional performance testing will be documented in a ________________________Report.
5. Decisions regarding deficiencies and corrections are made at as low a level as possible, preferably between ________________, ____________ and ____________.

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Score = ____________

Rating: _____________

Name: __________________________ Date: _______________

ANSWER SHEET

1. **General contractor and sub-contractors**
2. **Hardware and/or software**
3. **Observations**
4. **Deficiency**
5. **Commissioning agent, sub-contractor and general manager**

Operation Sheet 2	Testing electrical equipment /system

PURPOSE: - after performing this operation the trainee's should be able to identifying of electrical equipment and can perform testing.

Conditions: -

EQUIPMENT AND TOOLS: - combination pliers, multimeter insulation tester,

MATERIALS: - wires, cables, paper, connectors, dividers.

PROCEDURE:

- An electrical testing is performed by using electrical testing devices, other tools and finally the result is obtained.

General electrical testing Instructions

When test equipment with any of the tools mentioned, observe the following precautions:

1. Do not attempt to use testing when power is on position
2. When using the testing when power is in on position, make sure make sure that you are working safely.
3. Make sure all testing devices are properly calibrated and standard.
4. When using any type of testing devices, hold the devices properly.
5. After finishing all tests (commissioning), please collect, clean and return back the testing instruments and hand tools to their proper positions.

PRECAUTIONS: - Apply all the necessary safety equipments.

QUALITY CRITERIA: - the trainee's should be able to perform full sectioning of solid objects by any direction of cut.

LAP Test 1(learning activity performance or questions prepared to measure the performance of individuals in the operation sheet)	Practical Demonstration

Name: _____________________________ Date: ________________________

Time started: _________________ Time finished: ________________

Instruction:

1. Show the necessary hand tools and testing devices
2. Wear all the necessary PPE
3. Test electrical equipment according to the standard.
4. Check to remove soldering points.

Name: _____________________________ Date: ________________________

Time started: _________________ Time finished: ________________

Instructions: You are required to perform the following individually with the presence of your trainer.

1. Show how to identify and test electrical equipment
2. Show the results?
3. Show when commissioning used?

REFERENCES MATERIALS

1. **Advanced Electrical Installation Work FIFTH EDITION**

2. **Practical Troubleshooting of Electrical Equipment and Control Circuits**

3. **TTLM**