INDUSTERIAL ELECTRICAL MACHINES AND DRIVES SERVICING

Level II

LEARNING GUIDE # 33

Unit of competence: Industrial Electrical Machines and Drives Servicing Level II

Module Title: Maintaining and repairing industrial electrical machines and drives

LG Code: EEL EMD2 M08LO4-LG33

TTLM Code: EEL EMD2 TTLM081019V1

LO4: Notify completion of work

Instruction Sheet :1	Learning Guide 33

This learning guide is developed to provide you the necessary information regarding the following learning outcome and content coverage

- Notifying the completion of work to immediate supervisor
- Making performance tests
- preparing and submitting service report

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

- Notify the completion of work to immediate supervisor Notify
- Making performance tests
- preparing and submitting service report

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the “Information Sheet 1, Sheet 2 and Sheet 8” in page 4, 7and 16 respectively”.
4. Accomplish the “Self-check 1, Self-check 2 and Self-check 3” in page 6,15 and 17 respectively”.
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1 and Operation Sheet 2” in page 18.
6. Do the “LAP test” in page 19

Information Sheet – 1	Notify the completion of work to immediate supervisor Notify

1.1. INTRODUCTION

Written notice issued by the owner of a project (or his or her agent) to notify concerned parties that all work on the project has been completed. This notice also sets the period within which concerned parties may exercise their lien rights against one another.

A document recorded by a property owner to notify potential Mechanics Lien claimants that a specific construction project has been completed. The effect of a properly recorded Notice of Completion is to reduce the time in which a subcontractor, material supplier or general contractor can record a Mechanics Lien against a private works construction project.

1.2. Works completion

This concept is not defined nor is there any set date but it follows from practical completion. The process starts with the principal agent issuing a works completion list to the contractor which details defective and incomplete work present at practical completion but which are not required to achieve practical completion. The contractor must remedy the defects in this list in order to achieve works completion.

Once the contractor has addressed all incomplete and defective items on the 'works completion list' he must notify the principal agent to inspect these items, and if satisfied, issue a certificate of works completion. If the principal agent remains unsatisfied then he is required to identify which items have not been completed or rectified to his satisfaction and the contractor must carry out the rectification and completion procedure again in accordance with sub-clause. This procedure may be repeated several times until the principal agent is satisfied that all the items on the work completion list have been appropriately addressed.

Alternatively, should the principal agent not issue a works completion list within 5 working days of the date of practical completion the contractor is obliged to notify both the employer and principal agent in this regard and the principal agent is required to submit a works completion list within 5 working days of receipt of the contractor's notice. Should the principal agent fail to submit the works completion list thereafter, works

completion shall be deemed to have been achieved on the expiry of the initial 5 working day period after the issue of the certificate of practical completion.

The only evident incentives that exist for the contractor in relation to works completion is that the contractor has 20 working days to complete and / or rectify the items on the works completion list in order not to forego compensatory interest on the value of outstanding work . The issue of the works completion certificate marks the commencement of the 90 calendar day defects liability period. (NB The Contractor is not entitled to compensatory interest on the value of outstanding work).

1.3. Final completion

At the end of the defects liability period, or when the contractor believes the defects liability period has come to an end, he must submit a notice to the principal agent who is obliged to inspect the works within the period specified in order to determine whether any defects are present. Should any defects be identified, the principal agent is obliged to provide the contractor with a defects list, which have arisen during the defects liability period and which the contractor must rectify in order to achieve final completion of the works.

Similarly, as provided for under works completion, if the principal agent does not issue a defects list within the period prescribed of 5 working days from the end of the defects liability period, the contractor is obliged to notify both the employer and principal agent in this regard and the principal agent is required to submit the defects list within 5 working days of receipt of the contractor's notice. Should the principal agent fail to submit the works completion list thereafter, final completion shall be deemed to have been achieved on the expiry of the initial 5 working day period after the end of the defects liability period.

The achievement of final completion by the contractor has the following consequences:

- all the contractor's liabilities and obligations in relation to a subcontractor's defects comes to an end and any remaining portion of the subcontractor's defects period is agreed and assumed by the employer ;

- All guarantees, warranties and indemnities provided by the contractor, subcontractors and suppliers are ceded to the employer on the date which the certificate of final completion is issued ; and
- The certificate of final completion constitutes conclusive evidence as to the sufficiency of the works and that the contractors obligations have been fulfilled other than latent defects.

Practical completion, works completion and final completion deal exclusively with the construction period. Once the contractor has achieved final completion he still retains certain obligations in relation to the latent defects liability period. The latent defects liability period commences when construction begins and ends 5 years after the date when final completion was achieved

Self Check 1	Written test

Name: _____ Date: _____

Directions: Answer all the questions listed below. Say true or false

1. Concept is not defined nor is there any set date but it follows from practical completion
2. A document recorded by a property owner to notify potential Mechanics Lien claimants that a specific construction project has been completed.

Note: **Satisfactory rating - 1 points** **Unsatisfactory - below 1 points**

Score = _____

Rating: _____

Name: _____ Date: _____

Information Sheet – 2	Make performance tests

2.1. Introduction

Testing electric motors doesn't have to be a mystery. Knowledge of the basics together with powerful new test equipment vastly simplifies the job.

Electric motors have had a reputation for being a mix of science and magic. So when a motor fails to operate it may not be obvious what the problem is. Knowing some basic methods and techniques along with having a few test instruments handy helps detect and diagnose problems with ease.

When an electric motor fails to start, runs intermittently or hot, or continually trips its over current device, there my be a variety of causes. Sometimes the trouble lies within the power supply, including branch circuit conductors or a motor controller. Another possibility is that the driven load is jammed, binding or mismatched. If the motor itself has developed a fault, the fault may be a burnt wire or connection, a winding failure including insulation deterioration, or a deteriorating bearing.

A number of diagnostic tools, such as clamp-on ammeters, temperature sensors, a Megger or oscilloscope, can help illuminate the problem. Preliminary tests generally are done using the ubiquitous multimeter. This tester is capable of providing diagnostic information for all kinds of motors.

- **Electrical measurements**

If the motor is completely unresponsive, no ac humming or false starts, take a voltage reading at the motor terminals. If there is no voltage or reduced voltage, work back upstream. Take readings at accessible points including disconnects, the motor controller, any fuses or junction boxes, and so on, back to the over-current device output at the entrance panel. What you're looking for is essentially the same voltage level as measured at the entrance panel main breaker.

When there is no electrical load, the same voltage should appear at both ends of the branch circuit conductors. When the circuit electrical load is close to the circuit capacity, the voltage drop should not exceed 3% for optimum motor efficiency. In a three-phase hookup, all legs should have substantially equal voltage readings, with no dropped phase. If these readings vary by a few volts, it may be possible to equalize them by rolling the connections, taking care not to reverse rotation. The idea is to match supply voltages and load impedances so as to balance the three legs.

If the electrical supply checks out, examine the motor itself. If possible, disengage the load. This may restore motor operation. With power disconnected and locked out, attempt to turn the motor by hand. In all but the largest motors the shaft should turn freely. If not, there is an obstruction inside or a seized bearing. Fairly new bearings are prone to seizure because the tolerances are tighter. This is especially true if there is ambient moisture or the motor has been unused for a while. Often good operation can be restored by oiling front and rear bearings without disassembling the motor.

If the shaft turns freely, set the multimeter to its ohms function to check resistance. The windings (all three in a three-phase motor) should read low but not zero ohms. The smaller the motor, the higher this reading will be, but it should not be open. It will usually be low enough (under 30 Ω) for the audible continuity indicator to sound.

- **General Inspections**

For the three-phase motor, do the following;

(1) Check the appearance of the motor. Check for burnt, damage to body or cooling fan orshaft.
(2) Manually rotate motor shaft to examine bearing condition. Look out for smooth and free shaft rotation. If shaft rotation is free and smooth, bearing is possibly in good condition, otherwise consider replacing, repair or carry out further diagnosis.
(3) As with all testing and inspections, the motor name plate provides valuable information that will help to ascertain the true health of the motor. Examine the name plate thoroughly and compare values of running amps test.

2.2. Phase Sequence Test

The correct phase sequence is required for the proper operation of any three phase system. It ensures that the load works as desired, when incorrect, the equipment such as the motor may malfunction, rotate in the reverse direction. The phase reversal may damage the motor or the equipment the motor is driving.

It is always important to ensure that the incoming 3-phase conductors have the correct phase sequence before connecting new equipment or before reconnecting motors after maintenance. This might not be obvious by visual inspection, hence the need for a reliable tool. The two commonly used methods are the rotating phase-sequence meter or the static phase-sequence indicator.

2.2.1. Phase sequence meter/indicator

The phase-sequence meter is the most straightforward and commonly used tool for determining the phase sequence. The meter may be digital using semiconductor devices, or rotational (analog) type.

Figure:2.1. A three phase sequence tester

2.2.2. Rotational phase sequence meter

These are small asynchronous motors consisting of an aluminum disk which serves as the rotor. The tester has three windings which are usually connected to the circuit under test. The principle of operation is similar to that of an induction motor.

The meter has coils whose one end of each is connected in a star configuration. The other three ends of the coils are attached to the motor power connections or the circuit under test. The meter contains an aluminum disk which rotates when the current through the coils creates a magnetic field.

The current through the three windings creates a magnetic field that depends on the phase sequence of the incoming power conductors; this causes the disk to rotate in the direction that depends on phase sequence. The meter terminals are marked with a certain phase sequence order. Once the disk rotates, the direction of the arrow on the disk shows the phase sequence, based on the marks.

The tool rotates clockwise when the phase sequence is correct (RYB) and anticlockwise when the phases are reversed. Some general-purpose indicators may determine the phase sequence, power factor and phase shift between the current and voltage.

2.2.3. Static Type Phase-Sequence Indicators

The static indicator is a simple configuration that uses two lamps and an inductor or capacitor. One lamp is connected to one phase such as R and the other to another phase such as Y, while the inductor or capacitor on the remaining third phase. A resistor may be used in series with the lamp to control the amount of current and voltage.

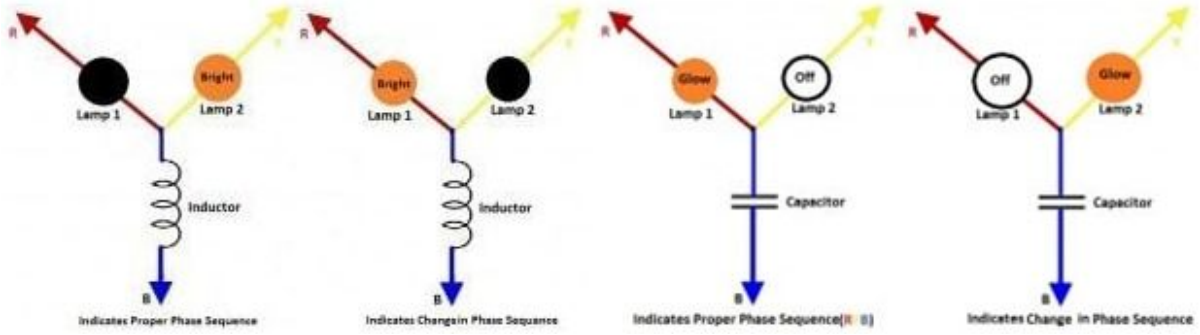
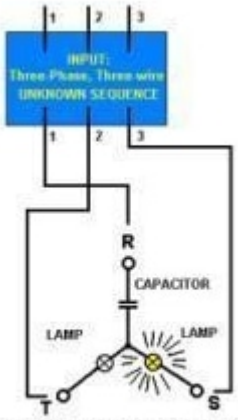


Figure: 2.2. Static phase sequence indicator

If using the inductor, lamp B will be more brighter than A if the phase sequence is correct, while Lamp A becomes brighter when the phases are reversed. However, using the capacitor tester, Lamp A will light on while lamp B will be off. If the sequence is incorrect, lamp B lights up while lamp A remains off.



The brightest lamp indicates the phase that follows R (the capacitor terminal of the indicator).

2.3. Actual Motor Operation Test

2.2.1. All types

- Check the appearance of the motor. Check for body damage or damage to the cooling fan blade or shaft.
- Manually rotate the shaft to check the bearing condition. Check for free & smooth rotation.
- Note the motor data from the motor NAME PLATE .
- **Earth Continuity:** Use your ohmmeter to verify the resistance between earth and motor frame is less than **0.5 Ω.**
- **Power supply –** correct voltage (230 volts per line), 415 v between LI to L2, L2 to L3, and, L3 to L1,

2.2.2. Single Phase

- ✓ Check the motor winding ohms reading using multimeter or ohmmeter.**(C to S, C to R, S to R)**.The reading for start to run should be equal to C to S + C to R.

Correct electrical terminal identification: There are three terminal connections ion a hermetically sealed motor compressor and are as follows: Common (C), Start (S) and Run (R). To identify the correct terminal connection the following procedure applies:

- ✓ The highest resistance reading is between the start and run terminals
- ✓ The middle resistance reading is between the start and common terminals.
- ✓ The lowest resistance reading is between the run and common terminals.

- **Insulation resistance** of motor winding using Insulation tester meter set to the 500 Volt scale. Check from windings to earth **(C to E, S to E, R to E)** Minimum test value of the electric motor is **1 Meg Ohm (1 MΩ).**
- With the motor running, check the running amps of the motor using Clamp on meter.

2.2.3. Three Phase

- Ensure the terminal for power supply is in good condition. Check the connection bar for terminal (U, V, W). Connection type - **STAR OR DELTA**.
- Confirm the power supply VOLTAGE for electric motor. 230/400.
- Using the multimeter, check the continuity of winding from phase to phase **(U to V, V to W , W to U)**.Each phase to phase must have a continuity if winding is OK.
- Check the motor winding ohms reading using multimeter or ohmmeter for phase to phase terminal**(U to V,V to W ,W to U)**.The ohms reading for each winding must be the same (or nearly the same).
- **Insulation resistance** of motor winding using Insulation tester meter set to the 500 Volt scale (1000v DC). 1. Check from phase to phase **(U to V, V to W, W to U)** and 2. check from phase to earthing **(U to E, V to E , W to E)**. Minimum test value of the electric motor is **1 Meg Ohm (1 MΩ).**

- With the motor running, check the running amps of the motor using Clamp on meter. Compare to the FLA on the name plate of motor.
- If every step is completed, decide the condition of electrical motor either OK or NEED TO REPAIR.

Every 3 phase motor has six (6) terminals with the supply voltage connected to three (3) of those terminals. The most common configuration of a three-phase motor is the Delta (∆) – Star (Wye) configuration with the Delta side connected to supply voltage. The terminal configuration of a 3 phase motor is shown below:

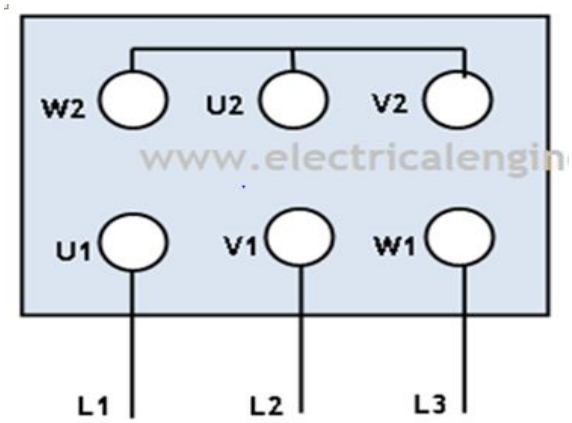


Figure 2.3. Terminals Configuration of a 3 Phase Motor

The **W2U2V2** terminal set is the star side of the 3 phase motor while the **U1VIW1** is the Delta side of the motor connected to the supply voltage.

The 3 phase motor is a rugged piece of equipment but as with everything man made, there comes a time when this beautiful piece of machinery fails either due to old age, misapplication, mal-operation or any other adverse cause.

The most common failure mode of a 3 phase AC motor is burnt winding or shorted winding leading to the damage of the motor. Often it is required to test the winding of the 3 phase windings with the aid of a multimeter or ohmmeter to determine whether the motor is still good or burnt or shorted.

2.3.1. How to Test the Winding of a 3 phase Motor

To determine whether a 3 phase motor is still good or has gone bad, a simple ohmmeter test across the windings of the motor will reveal its true state of health. As shown below, the indicated terminal matrix (***blue lines***) shows the way the windings of a 3 phase motor should be tested with an Ohmmeter:

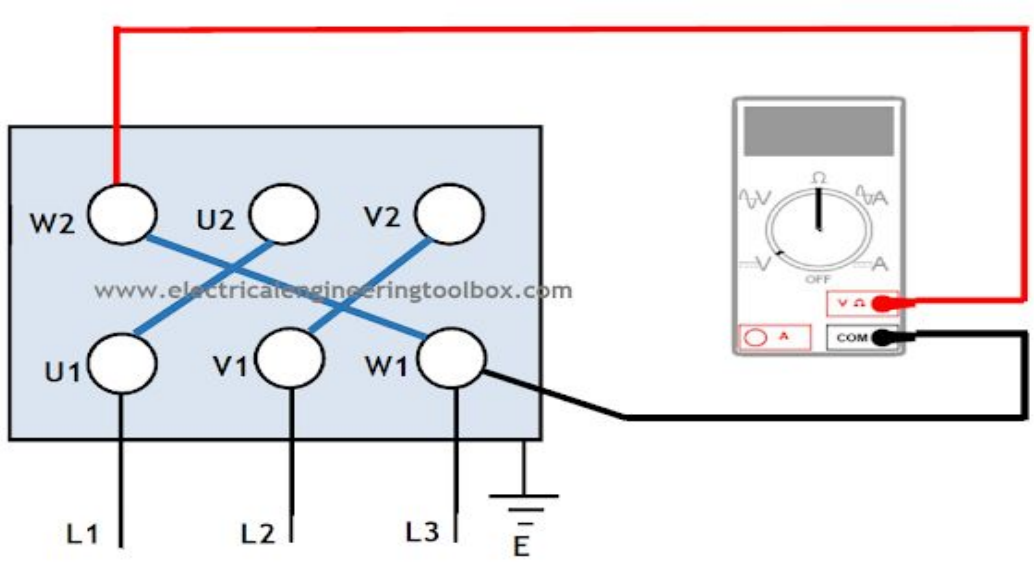


Figure 3.3. windings test of a 3 Phase Motor with an Ohmmeter

The first thing to do before testing the windings of the motor is to remove the links linking terminals **W2U2V2** and the disconnect the motor from supply (L1, L2, L3). A multimeter terminals placed across this matrix of terminals will indicate the following readings for a good 3 phase motor:

- ✓ Terminals **W1W2**, **U1U2**, **V1V2** will indicate ***continuity*** for a good motor
- ✓ Every other terminal combinations should indicate ***Open*** for a good motor
- ✓ Readings between any of the six (6) terminals and the motor frame signifying earth should indicate ***open*** for a good motor.

2.3.2. Ohmmeter Readings for a Bad 3 phase Motor

In the case of a burnt or bad 3 phase motor, this matrix of terminals should indicate the opposite readings for a bad motor:

- ✓ If any of the terminal combinations W1W2, U1U2, V1V2 should indicate ***open*** then the motor is bad.
- ✓ If any other terminal combinations should indicate ***continuity*** instead of ***open***, then the motor is bad.
- ✓ If the reading between any of the six (6) terminals and motor frame should indicate ***continuity***, then the motor is dead.

Self-Check -5	Written Test

Directions: Answer all the questions listed below

I. True / False

_____ 1. The phase-sequence meter is the most commonly used tool for determining the phase sequence

_____ 2. static indicator is a simple configuration that uses two lamps and an inductor or capacitor.

_____ 3. Using Ohm meter one can know whether a 3 phase motor is still good or has gone bad.

_____ 4. If the reading between any of the six (6) terminals and motor frame should indicate **continuity**, then the motor is normal.

Note: **Satisfactory rating - 2 points** **Unsatisfactory - below 2 points**

Score = _____

Rating: _____

Name: _____ Date: _____

Information Sheet :3	Prepare and submitting service report

3.1. While reporting include the follow points

		MDL NO	
HP		SER. NO.	
SPEED		FRAME	
STATOR VOLT		TYPE	
AMPS		ID NUMBER	

OF ROTOR BARS _____ # OF STATOR SLOTS _____

INITIAL CONDITION	
TERM. BOX COVER	
TERM. BOX	
COUPLING /PULLEY	
OTHER	
DRV END BRG HOUSING FIT	
OPP. END BRG HOUSING FIT	
CAUSE OF FAILURE:	

BEARINGS			
DRV END BRG REMOVED:SIZE		MANUFACTURER	
OPP END BRG REMOVED: SIZE		MANUFACTURER	
NOTE:			

WINDING	
WINDING CONDITION	
CORE CONDITION	

NO LOAD TEST			
VOLTAGE L1		AMPS L1	
VOLTAGE L2		AMPS L2	
VOLTAGE L3		AMPS L3	
		RPM	

FULL LOAD TEST			
VOLTAGE L1		AMPS L1	
VOLTAGE L2		AMPS L2	
VOLTAGE L3		AMPS L3	
		RPM	

OUTPUT HORSE POWER	
TORQUE	

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Say True/False

1. When service report is written initial condition of the machine may not be written.
2. When service report is written motor no load test can be written.

Note: **Satisfactory rating – 1 points** **Unsatisfactory - below 1 points**

Score = _____

Rating: _____

Name: _____ Date: _____

Operation Sheet :1	Single phase motor testing

Procedures

1. Check the motor winding (C to S, C to R, S to R).
2. Check Insulation resistance of motor winding from windings to earth (C to E, S to E, R to E).
3. With the motor running, check the running amps of the motor

Operation Sheet :2	Three phase motor testing

Procedures

1. Ensure the terminal for power supply is in good condition.
2. Check the connection bar for terminal (U, V, W) connection type
3. Confirm the power supply VOLTAGE for electric motor.
4. Using the multimeter, check the continuity of winding from phase to phase (U to V, V to W , W to U).
5. Check the motor winding ohms reading for phase to phase terminal(U to V,V to W ,W to U).
6. Check insulation resistance of motor winding using
7. Check the running amps of the motor
8. If every step is completed, decide the condition of electrical motor

LAP Test	Practical Demonstration

Name: _____ Date: _____
Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 4hour

Task 1. Test single phase motor

Task 2. Test three phase motor

List of Reference Materials

1. A. Bellini, F. Filippetti, C. Tassoni, G. A. Capolino, "Advances in diagnostic techniques for induction motors", *IEEE Trans. Energy Convers.*, vol. 55, no. 12, pp. 4109-4126, Dec. 2008.

2. M. J. Devaney, L. Eren, "Detecting motor bearing faults", *IEEE Instrum. Meas. Mag.*, vol. 7, no. 4, pp. 30-50, Dec. 2004.

3. J. Faiz, B. M. Ebrahimi, "Mixed fault diagnosis in three-phase squirrel-cage induction motor using analysis of airgap magnetic field", *in Proc. Prog. Electro-Magn. Res. Symp.*, pp. 239-355, 2006.

4. M. E. H. Benbouzid, "A review of induction motors signature analysis as a medium of faults detection", *IEEE Trans. Ind. Electron.*, vol. 47, no. 5, pp. 984-993, Oct. 2000.

5. Eectric Machinery, 6e, Fitzgerald.

6. Principles of electrical machines(mehta)

7. Theraja

The trainers (who developed the Learning Guide)

No	Trainer Name	Education back graund	Region
1	SERKABEBA ABERA	MSC	DEBUB
2	MULU DAMANE	MSC	ADDIAABEBA
3	ABERA GEBRE	BSC	DIRADAWA
4	ESUBALEW AMSALU	MSC	HARER
5	MERON HUSEN	BSC	HARER
6	SHIMELS CHEKOLE	BSC	AMHARA
7	FISIHA BIREHANU	MSC	AMHARA
8	YIMER SEID	MSC	AFAR
9	HINDA IBRAHIM	BSC	SOMALI
10	TADDELE GASHAW	MSC	SOMALI