Ethiopian TVET-System

INDUSTRIAL ELECTRICAL MACHIN DRIVE TECHNOLOGY

Level-II

Based on May 2011 Occupational Standards

October, 2019

Module Title: **Performing Commissioning of Electrical Equipment/ Systems**

TTLM Code: EELEMD2TTLM1019

This module includes the following Learning Guides

LG38: Plan and Prepare Commissioning Activities

LG Code: EEL EMD2 M06LO1LG38

LG39: Commission Electrical Equipment/ Systems

LG Code: EEL EMD2 M06LO2- LG39

LG40: Turn-Over Electrical Equipment/Systems

LG Code: EEL EMD2 M06 0919 LO3- LG40

Instruction Sheet	LG38: Plan and Prepare Commissioning Activities

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

- Safety policies and procedures
- Confirm work instructions
- Plan Commissioning procedures
- Obtaining Tools, materials and PPE
- Obtaining, Estimating and inspecting Tools, equipment and testing devices
- Identifying and preventing Potential hazards
- Coordinating Commissioning activities
- Performing electrical testing

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**:

- Safety policies and procedures
- Confirm work instructions
- Plan Commission procedures
- Obtain Tools, materials and PPE
- Obtain, Estimate and inspect Tools, equipment and test devices
- Identify and prevent Potential hazards
- Coordinate Commission activities
- Perform electrical testing

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	Safety Policies and Procedures

1.1. Safety Policies and Procedures

Safe working procedures when testing Electrical Installation whether you are carrying out the test procedure:

(i) As a part of a new installation

(ii) Upon the completion of an extension to an existing installation

(iii) Because you are trying to discover the cause of a fault on an installation or

(iv) Because you are carrying out a periodic test and inspection of a building, you must always be aware of your safety, the safety of others using the building and the possible damage which you're testing might cause to other systems in the building.

For your own safety:

- ✓ Always use 'approved' test instruments and probes.
- ✓ Ensure that the test instrument carries a valid calibration certificate otherwise the results may be invalid.
- ✓ Secure all isolation devices in the 'off' position.
- ✓ Put up warning notices so that other workers will know what is happening.
- ✓ Notify everyone in the building that testing is about to start and for approximately how long it will continue.
- ✓ Obtain a 'permit-to-work' if this is relevant.
- ✓ Obtain approval to have systems shut down which might be damaged by your testing activities.

For example, computer systems may 'crash' when supplies are switched off. Ventilation and fume extraction systems will stop working when you disconnect the supplies. For the safety of other people:

- Fix warning notices around your work area.
- Use cones and highly visible warning tape to screen off your work area.
- Make an effort to let everyone in the building know that testing is about to begin. You might be able to do this while you carry out the initial inspection of the installation.

- Obtain verbal or written authorization to shut down information technology, emergency operation or stand-by circuits.

To safeguard other systems:

- Computer systems can be severely damaged by a loss of supply or the injection of a high test voltage from, for example, an insulation resistance test. Computer systems would normally be disconnected during the test period but this will generally require some organization before the testing begins. Commercial organizations may be unable to continue to work without their computer systems and, in these circumstances it may be necessary to test outside the normal working day.
- Any resistance measurements made on electronic equipment or electronic circuits must be achieved with a battery operated ohmmeter in order to avoid damaging the electronic circuits.
- Hospitals and factories may have emergency stand-by generators which re-energize essential circuits in the event of a mains failure. Your isolation of the circuit for testing may cause the emergency systems to operate. Discuss any special systems with the person authorizing the work before testing begins.

Self-Check -1	**Written Test**

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

SAY TRUE OR FALSE

1. Safe working procedure while testing Electrical equipment/system is not mandatory.
2. Always use ‘approved’ test instruments and probes.
3. Secure all isolation devices in the ‘ON’ position.
4. For the safety of other people, fix warning notices around your work area.
5. Computer systems can be severely damaged by a loss of supply.

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

Score = _____

Rating: _____

Name: _____ Date: _____

ANSWER SHEET

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

Information Sheet #2	Confirm Work Instructions

1.2. Confirm Work Instructions

The purpose of electrical testing on systems and their components is two-fold. The first is to check the installation of the equipment and perform component and systems tests to ensure that, when energized, the system will function properly. The second is to develop a set of baseline test results for comparison in future testing to identify equipment deterioration. Commissioning tests are usually performed by independent contractors, the

installation contractor, or the manufacturer. Each commissioning test should be witnessed and approved by a person not associated professionally with the person performing the test.

The individuals who perform the acceptance tests should be certified and/or licensed for the equipment under test. The system should be initially checked for damage, deterioration, and component failures using specific component checks, inspections, and tests defined by the equipment manufacturer. Then the interconnection of the system components should be checked, using de-energized and energized methods, to verify the proper interconnection and operation of the components, including on/off control, system process interlocks, and protective relaying functions. Once the above tests are complete, the system can be energized and operational tests and measurements should be performed.

All steps and results of the testing should be carefully documented for review and for use in the future for comparison with the results of future tests. Many of the same component tests initially run will be performed at regular intervals as part of a maintenance program. The new results will be compared to the initial results, where variations may be indicative of problems like deterioration of insulation or dirty equipment. The steps involved are to review the system and equipment, develop a general system and specific equipment test plan, provide inspection and checks, perform component testing, verify and check the continuity of wiring, check control functions, calibrate instruments and relays, energize portions of the circuits and check for proper operation in a specific order, and, once complete, perform specific checks and control tests on the complete system during initial period of operation.

Self-Check -2	**Written Test**

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

SAY TRUE OR FALSE

1. The purpose of electrical testing on systems and their components is two-fold.
2. Each commissioning test should be witnessed and approved by a person associated professionally with the person performing the test.
3. The individuals who perform the acceptance tests should be certified and/or licensed for the equipment under test.
4. All steps and results of the testing should not be carefully documented.
5. The interconnection of the system components should be checked, using de-energized and energized methods.

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

Score = _____

Rating: _____

Name: _____ Date: _____

ANSWER SHEET

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

Information Sheet #3	Plan Commissioning Procedures

1.3.Plan Commissioning Procedures

The Commissioning Plan: shall include the requirements for planning, scheduling, coordinating, executing, and documenting Pre-Commissioning, Commissioning, Startup, and Activation activities.

The main objective of the Commissioning Plan: is to provide an organized and thorough approach to the validation of the equipment, systems, and processes to be completed by the Contractor.

Through the Commissioning Plan, the Design Consultant prepares detailed test plans and procedures for commissioning the equipment and systems, and prepares a preliminary schedule of commissioning test and training activities. Final acceptance of the Commissioning Plan shall be provided by the District to the Contractor.

Testing: As part of the Commissioning Plan, the Design Consultant shall develop FAT, PAT, and RAT test plans and procedures. These test plans and procedures detail the coordinated, sequential testing of each system component and piece of controlled equipment installed under the Contract.

Test plans and procedures shall identify, by system and specific tag number, each device or control station to be manipulated or observed during the test procedure and the specific results to be observed or obtained.

Test plans also shall be specific as to the support systems required to complete the test work, temporary systems required during the test work (including any temporary construction needed for testing), representatives to be present, and expected test duration.

The commissioning plan: A tool to structure the commissioning process

Whatever organization approach is chosen, the key challenge to commission a system is to follow a well-managed process. A central document for that purpose is the Commissioning Plan which defines the actions to be performed.

The Commissioning Plan is the key tool that gives the different players an understanding of what is meant by commissioning on a specific project, what amount of effort and money will be required and how it will be managed. The global content of this Commissioning Plan will be defined at the beginning of the project and will be refined all along the project.

Three types of tools were used within the Annex to support the definition and application of the Commissioning Plan.
The following gives an overview of these three types of tools:

1. **Standard Models of Commissioning plans**

These standard models include typical lists of tasks with a description of the content of each task. They can be used as a basis to define customized Commissioning Plans adapted to a given project.

2. **Checklists**

The minimum version of a Commissioning Plan is a checklist defining the verifications to be performed as the project progresses to ensure that critical actions were effectively performed.

The key advantage of the checklist is its simplicity. There would be no need to use a special software or for in-depth training of the users.

The main disadvantage is that it defines what to do but not how to do it and does not include a documentation of the results obtained.

In simple projects, where an independent commissioning authority generally will not be involved, the checklist enables the project manager to apply a minimum of quality control. Check points are especially important when proceeding from one project phase to the next. These checklists will be used by each party involved in the project.

3. Matrix for Quality Control

Its intention is to control the total production process including specifications, design, construction, hand-over and operation. It focuses on avoiding failures on all strategic aspects and phases in this process.

Commissioning: is done for the number of reasons:

- clarifying system performance requirements set by the owner,
- auditing different judgments and actions by the commissioning related parties in order to realize the performance,
- writing necessary and sufficient documentation, and
- Verifying that the system enables proper operation and maintenance through functional performance testing.
- Commissioning should be applied through the whole life cycle of the plants.

Commissioning will probably develop for three main reasons:

- **Energy and environment related reasons**: Global warming has increased the pressure to reduce energy use in plants.
- **Business related reasons:** Many companies are developing new services to diversify their activities in the plants and energy industries. They see the commissioning as a way to develop new business for the benefit of their customers.
- **Technological reasons**: automation systems are now standard in new buildings and are being installed in many older ones. These systems automatically collect plant operating data and offer possibilities for innovative commissioning services.

The primary obstacles that hinder the acceptance of commissioning as a routine process for all plants are clearly:

- **lack of awareness,**
- **lack of time, and**
- **Too high costs.**

Hence, efforts for improvement should consider how new tools, [methods and organizations can increase the awareness of commissioning, decrease the cost and demonstrate the benefits obtained by performing commissioning.

- **Definition of the Commissioning Process**

Commissioning is a quality-oriented process for achieving, verifying, and documenting whether the performance of systems and assemblies meet defined objectives and criteria or not.

- **Types of commissioning**

In practice, one can differentiate four types of commissioning which are represented below:

- ✓ **Initial Commissioning** (I-Cx) is a systematic process applied to production of a new systems and/or an installation of new systems.
- ✓ **Retro-Commissioning** (Retro-Cx) is the first time commissioning which is implemented in an existing system in which a documented commissioning process was not previously implemented.
- ✓ **Re-Commissioning** (Re-Cx) is a commissioning process implemented after I-Cx or Retro-Cx when the owner hopes to verify, improve and document the performance of systems.
- ✓ **On-Going Commissioning** (On-Going Cx) is a commissioning process conducted continually for the purposes of maintaining, improving and optimizing the performance of systems after I-Cx or Retro-Cx.

Self-Check -3	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. _____shall include the requirements for planning, scheduling, coordinating, executing, and documenting.
2. Whatever organization approach is chosen, the key challenge to commission a system is to follow a _____.
3. Commissioning will probably develop for three main reasons such as:_____,_____&_____.
4. The primary obstacles that hinder the acceptance of commissioning as a routine process for all plants are clearly:_____,_____&_____.
5. _____ is a quality-oriented process for achieving, verifying, and documenting whether the performance of systems and assemblies meet defined objectives and criteria or not.
6. In practice, there are four types of commissioning such as:_____,_____,_____ & _____.

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

Score = _____

Rating: _____

Name: _____ Date: _____

ANSWER SHEET

1.The commissioning plan

2. a well-managed process

3.energy and environmental related reasons, business related reasons, technological reasons

4. lack of awareness, lack of time, too high costs

5. Commissioning

6. initial commissioning, retro-commissioning, re-commissioning, on-going commissioning

Information Sheet #4	Obtaining Tools, Materials and PPE

1.4 Obtaining Tools, Materials and PPE

Identify Tools and Testing Devices

No	Name	Description
1	Combination pliers	To grip, cut, bend, draw and to twist wires
2	End cutting pliers	To cut wires
3	Diagonal cutting	To cut wires
4	Electrician knife	To cut and remove insulation
5	Screw drivers	For tightening and loosening screws
6	Test lamps	To check the presence of supply and continuity of devices
7	Hammer ball peen	To cut grooves on wooden boards
8	Mallet	To use with firmer chisels
9	Electric hand drill	To make holes in wood and metal
10	Plumb-bob	To make vertical lines on walls
11	Spanners and wrenches	To tighten and loosen nuts and bolts
12	Soldering iron	Used to heat-up the soldering iron

13	Crimping tool	As soldering on aluminum is difficult, this plies is used to crimp the joints or the lugs
14	Wire striper and cutter	Used for removing insulation of pvc
15	Multi-tester (VOM)	To measure volt, current & resistance
16	Ammeter	To measure the flow of current
17	Signal generator	To display signal out put
18	Pressure meter	meters indicate pressure of liquid or gas ranges
19	Thermometer	Used to measure air or temperature

Identify Materials and Components

No	Name	Description
1	Wires	bare conductors
2	Terminal lugs	The end of Terminal wire marker
3	Terminal blocks	Wire connector
4	Terminal wire marker	the connection of wire in a given circuit
5	Limit switches	Like stop used interrupt the power
6	Relays	Used for over load protection
7	Sensors	Detects or measure a physical quantity
8	Heat/temperature Pressure	Type of switch Sensing
9	Flow	Detect a liquid or gas flow rate capacity

Personal Protective Equipments (PPE)

No	Name	Description
1	Safety helmet (hard hat/bump hat)	Used for Protecting from over head
2	Safety shoes	Safe our leg from wet area & other electrical hazards
3	Ear muffs	From sounds
4	Goggles/Face shield	Protect from sparks
5	Safety belt/Harness	Safe during to claim (maintain) towers
6	Safety Gloves	Safe our hands from electrical & chemicals
7	Safety Mask (gas/fumes, dust)	Safe from gas/ fumes, dust

8	Proper working clothes	

Self-Check -4	Written Test

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

Choose the Best Answer

1._____is used to grip, cut, bend, draw and to twist wires.

A. Combination Pliers B. End Cutting Pliers

C. Diagonal Cutting Pliers D. Electrician Knife

2. _____is used for tightening and loosening screws.

A. Combination Pliers B. Screw Driver

C. Diagonal Cutting Pliers D. Electrician Knife

3. _____is used to check the presence of supply and continuity of devices.

A. Combination Pliers B. Screw Driver

C. Test Lamps D. Electrician Knife

4. _____is used to measure volt, current & resistance.

A. Ammeter B. Multi-tester (VOM)

C. Pressure meter D. Signal generator

5. _____is used for over load protection.

A. Limit switches B. Sensors

C. Overload Relays D. Heat/temperature Pressure

6. _____is used to safe our leg from wet area & other electrical hazards.

A. Safety shoes B. Goggles/Face shield

C. Safety belt/Harness D. Safety Gloves

7. _____is used to safe our hands from electrical & chemicals.

A. Safety shoes B. Goggles/Face shield

C. Safety belt/Harness D. Safety Gloves

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

Score = _____

Rating: _____

Name: _____ Date: _____

ANSWER SHEET

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

Information Sheet #5	Obtaining, Estimating and Inspecting Tools, Equipment and Testing Devices

1.5 Obtaining, Estimating and Inspecting Tools, Equipment and Testing Devices

Tools, equipment and testing devices including:

- Electrical hand tools
  - ✓ Pliers
  - ✓ Screwdrivers
  - ✓ Wrenches
  - ✓ Wire splicer's
  - ✓ Electrician knives
- Testing instruments
  - ✓ Multi-tester (VOM)
  - ✓ Ammeter
  - ✓ Insulation resistance tester
  - ✓ Ground resistance tester
  - ✓ Lux meter
  - ✓ Thermal scanner
  - ✓ Flow meter
  - ✓ Pressure gauge
  - ✓ Pressure Analyzer/ Gauge manifold
  - ✓ Leak tester
- Labeling machine
- Warning sign ages
- Lock-out/Tag-out
- Phase-sequence indicator
- Thermometer
- Tachometer
- Telephone/telephone handset

Self-Check -5	Written Test

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

I. Choose The Best Answer

1. Which one of the following is not electrical hand tool?
   A. Pliers B. Screw Driver
   C. Ammeter D. Electrician Knife
2. Which one of the following is an electrical testing instrument?
   A. Multimeter B. Ground Resistance Tester
   C. Insulation Resistance Tester D. All of these
3. _____is used to measure shaft speed of electrical motor.
   A. Tachometer B. Phase Sequence Indicator
   C. Labeling Machine D. All of These

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

Score = _____

Rating: _____

Name: _____ Date: _____

ANSWER SHEET

1. **C**
2. **D**
3. **A**

Information Sheet #6	**Identifying and Preventing Potential Hazards**

1.6 Identifying and Preventing Potential Hazards

Commissioning is done for the number of reasons: clarifying system performance requirements set by the owner, auditing different judgments and actions by the commissioning related parties in order to realize the performance, writing necessary and sufficient documentation, and Verifying that the system enables proper operation and maintenance through functional performance testing.

So, identifying and preventing potential hazards for electrical equipment/system is our day to day activities. The following are some of the Potential hazards which are mostly happened in the workshop to be commissioned.

- Live wires
- Oil spill
- Chemical hazards
- Flammable materials
- Sources of energy
- Moving machine parts
- Sharp/pointed objects
- Noise hazards
- Confined space

Self-Check -6	Written Test

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

Choose the Best Answer

1. Which of the following are potential hazards?
    A. live wires
    B. oil spill
    C. chemical hazards
    D. flammable materials
    E. all of these
2. Which one of the following is a potential hazard concerned to electrical conductors?
    A. live wires
    B. oil spill
    C. chemical hazards
    D. flammable materials
    E. all of these
3. Which one of the following is a potential hazard related to machines?
    A. sharp pointed objects
    B. moving machines part
    C. noise hazard
    D. confined space
    E. none of these

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

Score = _____

Rating: _____

Name: _____ Date: _____

ANSWER SHEET

1. **E**
2. **A**
3. **B**

Information Sheet #7	Coordinating Commissioning Activities

1.7 Coordinating Commissioning Activities

Commissioning will probably develop for three main reasons: energy and environment related reasons, business related reasons, and technological reasons. So, every concerned body must be involved in coordinating commissioning activities.

An electrician working for an electrical contracting company works as a part of the broader construction industry. This is a multi-million-pound industry carrying out all types of building work, from basic housing to hotels, factories, schools, shops, offices and airports. The construction industry is one of the UK's biggest employers, and carries out contracts to the value of about 10% of the UK's gross national product. Although a major employer, the construction industry is also very fragmented.

Firms vary widely in size, from the local builder employing two or three people to the big national companies employing thousands. Of the total workforce of the construction industry, 92% are employed in small firms of less than 25 people. The yearly turnover of the construction industry is about £35 billion. Of this total sum, about 60% is spent on new building projects and the remaining 40% on maintenance, renovation or restoration of mostly housing.

In all these various construction projects the electro technical industries play an important role, supplying essential electrical services to meet the needs of those who will use the completed building.

Self-Check -7	Written Test

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

Say True or False

1. Every concerned body must not be involved in coordinating commissioning activities.

2. An electrician working for an electrical contracting company works as a part of the broader construction industry.
3. Commissioning is vast work and so it is a major employer in the construction industry.

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

Score = _____

Rating: _____

Name: _____ Date: _____

ANSWER SHEET

1. FALSE
2. TRUE
3. TRUE

Information Sheet #8	Perform Electrical Testing

1.8 Perform Electrical Testing

Electrical testing

The electrical contractor is charged with a responsibility to carry out a number of tests on an electrical installation and electrical equipment. The individual tests are dealt with in the IEE Regulations.

The reasons for testing the installation are:

- to ensure that the installation complies with the Regulations,
- to ensure that the installation meets the specification,
- To ensure that the installation is safe to use.

Those who are to carry out the electrical tests must first consider the following safety factors:

- An assessment of safe working practice must be made before testing begins.
- All safety precautions must be put in place before testing begins.
- Everyone must be notified that the test process is about to take place, for example the client and other workers who may be affected by the tests.
- 'Permits-to-Work' must be obtained where relevant.
- All sources of information relevant to the tests have been obtained.
- The relevant circuits and equipment have been identified.
- Safe isolation procedures have been carried out – care must be exercised here, in occupied premises, not to switch off computer systems without first obtaining permission.
- Those who are to carry out the tests are competent to do so.

The electrical contractor is charged by the IEE Regulations for Electrical Installations to test all new installations and major extensions during erection and upon completion before being put into service. The contractor may also be called upon to test installations and equipment in order to identify and remove faults.

These requirements imply the use of appropriate test instruments, and in order to take accurate readings consideration should be given to the following points:

- ✓ Is the instrument suitable for this test?
- ✓ Have the correct scales been selected?
- ✓ Is the test instrument correctly connected to the circuit?

Many commercial instruments are capable of making more than one test or have a range of scales to choose from. A range selector switch is usually used to choose the appropriate scale. A scale range should be chosen which suits the range of the current, voltage or resistance being measured. For example, when taking a reading in the 8 or 9 V range the obvious scale.

Self-Check -8	Written Test

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

SAY TRUE OR FALSE

1. The individual electrical tests are dealt with in the IEE Regulations.
2. One of the reasons of testing electrical installation is to ensure that the installation meets the specification.
3. All safety prequetions must not be put in place before testing begins.
4. “Is the instrument suitable for this test” is one of the requirements imply the use of appropriate test instruments.
5. Many commercial instruments are not capable of making more than one test or have a range of scales to choose from.

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

Score = _____

Rating: _____

Name: _____ Date: _____

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

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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)

Self-Check -1	Written Test

is achieved over time.

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!

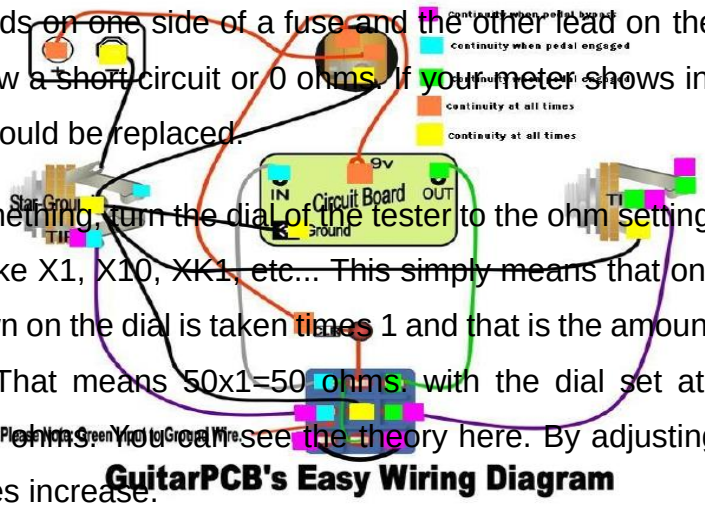
Continuity testers are also great for checking wire runs for a complete circuit. You may also find short circuits in wiring with this tester; say two wires have melted together inside the outer jacket of NM sheathed cable.

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 w here appropriate so that they arenot damaged by the test voltage.

(d)where the circuits contain voltage sensitive devices, the testshould measure the insulatio n 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 isola ted; and

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

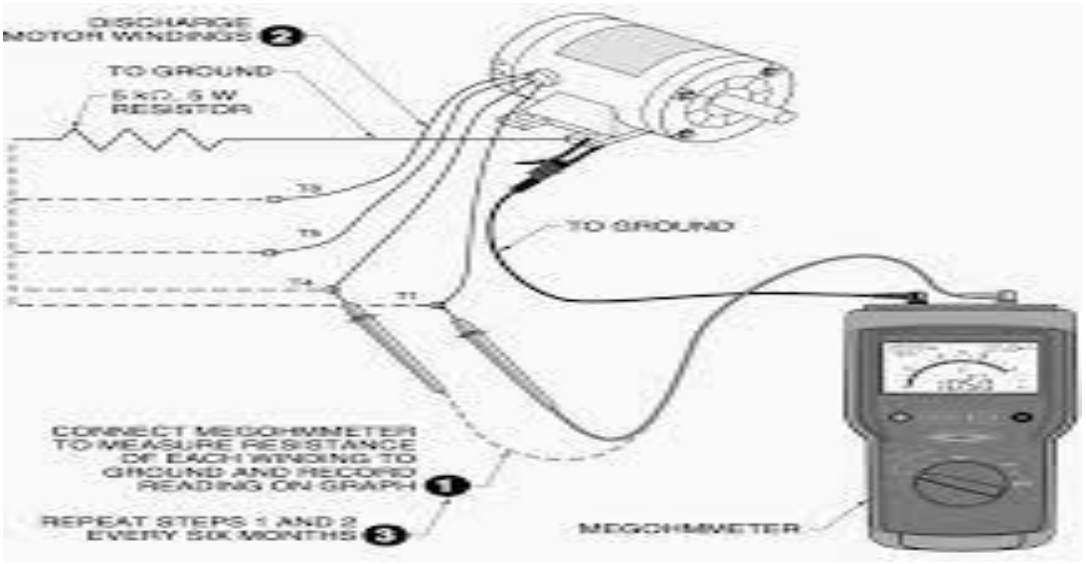


Fig.2. ELECTRICAL INSULATION TEST

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.

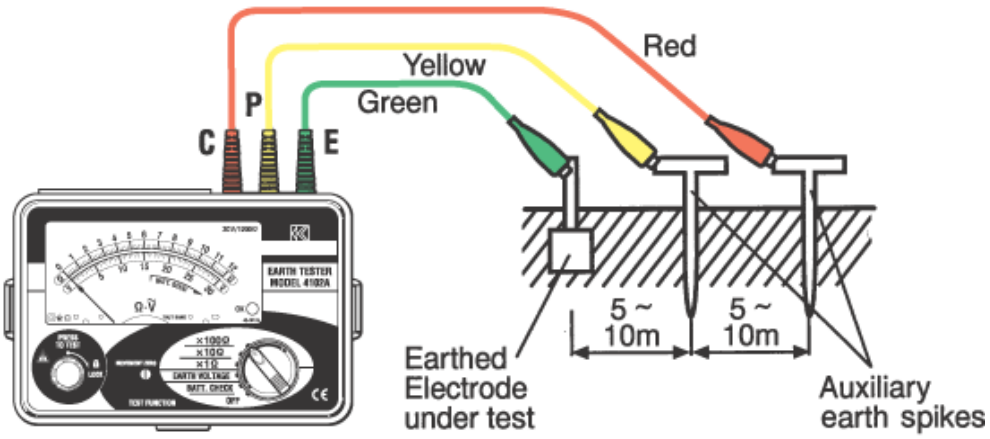


Fig. 3b. Earth Resistance Test

2.2.4 PHASE SEQUENCE TEST

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

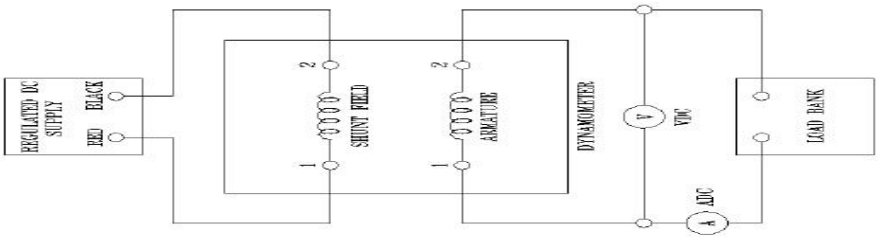
2.2.5. LOAD TEST

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 cur-

rent (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.



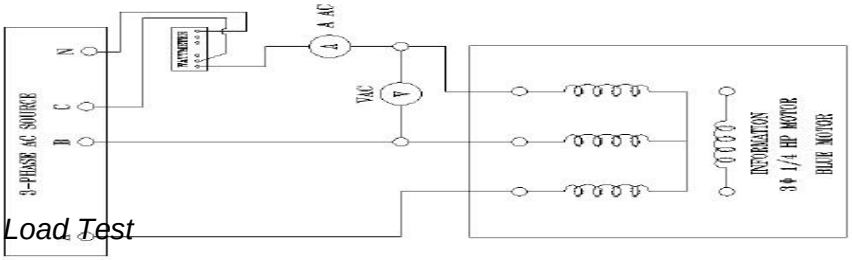


Fig.5 Load Test

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 armature 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 an equilibrium rotor speed. Thisequilibrium rotor speed must be less than synchronous speed since there must be a slip to producetorque.

The frequencydependent nature of the rotor impedances causes the torque versus speedcharacteristic of the induction motor to be quite nonlinear. Figure shows a typical characteristic.Designers have learned to design rotors for specific torque characteristics. 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 resistance. 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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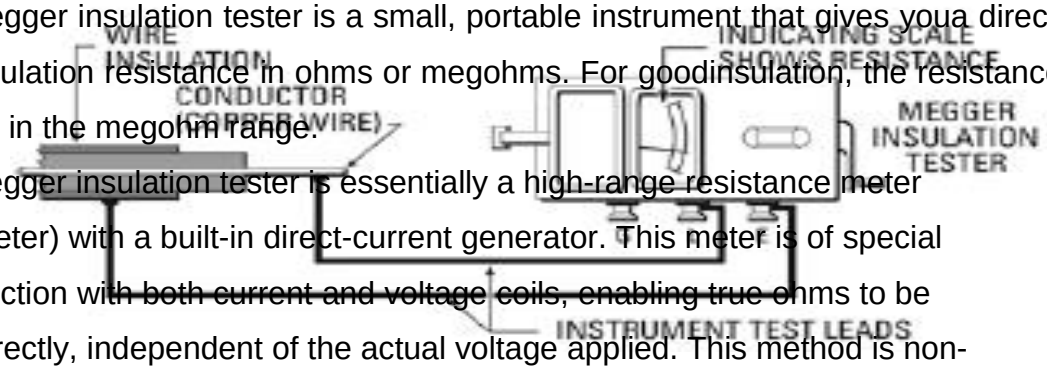

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The generator can be hand-cranked or line-operated to develop a high dC voltage which causes a small current through and over surfaces of the insulation being tested (Fig. 2). This current (usually at an applied voltage of 500 volts or more) is measured 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 verifying the correct motor rotationand wiring phase sequence. Improper connections can cause 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 rotation direction without use oftest leads. This is particularly useful for fastrunning motors when the motor rotation cannot be visually determined or whenthe drive shaft is not visible.Durably 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 essential tool for motor rotation and phase sequence testing incommercial and industrial environments 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

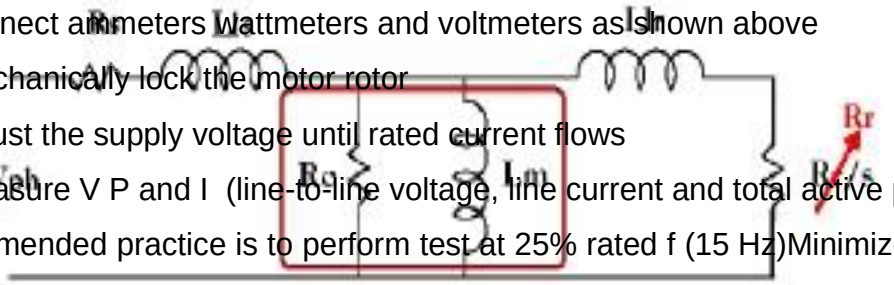
Locked-Rotor Test Procedure

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

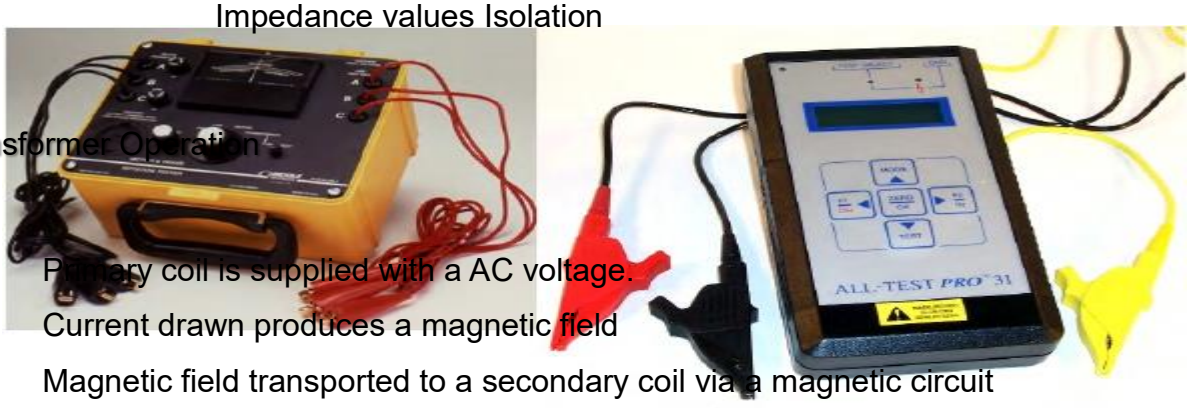
The open circuit and short circuit test are performed for determining the parameter of the transformer like their sufficiency, voltage regulation, constant etc. these tests are performed without the actual loading and because of this reason the very less power is required for the test.

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 generation 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, p otentially 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

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: _____

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: _____

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?

Instruction Sheet	LG40: Turn-Over Electrical Equipment/Systems

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

- Undertaking Inspect electrical equipment/system
- Checking and returning tools, equipment and any excess resources and materials cleaning
- Preparing and submitting written report
- Accomplishing monitoring data sheet for the newly installed system
- Providing Orientation and technical assistance

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**:

- Undertake Inspect electrical equipment/system
- Check and return tools, equipment and any excess resources and materials clean
- Prepare and submit written report
- Accomplish monitor data sheet for the newly installed system
- Provide Orientation and technical assistance

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	Undertaking Inspect Electrical Equipment/System

3.1 Undertaking Inspect Electrical Equipment/System

The purpose of this testing manual is to provide guidelines for inspection and testing of Various Electrical Equipment in compliance to relevant international standards/specifications.It provides information on procedures and testing of Major Electrical equipment's to be followed during testing by engineers and also furnish evidenc ethat an electrical equipment/device is free of inherent flaws or faults.

The tests on equipment/system have been broadly categorized into two categories viz.Fa ctory Acceptance Test (FAT) and Site Acceptance Tests (SAT). These tests have been tailored to ensure design, construction and performance requirements of each equipment

This testingmanual includes High Voltage Switchboards, Low Voltage Switchboards, Transformer, Diesel Generator Sets, Induction Motors, Cables, Uninterrupted Power Supply (UPS), Ring Main Unit, Light Fittings, MOV Actuators, Isolator Switch andE arthing Systems etc. However in this Paper only highlights the high voltage cables andrel ated test methods.

Benefits

Most useful practical information regarding the Factory Acceptance Tests (FAT) &Site Ac ceptance Tests (SAT) activities.

Highlights the type of test and their desired result values. These values are derived from the International standards, manufacturer's guidelines and good practical experiences.

It covers for all major Electrical Equipment.

Simplifies procedures/integration requirements are fulfilled.

Improve the quality control of the project and simplify the procedures for engineers.

Saving of material searching time.

Factory Acceptance Tests (FAT)

The Routine tests shall be made with each Electrical Equipment and, whenever practicab le,at the manufacturer's works to ensure that the product is in accordance with the equip menton which the type tests have been carried out.

The factory acceptance tests consist of Routine, Type Tests and Special tests (pro jectspecific) as per company and International standards. Routine tests may comprise,

Functional tests - Mechanical Operation Test -Test on auxiliary equipment- Verification ofcorrect wiring.

Dielectric Tests - It is presumed that every such equipment would also comply with the type test, since design is identical.

The factory inspection and testing are conducted according to Company/internation alstandards.

INSPECTION OF INSTALLED APPARATUS

Installation, appliances connected to it. In adverse events, the leakage current flowing through it may cause severe electrical shock to the person coming in physical contact with

it. In order to test this, the main switch should be in open position. All other circuit contacts like bulbs and switches should be ON position. The Earth continuity tester is then connected between the switch / conduit and an independent earth. The tester will indicate the value of resistance. In all cases the value should not exceed more than 1 ohm. If the value appears higher than 1 ohm it indicates that the switch / conduit is not properly earthed.

Visual Inspection

A regular visual inspection should be carried out in all electrical installations. A visual inspection of this type does not necessarily need to be carried out by an electrician, but it should reveal any areas which are obviously in need of attention.

A visual inspection should look for:

- Breakages
- Wear & deterioration
- signs of over heating
- missing parts (covers, screws) and
- Loose fixings and confirm
- Switchgear accessibility (no obstructions) and
- Doors of enclosures are secure It should also check the operation of
- Equipment – switch on & off where equipment is not in regular use or where it is left off or on standby for long periods and
- Residual current devices using test button.(It is recommended that, independent of any other inspection and test regime, residual current devices undergo a push-button test at least twice per year to ensure that they operate correctly when needed).

These routine checks need not to be carried out by an electrically skilled person but should be done by someone who is able to safely use the installation and recognise any obvious defects.

FUNCTIONAL TEST OF INSTALLED APPARATUS

Functional test

Whether they are properly installed and adjusted, all assemblies, such as switchgear and control gear assemblies, drives, controls and interlocks, should be functionally tested to show that they are properly mounted, adjusted and installed in accordance with the

relevant requirements of the standard. Protective devices must be functionally tested and checked.

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 two broad categories of tests on electrical equipment /system are:

A. factory acceptance test B. site acceptance test C. both A & B are answers D. all of these E. none of these

2. The testing manuals include:

A. induction motor B. switch boards C. cables D. all of these E. none of these

3. Which of the following are benefits of factory and site acceptance tests?

A.It covers for all major Electrical Equipment

B. Simplifies procedures/integration requirements

C. Improve the quality control of the project

D. Saving of material searching time.

E. All of these

4. A visual test should look for except:

A. Breakages

B. Wear & deterioration

C. signs of over heating

D. Switchgear accessibility

E. None of these

5. Functional Test of Installed Apparatus Include

A. All Assemblies B. Drives C. Controls D. All of These E. None of These

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

Score = _____

Rating: _____

Name: _____ Date: _____

ANSWER SHEET

1. C
2. D
3. E
4. E
5. D

Information Sheet-2	**Checking and Returning Tools, Equipment and Any Excess Resources and Materials Cleaning**

3.2. Checking and Returning Tools, Equipment and Any Excess Resources and Materials Cleaning

After checking and returning tools, equipment and any excess resources to their proper places, materials cleaning are very important tasks in working areas.

Cleaning is the removal of all visible soil in an approved way with the use of mechanical and chemical action or both, so that all areas are cleaned and sanitised to a high standard. Cleaning is an investment in the assets of a building especially in electrical equipment/ system area. Maintenance is the upkeep of all furniture, fittings and equipment to an exacting standard within the property so that all areas look consistently new and pristine.

Why do we clean?

There are many reasons why we clean but the most important ones are -

Health Regulations

If your local government authority has health regulations regarding cleaning and sanitizing, then you must know these and follow their recommendations at all times. It is

important when you are cleaning that you clean to a high standard that has been set for you by your supervisor or manager. Failure to clean properly and remove rubbish may result in pest infestation and bad smells caused by rotting rubbish. Failure to clean will ultimately lead to a loss of business through guest complaints and investigations by local health inspectors. If these are not cleaned and maintained regularly, fixtures and fittings will need to be replaced more often, at an ever increasing cost to the property owner e.g. If a carpet is never vacuumed or spot cleaned, eventually the carpet will deteriorate to the point where it will need to be replaced as it cannot be recovered through cleaning.

To Maintain a Safe and Clean Environment If the property is clean and well-maintained it is more likely to be safe. If spills are not cleaned promptly people can slip and be hurt. If carpets have holes or chairs are broken this can lead to injuries and possible financial compensation claims against the hotel.

To Improve Staff Morale All staffs who serve the general public must feel positive about their work environment particularly electrical equipment/ system area, if they are to give good service. There should not be different cleaning and maintenance standards between front and back of workshop areas. All staff needs to feel they work in a safe and clean place. This will improve staff morale and lead to happy staffs that will care for the visitors who will want to return so ensuring staff retain their employment.

Where do we clean?

The short answer to this question is EVERYWHERE particularly electrical equipment/ system area. As a member of the cleaning team, you may be responsible for front of workshop areas or back of building areas or some of both. Front of workshop is where all trainers and trainees as well as workshop assistants and customers have access during their stay. Back of workshop areas are where staff works and to where visitors do not have access.

Self-Check -2	Written Test

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

SAY TRUE OR FALSE

1. After checking and returning tools, equipment and any excess resources to their proper places, materials cleaning are very important tasks in working areas.
2. Cleaning is the removal of all visible soil in an approved way with the use of mechanical and chemical action or both.
3. There are many reasons why we clean electrical equipment/system areas, but the most important one is health regulations.
4. To maintain a safe and clean environment and if the property is clean and well-maintained, it is not more likely to be safe.
5. To improve staff morale all staffs who serve the work shop must feel negative about their work environment.

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

Score = _____

Rating: _____

Name: _____ Date: _____

ANSWER SHEET

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

Information Sheet-3	Preparing and Submitting Written Report

3.3. Preparing and Submitting Written Report

Report Writing Where

Relates to the location the event took place, or subsequent locations, depending on the type of incident.

Why

It may explain the reason for the occurrence, but can not be speculation or unfounded opinion.

How

Relates to how the event came to your attention, how it occurred. This means thecomplete details about how the event happened from start to finish.

Report Organization

Introduction

Should include the date and time, the location, people involved, and whathappened.

Body

Chronological narrative of what actually occurred, observations made, and subsequent interviews and inquires, witnesses names, statements, and descriptions.

Conclusion

What follow-up actions are still required and expected time of completion, preventative action taken, and a brief summary of points that are not completely answered in the body of the report.

Formal Reports

A formal report contains the following:

1. Title Page: includes the title of the project/report, to whom the report is submitted, by wh om it isprepared, the date it is written (*not* the date the report is due!), and the **abstract**. (An example title page isshown on the next page.)

2. Abstract: a *short* paragraph indicating what the project was and what solution was found

3. Table of Contents: contains page numbers of the titles and subtitles of different section s of the report.

4. Introduction: a brief description of the problem, how it was approached, and what proc edure wasused to solve it. It may also give the reader some information on what was done in the sections followingthe introduction (for longer reports).

5. Development: describes the details of the methods, procedures, techniques, etc., use d in solving theproblem. This section usually has subsections such as model development , calculations, experimentalprocedure, applications, etc.

6. Discussion: a discussion of the findings and any discrepancies.

7. Conclusion and Suggestions: This section is a brief summary of what the findings wer e and what thesignificance of the work is. If it is a research project, it also contains sugges tions about future researchareas

8. References: This is a list of the books, reports, papers, Internet sources, and computer software thatwere used to complete the project and write the report. All references listed m ust be cited in the report; **ifno references are *cited*, don't *list* any.** References are listed in the same order in which they were *first* cited.

Informal Reports

An informal report consists of a memo plus attachments and contains the following sections:

- **Heading** (required)**:** To whom the report is submitted, who wrote it, when it was *wri tten* (*not* the datethe report is due!), and what it is about. (An example of the first page of an informal report is included onthe following page.)
- **Summary** (required)**:** The summary is a brief (one or two paragraphs) description of t he project andthe results, plus a brief mention of cost and schedule (so that managers d on't have to read the entire report

to find this information). It should never extend onto the second page of the report and in m ost cases willnot contain figures, tables, or equations.

- **Design** (optional)**:** Describes how the circuit or system was designed.
- **Testing** (optional)**:** Describes how the circuit or system was constructed and tested.
- **Simulations** (optional)**:** This section includes the *results* of any numerical simulations done for theproject. (Listings of computer code belong in an attachment unless develo

pment of the code was thepurpose of the project.) If the simulations are an integral par t of the design process, include thesimulation results in the **Design** section and omit thi s section.

- **Results** or **Conclusion** (required): This section summarizes the results of the project, compares themeasured results to the design goals and numerical simul ations, gives detailed breakdowns of costs andtime spent (if required), etc.
- **References** (required if any references are cited)**:** This section contains a list of all ref s should be listed in numericalorder (of course!) and in the order in which they are *fi rst* cited. The **References** are *not* placed on aseparate page.
- **Attachments** (optional)**:** Attachments to an informal report serve the same function as appendices ina formal report. Attachments are numbered (or lettered) and are att ached to the end of the report innumerical (or alphabetical) order. The order must b e the same as the order in which the attachments were*first* cited in the report. *All att achments must be cited by number* (*or letter*) *in the text of the report*. Pagenumbers are not required on attachments.

In an informal report, each section does *not* have to start on a separate page. However, nev er end apage with a section heading.

Self-Check -3	**Written Test**

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

Choose the Best Answer

1. Report writing relates to the location the event took place or subsequent locations depending on the type incident.
   A. True B. False
2. A formal report contains the following formats except:
   A.titlepage B.abstract C. table of contents D.introduction E. none of these
3. Informal report consists of a memo plus attachments and contains:
   A. heading B.summary C. design D. testing E. all of these
4. _____ includes the title of the project /report:
   A.titlepage B.abstract C. table of contents D.introduction E. none of these
5. _____ describes how the circuit or system was designed:
   A. testing B.design C. simulation D. result E. none of these

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

Score = _____

Rating: _____

Name: _____ Date: _____

ANSWER SHEET

1. A
2. E
3. E
4. A
5. B

Information Sheet-4	**Accomplishing Monitoring Data Sheet for the Newly Installed System**

3.4 Accomplishing Monitoring Data Sheet for the Newly Installed System

Accomplishing Monitoring Data Sheet for the Newly Installed electrical equipment /System is a mandatory issue for the new buildings.

Functional performance testing verifies the intended operation of individual components and system interactions under various conditions and modes of operation. The systems are run through all of the sequences of operation and the response of components is verified. Testing proceeds from components to subsystems to systems, and finally to interlocks and connections between systems.

The commissioning agent prepares functional performance test plans so that the complete sequence of operations is included. The commissioning agent obtains all documentation, including an updated points list, control sequences, and setpoints. If necessary, the commissioning agent may request clarifications from contractors and the design team regarding sequences and operation. Prior to execution, the commissioning agent provides a copy of the primary equipment tests to the installing subcontractor and general contractor who can review the tests for feasibility, safety, warranty and equipment protection for electrical equipment /system.

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. Functional performance testing verifies the intended operation of individual components and system interactions.

2. Testing proceeds from components to systems, and finally to interlocks and connections between systems.
3. The commissioning agent prepares functional performance test plans, however, the complete sequence of operations is not included.
4. General contractor reviews the tests for feasibility, safety, warranty and equipment protection for electrical equipment /system.

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

Score = _____

Rating: _____

Name: _____ Date: _____

Information Sheet-5	Providing Orientation and Technical Assistance

3.5 Providing Orientation and Technical Assistance

Providing technical orientation and technical assistance for the operator or maintenance man is a vital issue in order to sustained electrical commissioning for electrical equipment / system in the workshop.

Effective maintenance personnel training is a critical to the long term performance of the electrical equipment/system. The commissioning agent will assist the owner and general contractor in organizing the training sessions by identifying the appropriate staff for each session and creating an overall training plan. For each training session, the contractors provide a detailed agenda for each piece of equipment or system for which training is required. The agenda describes the training scope, duration, and methods, along with the name and qualifications of the trainers.

The commissioning agent develops a plan for including in the training session contractors / trainers from different disciplines, when appropriate. The trainer documents each training session (duration, general subjects covered, and attendees). The commissioning agent may witness any of the training sessions.

Self-Check –5	Written Test

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

Choose the Best Answer

1. Providing technical orientation and technical assistance for the operator or maintenance man is a vital issue.

   A.TRUE B. FALSE

2. Effective maintenance personnel training is not a critical to the long term performance of the electrical equipment/system.

   A.TRUE B. FALSE

3. The commissioning agent assists the owner and general contractor in organizing the training sessions.

   A.TRUE B. FALSE

4. The contractors provide a detailed agenda for each piece of equipment or system for which training is required.

   A.TRUE B. FALSE

5. The ORIENTATION agenda describes:

   A. Training scope B. Duration C. Methods D. All of these E. None of these

6. The trainer documents each training session which consists of :

   A. Duration B. General subjects covered C. Attendees D. All of these E. None of these

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

Score = _____

Rating: _____

Name: _____ Date: _____

REFERENCES MATERIALS

1. Advanced Electrical Installation Work FIFTH EDITION

2. Practical Troubleshooting of Electrical Equipment and Control Circuits

3. TTLM