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GENERATOR MECHANIC

LEARNER GUIDE

National Vocational Certificate Level 4

Version 1 - November, 2019

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Contents

Introduction

Welcome to your Learner's Guide for the *Generator Mechanic* Programme. It will help you to complete the programme and to go on to complete further study or go straight into employment.

The *Generator Mechanic* programme is to engage young people with a programme of development that will provide them with the knowledge, skills and understanding to start this career in Pakistan. The programme has been developed to address specific issues, such as the national, regional and local cultures, the manpower availability within the country, and meeting and exceeding the needs and expectations of their customers.

The main elements of your learner's guide are:

- **Introduction:**
  - This includes a brief description of your guide and guidelines for you to use it effectively
- **Modules:**
  - The modules form the sections in your learner's guide
- **Learning Units:**
  - Learning Units are the main sections within each module
- **Learning outcomes**:
  - Learning outcomes of each learning units are taken from the curriculum document
- **Learning Elements:**
  - This is the main content of your learner's guide with detail of the knowledge and skills (practical activities, projects, assignments, practices etc.) you will require to achieve learning outcomes stated in the curriculum
  - This section will include examples, photographs and illustrations relating to each learning outcome
- **Summary of modules**:
  - This contains the summary of the modules that make up your learner's guide
- **Frequently asked questions**:
  - These have been added to provide further explanation and clarity on some of the difficult concepts and areas. This further helps you in preparing for your assessment.
- **Multiple choice questions for self-test**:
  - These are provided as an exercise at the end of your learner's guide to help you in preparing for your assessment.

Overview of the program

Course: *Generator Mechanic Level 4*	**Total Course Duration:** 490 Hours
Course Overview:	
In this training program trainee will learn and acquire specialized knowledge and particle skills required to function as a Generator mechanic both at domestic and commercial levels. Generator Mechanic will responsible to maintain safety, maintain tools & equipment, identification of faults, diagnose mechanical faults, repair/replace mechanical components, electrical AC Installation, diagnose electrical fault, as per the procedures involved. The specific objectives of developing these qualifications are as under: • Improve the overall quality of training delivery and setting national benchmarks for training of generator mechanic in the country • Provide flexible pathways and progressions to learners enabling them to receive relevant, up-to-date and recent skills • Provide basis for competency-based assessment which is recognized and accepted by employers • Establish a standardized and sustainable system of training for generator mechanic in the country	

Module Title and Aim	Learning Units	Theory Days/hours	Workplace Days/hours	Timeframe of Modules
Module 1: **Contribute to Work Related Health and Safety (WHS) Initiatives** **Aim:** This unit describes the skills and knowledge required to manage the identification, review, development, implementation and evaluation of effective participation and consultation processes as an integral part of managing work health and safety (WHS).	**LU1.** Contribute to initiate work-related health and safety measures **LU2.** Contribute to establish work-related health and safety measures **LU3.** Contribute to ensure legal requirements of WHS measures **LU4.** Contribute to review WHS measures **LU5.** Evaluate the organization's WHS system	**06**	**24**	**30**

Module 2: **Analyze with Workplace Policy and Procedures** **Aim:** This unit describes the skills and knowledge required to implement a workplace policy & procedures and to modify the policy to suit changed circumstances. It applies to individuals with managerial responsibilities who undertake work developing approaches to create, monitor and improve strategies and policies within workplaces and engage with a range of relevant stakeholders and specialists.	**LU1.** Manage work timeframes **LU2.** Manage to convene meeting **LU3.** Decision making at workplace **LU4.** Set and meet own work priorities at instant **LU5.** Develop and maintain professional competence **LU6.** Follow and implement work safety requirements	**06**	**24**	**30**
Module 3: **Perform Advanced Communication** Aim: This unit describes the performance outcomes, skills and knowledge required to develop communication skills used professionally. It covers plan and organize work and conduct trainings at workplace, along with demonstrating professional skills independently	**LU1.** Demonstrate professional skills **LU2.** Plan and Organize work **LU3.** Provide trainings at workplace	**06**	**24**	**30**
Module 4: **Develop Advance Computer Application Skills** **Aim:** This unit provides an overview of Microsoft Office programs to create personal, academic and business documents following current professional and/or industry standards, i.e. Data Entry, Power Point Presentation and managing data base and graphics for Design. It applies to individuals employed in a range of work environments who	**LU1.** Manage Information System to complete a task **LU2.** Prepare Presentation using computers **LU3.** Use Microsoft Access to manage database **LU4.** Develop graphics for Design	**08**	**32**	**40**

need to be able to present a set range of data in a simple and direct forms				
Module 5: **Manage Human Resource Services** **Aim:** This unit describes the skills and knowledge required to plan, manage and evaluate delivery of human resource services, integrating business ethics. It applies to individuals with responsibility for coordinating a range of human resource services across an organization. They may have staff reporting to them.	**LU1.** Determine strategies for delivery of human resource services **LU2.** Manage the delivery of human resource services **LU3.** Evaluate human resource service delivery **LU4.** Manage integration of business ethics in human resource practices	**04**	**16**	**20**
Module 6: **Develop Entrepreneurial Skills** **Aim:** This Competency Standard identifies the competencies required to develop entrepreneurial skills, in accordance with the organization's approved guidelines and procedures. You will be expected to develop a business plan, collect information regarding funding sources, develop a marketing plan and develop basic business communication skills. Your underpinning knowledge regarding entrepreneurial skills will be sufficient to provide you the basis for your work.	**LU1.** Develop a business plan **LU2.** Collect information regarding funding sources **LU3.** Develop a marketing plan **LU4.** Develop basic business communication skills	**06**	**24**	**30**
Module 7: **Perform Winding** **Aim:** After completing this learning module, the learner will be able to make winding, perform paper insulation, insert coils relevant slots, connect coils, perform varnishing as per standard and perform winding continuity Test.	**LU1**. Make winding Coils **LU2**.Perform paper insulation **LU3.** Insert coils in relevant slots **LU4.**Connect coils **LU5.**Perform varnishing as per standard **LU6.** Perform winding continuity Test	38	152	190

Module 8: **Perform tests as per specification** **Aim:** After completing this learning module, the learner will be able to perform voltage testing, perform frequency testing procedure, test heat testing procedure, observe speed testing procedure and write test load report for record.	LU1.Perform test on full load **LU2.** Record Voltage **LU3**.Record Ampere **LU4.** Record frequency **LU5.** Record Temperature **LU6.** Record Engine Speed **LU7.** Compile all the Test result	10	40	50
Module 9: Plan Work **Aim:** After completing this learning module, the learner will be able to ensure all paperwork is filled out in a clear, legible and accurate format, and completed with required information. Also ensure all required information is documented in accordance with SOP's.	**LU1**. Assess site hazards **LU2**. Ensure work procedures **LU3**. Follow symbols **LU4.** Ensure drawing parameters **LU5.** Ensure environmental concerns	16	54	70
	TOTAL	**180**	**390**	**490**

GENERATOR MECHANIC

Module-7

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Module 7: Perform Winding:

Objective of the module: After completing this learning module, the learner will be able to make winding, perform paper insulation, insert coils relevant slots, connect coils, perform varnishing as per standard and perform winding continuity Test.

Duration:	Total hours	190	Theory	38	Practical	150

Learning Unit	Learning Outcomes	Learning Elements	Materials (Tools & Equipment) Required
LU1. **Make winding coils**	**.** Select wire as per required gauge **.** Make coils as per specifications	**Knowledge and Understanding of:** • Types of winding, Pitch in the winding, Short pitch and full pitch winding, Front pitch and back pitch, Calculation of short pitch angle, Pitch factor, • Single layer and Double layer winding, Fractional slot winding, concentrated winding, chain winding • Types of winding wires • Standard wire gauge, measurement of wire gauge by SWG, range of standard wire gauge • Describe coil making techniques including number of turns, number of coils and coil pitch • Wild winding, helical winding, orthocyclic winding, Different winding processes such as linear winding, flyer winding, needle winding technology, toroidal core winding technology • Making coils as per specifications.	○ . Laminated core ○ . Enameled copper wire of different SWG ○ . Wire gauge ○ . Winding coil firms ○ . Tool kit
LU2. **Perform paper**	**.** Select insulation paper	**Knowledge and Understanding of:**	• . Laminated core

insulation	. Cut insulation paper as per slot size . Insert insulation paper in stator /rotor slots	• Types of insulation paper • Types of insulation classes • Techniques for insertion insulation paper in stator/rotor slots	• . Insulated paper of different SWG • . Steel foot rule • . Scissor
LU3. **Insert coils in relevant slots**	. Insert coil in internal slot as per pitch . Insert coil in external slot as per pitch . Insert wedge/insulation paper	**Knowledge and Understanding of:** • Insertion procedure of coils in proper slots (internal and external) as per pitch	• . Laminated core • . Winding coils ○ . Insulating paper ○ . Rawhide mallet ○ . Fiber stick
LU4. **Connect coils**	. Inter connect coil as per circuit diagram . Perform lacing of coils	**Knowledge and Understanding of:** • Coil connections procedure • Interconnecting coils as per circuit diagram • Lacing procedure of winding	• • . Winded laminated core • . Sleeves of different sizes • . Cotton tap • . Tool kit.
LU5. **Perform varnishing as per standard**	. Select varnish grade as per standard . Apply varnish to coil	**Knowledge and Understanding of:** • Varnishing procedure, Insulation varnish, Purpose of varnishing • Selecting varnish grade as per standard • Dry varnish	• . Winded laminated core • . Varnish

	. Dry varnish		• . Heat gun • . Steel tray
LU6. **Perform winding continuity Test**	. Adjust test parameters of test bench as per requirement . Perform continuity, high voltage, and power input tests . Record warning indication and follow as per SOPs	**Knowledge and Understanding of:** • Adjusting test parameters of test bench as per requirement • Continuity test, purpose of continuity test, procedure of performing continuity test. • High voltage test, purpose of high voltage test, procedure of performing high voltage test. • Power input test, purpose of power input test, procedure of performing power input test • Recording warning indication and following as per SOPs.	• Winded laminated core. • Clamp on mater • . Multimeter • . Series test lamp • . electrical tool kit

Examples and illustrations:

Coil Pitch or Coil Span:

Coil pitch or coil span is defined as the angular distance between the two coil sides of one coil. It is expressed in terms of electrical space degree. Coil pitch is 180 electrical space degree for full pitch coil and less than 180 degree for short pitch coil.

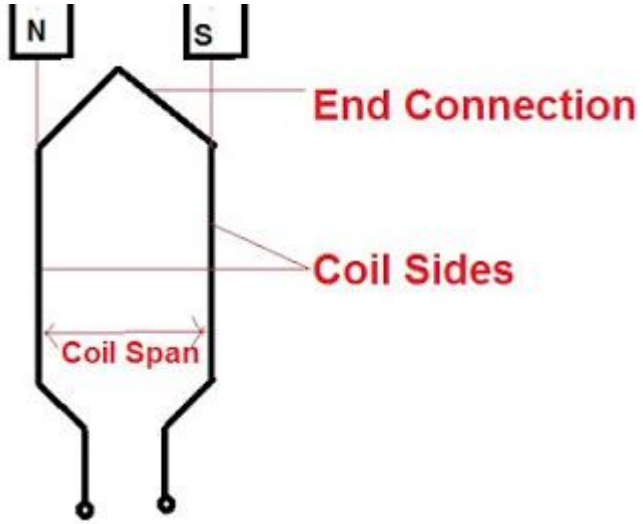
A coil is basically any number of turns. If there is only one turn, it is called single turn coil and if there is more than one turn then it is termed as multi-turn coil. A coil has two active length in which emf is generated. This active length of coil is called coil side. There are two coil sides in a single turn coil as can be seen from the figure below. Thus, number of coil sides in a coil having N number of turns will be 2N. These coil sides of any phase are distributed in various slots of stator and connected in such a fashion that their induced emfs are additive in nature.

There are two types of coils: Full pitch coil and short pitch coil:

Full Pitch Coil:

When the angular distance between the two coil sides is one pole pitch, it is called full pitch coil. This means that both the coil sides are lying under the pole in full pitch coil. Figure below shows a full pitch coil.

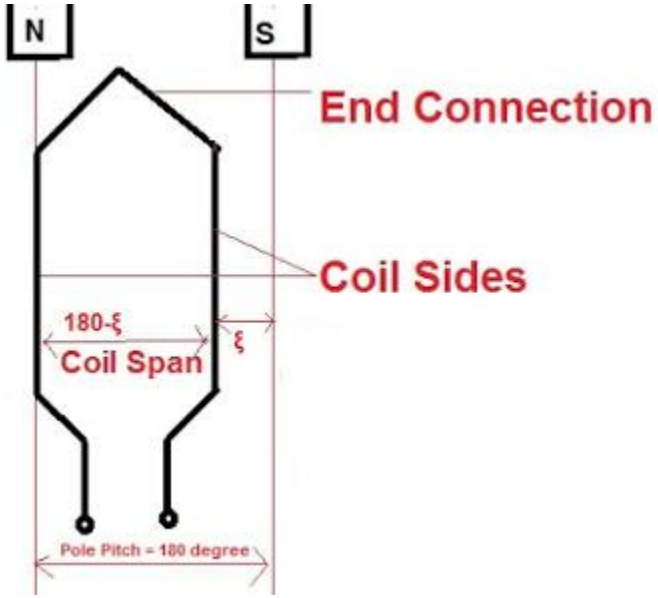
The electrical space angle between the active coil length or coil side is equal to one pole pitch. Since 1 pole pitch is the angular distance between the two consecutive poles which is equal to 180 electrical degree, therefore the coil span for full pitch coil is also equal to 180 electrical degree.



Short Pitch Coil:

If the angular distances between the two coil sides are less than one pole pitch, it is termed short pitch or fractional pitch coil. The coil span or coil pitch for short or fractional pitch coil is less than 180 electrical degree. In such coils, the two coil sides are not under the poles. Figure below shows a short pitched coil.

In the above figure, it can be easily seen that the coil span is departing by some angle ε from 180 electrical space degree. This is called chording angle.



Single Layer and Double Layer Winding:

Basically, there are two physical types of the windings. These are i) Single layer winding ii) Double layer winding. The sequential arrangement of coils around the armature is different for both these types of windings.

Single layer Winding:

In this type of winding, the complete slot is containing only one coil side of a coil. This type of winding is not normally used for machines having commutators.

In single layer windings permit the use of semi enclosed and closed types of slots. Also, the coils can be pushed through the slots from one end of the core and are connected during the process of windings at the other end. Here the insulation can be properly applied and consolidated which is advantageous in large output machines with high voltage.

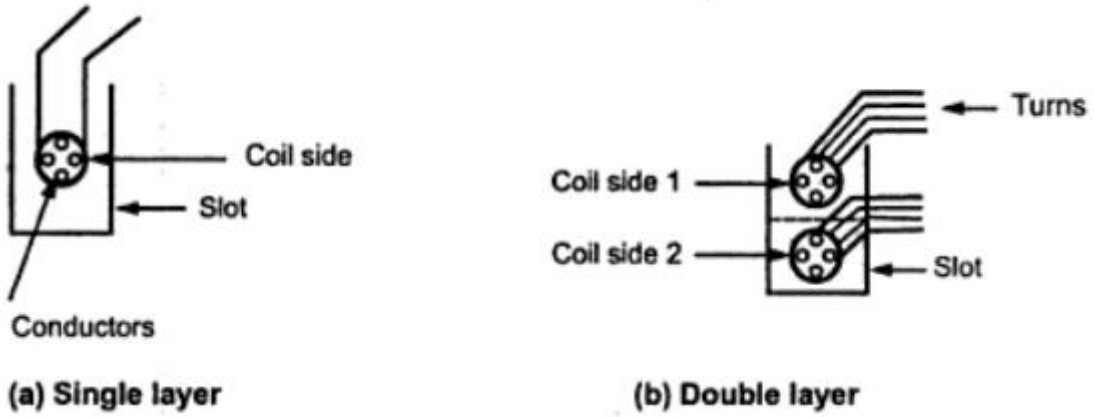
The single layer windings used in high voltage machines use small groups of concentrically placed coils. The interlinking between these coils is in such a way so as to minimize the space taken up outside the slot and in the overhang connections.

Double Layer Winding:

It consists of identical coils with one coil side of each coil in top half of the slot and the other coil side in bottom half of another slot which is nearly one pole pitch away.

The double layer winding has following advantages,

1) It provides neat arrangement as all coils are identical.
2) Greater flexibility can be achieved with double layer winding as coil span can be easily selected.



https://electricallive.com/2015/03/single-layer-and-double-layer-winding.html

High Voltage Test:

While during an open test (connection test, continuity test) the availability of a nominal connection between two test points should be validated, a high voltage test verifies if the insulation of this connection meets the requirements. Bevor, often a short test (low voltage test) is performed to detect a possible unwanted direct connection in order to avoid any further damage to the unit under test.

There are three types of high voltage tests:

- The breakdown test determines the voltage value, from when the insulation of a cable or a component is not sufficient anymore and an arc ignites (destroying test method).

- The electric strength test validates if the insulation of a cable or a component resist a certain, programmed voltage (qualitative)—mostly by using AC voltage.
- The insulation resistance test (insulation test) determines through multiple measurement methods the insulation resistance between two measurement points (quantitative)—mostly by using DC voltage

Winding of Three Phase Stators:

In its simplest form, the three-phase, random wound stator winding process consists of removing an existing winding from a stator and replacing it with a winding that duplicates the original winding performance characteristics. By performance characteristics, we mean the nameplate ratings (e.g., horsepower or kilowatt rating) and speed, of the motor or generator remain the same. It is for stators 600v or less.

The Steps consists of:

1. Taking Data
2. Core Testing
3. Coil Cutoff
4. Burnout Procedures
5. Winding Stripping Procedures
6. Core Preparation
7. Coil Making
8. Winding Insulation and Coil Insertion
9. Internal Connections
10. Lacing and Bracing of Windings
11. Inspection of Untreated Windings
12. Testing Untreated and Treated Windings
13. Winding Treatment

Step 1: Taking Data

In the first step, Taking Data, the key objective is to accurately determine winding data for a three-phase stator, including connection, turns, span(s), wire sizes, poles, and grouping; and core and coil dimensions. It is important that the new winding data match the original so that the motor produces the same performance characteristics (e.g., horsepower or kilowatt rating and speed) as prior to rewind, and that the energy efficiency rating is maintained. Further, it is important to note that some of the critical data cannot be determined later in the winding process. For example, if the turns are not counted correctly, they cannot be determined after disposing of the removed winding.

Step 2: Core Testing

In the next step, Core Testing, the main objectives are how to perform a core test using two different methods, and the materials and equipment needed. Another primary objective is recognizing the importance of, and how to evaluate, the results of core testing. A properly performed core test can detect core degradation prior to rewind. To achieve that, the core should be tested before and after the burnout process. The key here is to avoid inserting a new winding into a defective core, then having to repair the core and repeat the rewind process, or

worse, having to scrap the stator core. After performing some core tests, the student should have a better understanding of how much time and potential cost can be saved by performing core tests before and after winding removal. Also, by performing the core testing, the student will have a higher level of confidence that the stator core is in satisfactory condition for rewinding.

Step 3: Coil Cutoff

The critical objective of the Coil Cutoff step is to be able to cut off coil extensions without injury to the technician or the stator. Essentially the idea is to cut the copper wire, not any other metal part of the stator, and to do it in a manner that does not harm the stator or the person performing the task. Proper cutting of the coil extensions also reduces time and effort when pulling the coils out.

Step 4: Burnout Procedures

Following the cutting off of the coils, the next step is Burnout. Important objectives of the lesson on the Burnout process are to understand how the burnout oven works in a temperature-controlled manner, and how to operate and properly load the oven. The burnout oven breaks down the winding insulation, to facilitate winding removal. A key aspect of the burnout process is for the student to recognize that control of the part temperature is much more critical to the process than simply controlling chamber temperature. Also, in this lesson the student will learn the potential risks associated with an improperly loaded oven.

Step 5: Winding Stripping Procedures

The next step in the rewind process is Winding Stripping. Primary objectives in this lesson are understanding and using winding removal methods and equipment to remove the old winding safely, and avoiding damage to the stator core. Because stripping methods and equipment vary, the mentor should provide the student with specific instructions on winding stripping in their service center. Closely associated with Winding Stripping is Taking Data, as much of the important data is obtained during the stripping process, e.g., connection, turns, span(s), wire sizes, poles, and grouping. Note that this is a return to the data taking lesson that began the winding process.

Step 6: Core Preparation

After removal of the windings and insulation, the bare core must be made ready for winding insertion. Key objectives in Core Preparation are how to clean, inspect and prepare the bare core; and how to repair lamination damage and defects. This step assures that the core is in satisfactory condition prior to actual rewinding, and is associated with the Core Testing lesson. The prepared core is core tested to verify that core losses have not increased from the initial core test by an unacceptable amount. The repeated core test reinforces the aspects of the core test for the student, and provides a learning opportunity for the student to calculate the before versus after parameter comparisons.

Step 7: Coil Making

All of the steps and associated lessons to this point have dealt with existing windings and stator components. The first step in actual rewinding is Coil Making; that is, creating new coils from new magnet wire and other materials. The primary objectives of Coil Making are recognizing the materials, tools and equipment needed; and how to make random wound coils to be installed into a three-phase stator core. The student will

learn that the new coils must have equivalent turns and wire area as the original winding, and have the same physical features such as coil extensions. Coil making equipment varies considerably; therefore, the mentor should provide the student with specific instructions on the use of the coil winding equipment in their service center.

Step 8: Winding Insulation and Coil Insertion

Having made new coils, they need to be inserted into the core, bringing up the next step, Winding Insulation and Coil Insertion. The objectives of this lesson are to be able to determine the materials and tools needed; and how to install random-wound coils into a three-phase stator core. There are actually multiple steps in this process, dealing with insulating and inserting. The slots are insulated, then coils inserted, followed by insulating between coils. The student will also learn how to recognize a properly inserted set of coils.

Step **9: Internal Connections**

Even though the winding coils have been made and inserted correctly, the winding will not perform properly if it is not connected correctly. This is accomplished in the next step, Internal Connections. In addition to requiring physical accuracy and attention to detail, the student will learn the steps necessary to “lay out” and verify the accuracy of the connection. Critical objectives of this lesson are how to identify and lay out winding connections, and the procedures for actually connecting the winding. The student will also gain an appreciation for the unlimited variety of possible winding connections and layouts.

Step 10: Lacing and Bracing of Windings

The inserted winding coils should be snug in the slots, but will need reinforcement to reduce the tendency to move or shift. Varnish treatment and curing will do much to make the winding more rigid; however, there is another key step to be used to reinforce winding coils. That is Lacing and Bracing of Windings, with the main objectives being to make the winder proficient in the methods, materials and procedures for lacing and bracing of windings. The student will also learn how to determine the amount and type of bracing to use on different windings.

Step 11: Inspection of Untreated Windings

The next action step for the winding is to treat and cure it. This step is essentially irreversible. That is, the treated winding cannot easily be modified if, for example, the connection is incorrect or there is a ground fault. Therefore, the next steps in the winding sequence are to inspect and to test the untreated winding. The primary objective of Inspection of Untreated Windings is how to properly inspect and evaluate an inserted and untreated three-phase random winding for defects or imperfections. Upon completion of this lesson the student will be able to detect visual indications of unsatisfactory winding condition versus acceptable appearance.

Step 12: Testing Untreated and Treated Windings

Following inspection the companion critical objectives of Testing of Untreated and Treated Windings are how to perform and evaluate testing of untreated, and of treated, three-phase random windings. The student receives information on the applicable tests, how to perform them, and how to evaluate the results.

Step 13: Winding Treatment

Following inspection and testing of the untreated winding we move on to the final step in the winding process, Winding Treatment. This step is crucial to providing a winding with good heat transfer, high bond strength, and protection against contamination. The key objectives of Winding Treatment are to make the winder knowledgeable and proficient in the equipment and materials to varnish treat and cure windings; and the methods and procedures to varnish treat, cure and evaluate the finished three-phase random winding. The actual final step is testing the treated winding, described above.

Continuity Test:

A continuity test verifies that current will flow in an electrical circuit (i.e. that the circuit is continuous). The test is performed by placing a small voltage between 2 or more endpoints of the circuit. The flow of current can be verified qualitatively, by observing a light or buzzer in series with the circuit actuates or quantitatively, using a multimeter to measure the resistance between the endpoint.

In continuity testing the resistance between two points is measured. Low resistance means that the circuit is closed and there is electrical continuity. High resistance means that the circuit is open and continuity is lacking. Continuity testing can also help determine if two points are connected that should not be.

A continuity test is an important test in determining the damaged components or broken conductors in a circuit. It can also help in determining if the soldering is good, if the resistance is too high for flow of current or if the electrical wire is broken between two points. A continuity test can also help in verifying or reverse-engineering an electrical circuit or connection.

How to Test for Continuity?

Step 1: The circuit to be tested in the distribution board is selected and the Line conductor from the MCB is removed.

Step 2: Line conductor to the Earth conductor is connected (for simplicity, connect it to one of the spare terminals on the Earth bar). This way we will form a circuit which is half made up of the Line conductor and half made of the Earth conductor (provided that the terminations within the electrical accessories such as wall sockets are correct).

Step 3: Correct test function is selected on the test equipment, which is the low reading ohm meter function (Megger 1553).

Step 4: Next step is to null the test instrument if required (we do this by connecting the two test leads together and pressing the TEST button until the measured value on the display becomes zero ohm`s)

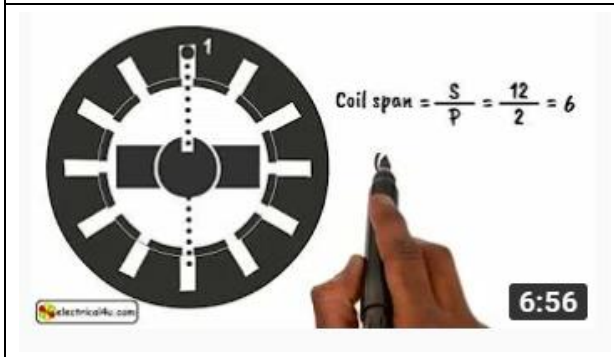
Step 5: Measurement between Line and Earth terminals at each outlet in the circuit is taken. The highest reading is recorded on the Schedule of Test Results as the value of (R1+R2).

Step 6: The Line conductor is returned back in to the MCB.

References:

1. https://electricalbaba.com/coil-pitch-coil-span-full-pitch-short-pitch-coil-chording-angle/
2. https://www.weetech.de/en/news-info/tester-abc/high-voltage-test-1/
3. https://easa.com/resources/software/how-to-wind-three-phase-stators
4. https://carelabz.com/continuity-testing/

VIDEOS:

	How to use a wire gauge tool https://www.youtube.com/watch?v=8jGjlKjF2vI
	Generator winding https://www.youtube.com/watch?v=UGbmLZxzLEg
	Full pitch and short pitch winding https://www.youtube.com/watch?v=pfj4w2Jz3xA

	Coil https://www.youtube.com/watch?v=kep6ewppqLE

	Alternator winding test https://www.youtube.com/watch?v=Z_YJk5uLeU8

GENERATOR MECHANIC

Module-8

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Module 8: Perform tests as per specification

Objective of the module: After completing this learning module, the learner will be able to perform voltage testing, perform frequency testing procedure, test heat testing procedure, observe speed testing procedure and write test load report for record.

Duration:	Total hours	50	Theory	10	Practical	40

Learning Unit	Learning Outcomes	Learning Elements	Materials (Tools & Equipment) Required
LU1. **Perform test on full load**	**P1.** Identify full load as per manufacturer **P2.** Connect load bank with generator **P3.** Select full load of load bank	**Knowledge and understanding of:** • Generator capacity and load bank • Identifying full load as per manufacturer	• . Clamp on mater • . Load bank • . Electrical toolkit ○
LU2. **Record Voltage**	**.** Record start time **.** Record fluctuation in voltage **.** Repeat the process up to 3-time intervals **.** Document the average Voltage	**Knowledge and understanding of:** • Working of multimeter • Voltage testing procedure including measurement of voltage with multimeter • Calculation of average value • Documenting the calculated values	**.** . Multimeter

LU3. **Record Ampere**	. Record start time . Record fluctuation in Current . Repeat the process up to 3-time intervals . Document the average Ampere	**Knowledge and understanding of:** • Working of clamp on meter • Current testing procedure including measurement of current with clamp on meter • Calculation of average value • Documenting the calculated values	• . Clamp on meter
LU4. **Record frequency**	. Record start time . Record fluctuation in Frequency . Repeat the process up to 3-time intervals . Document the average Frequency	**Knowledge and understanding of:** • Working of hertz meter • Frequency testing procedure including measurement of frequency with hertz meter • Calculation of average value • Documenting the calculated values	○ . Hertz meter ○ . Connecting wires
LU5. **Record Temperature**	. Record start time . Record fluctuation in Temperature . Repeat the process up to 3-time intervals . Document the average Temperature	**Knowledge and understanding of:** • Working of temperature gauge • Heat testing procedure including measurement of temperature with temperature meter • Calculation of average value • Documenting the calculated values	○ . Temperature gauge

LU6. **Record Engine Speed**	. Record start time . Record fluctuation in record per minute (RPM) . Repeat the process up to 3-time intervals . Document the average Speed	**Knowledge and understanding of:** • Working of tacho meter • Speed testing procedure including measurement of Speed (RPM) with Tacho meter • Calculation of average value • Documenting the calculated values	• Techo meter
LU7. **Compile all the Test result**	. Prepare table . Enter all the average data in the table . Take signatures on the document from the customer and expert	**Knowledge and understanding of** • Log book including writing values of recorded measurement at the appropriate section and taking signatures from the concerned bodies. • Preparing tables • Test report writing	○ Log book

Examples and illustrations:

How to Measure Ac Voltage with Multimeter?

1. Turn the dial to ṽ. Some digital multimeters (DMMs) also include m ṽ. If voltage in the circuit is unknown, set the range to the highest voltage setting and set the dial on ṽ.

   Note: Most Multimeters power up in Autorange mode. This automatically selects a measurement range based on voltage present.

2. First insert the black lead into the COM jack.
3. Next insert the red lead into the VΩ jack. When finished, remove the leads in reverse order: red first, then black.
4. Connect the test leads to the circuit: black lead first, red second.

   Note: ac voltage does not have polarity.

   Caution: Do not let fingers touch the lead tips. Do not allow the tips to contact one another.

5. Read the measurement in the display. When finished, remove the red lead first, black second.

Steps for measuring ac voltage with a digital multimeter.

How to Measure Current with Clamp Meter?

1. Turn the dial to the proper function, either A ac or A dc. You should see the jaws icon ( ) in the display, indicating that the measurement is coming from the jaw.

2. Note: When the measured current is < 0.5 A, the center dot in the display icon ( ) will flash on and off. When current is > 0.5 A, the center dot will be steady.
3. Before taking dc current measurements (if your meter is equipped to do so): Wait for the display to stabilize, then push the Zero button to ensure correct readings. Zeroing the meter removes dc offset from the reading. The Zero function works only when the dial is set in in the dc current measurement position.
4. Note: Before zeroing the meter, make sure the jaws are closed and no conductor is inside the jaw.
5. Press the jaw release level, open the jaws and insert the conductor to be measured inside the jaw.
6. Close the jaw; center the conductor using alignment marks on the jaw.
7. View the reading in the display.

To measure ac current using a flexible current probe:

Pre-measurement steps (to avoid electrical shock or personal injury):

- Do not apply the flexible probe around, or remove it from, hazardous live conductors. Take special care during fitting and removal of the flexible probe.
- De-energize the installation under test or wear suitable protective clothing.

Measurement Steps:

1. Connect the flexible current probe to the meter. See illustration below.
2. Connect the probe's flexible tubing around the conductor. If you are opening the end of the flexible probe to make the connection, be sure to close and latch it. You should be able to hear and feel the probe lock into place.

    - **Note:** When measuring current, center the conductor in the flexible current Probe. If possible, avoid taking measurements close to other current-carrying conductors.

3. Keep the probe coupling more than 1 inch (2.5cm) away from the conductor.
4. Turn the dial to the iFlex icon. When the dial is in the correct position, shows on the display, meaning that the readings are coming from the flexible probe.

    - **Note:** When the measured current is < 0.5 A, the center dot in the display icon ( ) will flash on and off. With current > 0.5 A, the center dot will be steady.

5. View the current value in the display.

If a flexible probe does not perform as expected:

1. Inspect the coupling system to make sure that it is connected and closed correctly or for any damage. If any foreign material is present, the coupling system will not close properly.
2. Inspect the cable between the probe and meter for any damage.

3. Verify the dial is in the correct position ( ).

Measuring ac current with a clamp meter's jaws. Note: Current flowing in opposite directions cancels each other. If current is moving in opposite directions, place just one conductor within the clamp during measurement.

Tachometer:

It works on the principle of a tachometer generator, which means when a motor is operated as a generator, it produces the voltage according to the velocity of the shaft. It is also known as revolution-counter, and its operating principle can be electromagnetic, electronic or optical-based. Power, accuracy, RPM range, measurements and display are the specifications of a tachometer. Tachometers can be analog or digital indicating meters.

How to measure frequency:

Circuits and equipment may be designed to operate at a fixed or variable frequency. They may perform abnormally if operated at a different frequency than specified.

For example, an ac motor designed to operate at 60 Hz operates slower if the frequency is less than 60 Hz, or faster if frequency exceeds 60 Hz. For ac motors, any change in frequency causes a proportional change in motor speed. A five percent reduction in frequency yields a five percent reduction in motor speed.

Some digital Multimeters include optional modes related to frequency measurement:

- **Frequency Counter mode:** It measures the frequency of ac signals. It can be used to measure frequency when troubleshooting electrical and electronic equipment.
- **MIN MAX Recording mode:** Permits frequency measurements to be recorded over a specific period. It provides the same function with voltage, current and resistance.
- **Autorange mode:** Automatically selects the frequency measurement range. If the frequency of the measured voltage is outside of the frequency measurement range, a digital multimeter cannot display an accurate measurement. Refer to the user's manual for specific frequency measurement ranges

Digital Multimeters with A Frequency Symbol on The Dial

1. Turn the dial to Hz.

- It usually shares a spot on the dial with at least one other function.
- Some meters enter the frequency through a secondary function accessed by pushing a button and setting the rotary switch to ac or dc.

2. First insert the black test lead into the COM jack.

3. Then insert the red lead into the V Ω jack.

When finished, remove the leads in reverse order: red first, then black.

4. Connect the black test lead first, the red test lead second.

When finished, remove the leads in reverse order: red first, then black.

5. Read the measurement in the display.

- The abbreviation Hz should appear to the right of the reading.

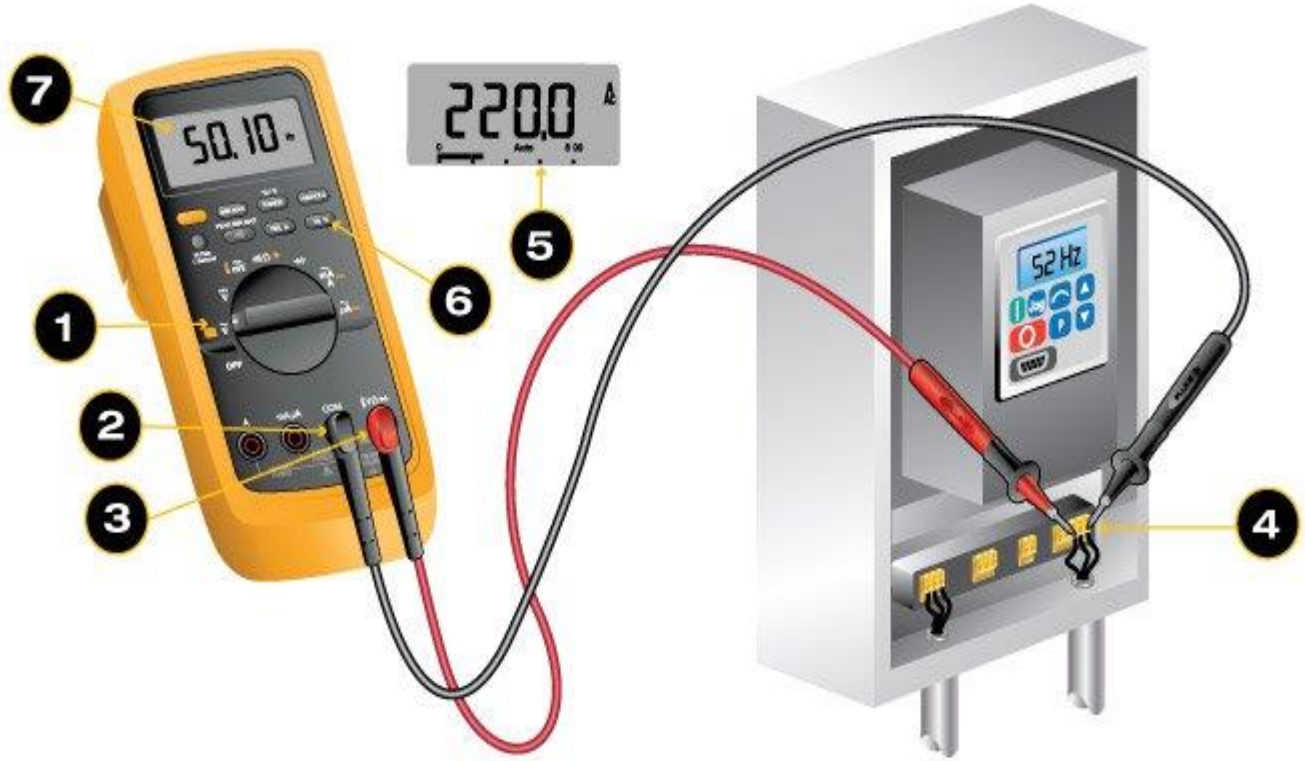
Digital Multimeters with A Frequency Button:

1. Turn the dial to ac voltage ($\tilde{V}$). If voltage in the circuit is unknown, set the range to highest voltage setting.

Most digital multimeters power up in Autorange mode, automatically selecting the measurement range based on the voltage present.

2. First insert the black test lead into the COM jack.

3. Then insert the red lead into the V Ω jack.



4. Connect the test leads to the circuit.
    - The position of the test leads is arbitrary.
    - When finished, remove the leads in reverse order: red first, then black.
5. Read the voltage measurement in the display.
6. With the multimeter still connected to the circuit, press the Hz button.
7. Read the frequency measurement in the display.
    - The Hz symbol should appear in the display to the right of the measurement.

Frequency measurement considerations:

In some circuits, there may be enough distortion on the line to prevent an accurate frequency measurement. Example: ac variable frequency drives (VFDs) can produce frequency distortions.

When testing VFDs, use the low-pass filter (LO) ac V (Ṽ) setting for accurate readings. For meters without the LO Ṽ setting, turn the dial to dc voltage, then press the Hz button again to measure the frequency on the dc voltage setting. If the meter allows for a decoupled frequency measurement, you might also try changing the voltage range to compensate for the noise.

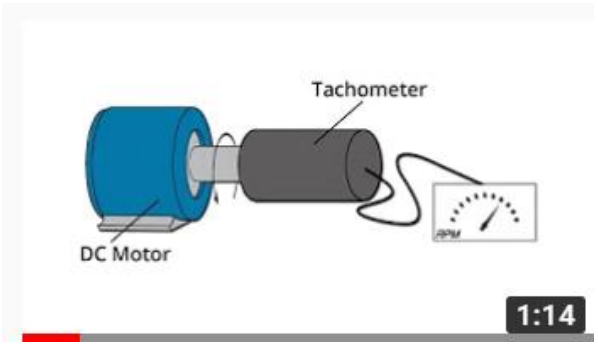
References:

- https://www.fluke.com/en/learn/best-practices/test-tools-basics/digital-multimeters/how-to-measure-ac-voltage-with-a-digital-multimeter
- https://automationforum.in/t/what-is-a-tachometer-and-types-of-tachometer/7222
- https://www.fluke.com/en/learn/best-practices/test-tools-basics/digital-multimeters/how-to-measure-frequency-with-a-digital-multimeter

VIDEOS:

	Measuring voltage with a Multimeter https://www.youtube.com/watch?v=_jjIDdWwgms

	How to measure current with a clamp meter https://www.youtube.com/watch?v=HfAz9iVQoiY
	How to test a temperature gauge https://www.youtube.com/watch?v=YxV6M7Ror5c
	Frequency measurement https://www.youtube.com/watch?v=foGhjGu-FUg

	Basics of a tachometer https://www.youtube.com/watch?v=TzWbGhELqz4&t=8s

GENERATOR MECHANIC

Module-9

LEARNER GUIDE

National Vocational Certificate Level 4

Version 1 - November, 2019

Module 9: Plan Work

Objective of the module: After completing this learning module, the learner will be able to ensure all paperwork is filled out in a clear, legible and accurate format, and completed with required information. Also ensure all required information is documented in accordance with SOP's.

Duration:	Total hours	54	Theory	16	Practical	70

Learning Unit	Learning Outcomes	Learning Elements	Materials (Tools & Equipment) Required
LU1. **Assess site hazards**	**.** Inspect site visually **.** Identify actual and potential hazards **.** Communicate with site supervisor/customer/supplier	**Knowledge and understanding of:** • Inspecting the site visually • Workplace hazards, Different types of hazards at workplace, hazards of working in a confined space, Risks in a confined space, • Risk, types of Risks, Risk Assessment, steps of risk assessment i.e. 1. Identify hazards, i.e. anything that may cause harm. ... 2. Decide who may be harmed, and how 3. Assess the risks and take action. 4. Make a record of the findings. 5. Review the risk assessment • Communication with site supervisor/customer/supplier	• safety Instructions chart

LU2. **Ensure work procedures**	. Identify Tools & equipment . Prepare job sheet /job card/work order . Follow job sequence . Demonstrate/co-ordinate activities with others	**Knowledge and understanding of:** • Identifying tools and equipment for ensuring work procedures. • Job sheet/ job card/work order • Following job sequence • Demonstrating/Co-coordinating activities with others	• Job card/Job sheet/work order
LU3. **Follow symbols**	. Follow warning symbols . Follow electrical symbols . Follow mechanical symbols	**Knowledge and understanding of:** • various types of warning symbols and marks including chemical hazard sign, custom safety sign. • Various Electrical symbols. • Various Mechanical symbols	. Warning symbols chart
LU4. **Ensure drawing parameters**	. Follow metric and imperial measurements . Adopt inter-conversion of metric and imperial measurement . Distinguish between plan, side view and section	**Knowledge and understanding of:** • Metric and imperial measurement system • Inter conversion of metric and imperial measurement • Distinguishing between plan, side, view and section	. Ruler set • measurement set • Sufficient Paper . Drawing material . cutting set
LU5. **Ensure environmental concerns**	. Identify actual and potential environmental concerns (proximity to water courses, noise levels, fuel leaks and hazardous materials)	**Knowledge and understanding of:** • environmental concerns (proximity to water courses, noise levels, fuel leaks and hazardous materials) • HSE Standards, importance of environmental health and safety standards,	• Writing materials on environment concerns (proximity to water courses, noise levels, fuel leaks and hazardous

	. Review environment concerns . Review work plan as per standard . Communicate report to site supervisor	• Industry standing operating procedures (SOPs) relating to safe work environment • Reviewing work plan as per standard. • Reporting to site supervisor	materials)

Examples and illustrations:

Identifying workplace hazards

Every workplace has hazards. As an employer, you have a legal responsibility to look after your employees' safety and protect them against health and safety hazards at work.

In order to manage workplace health and safety and help prevent accidents and sickness absence, it's important to identify, monitor and reduce the risk associated with workplace hazards

What are workplace hazards?

Simply put, workplace hazards are any aspect of work that cause health and safety risks and have the potential to harm.

Some hazards are more likely to be present in some workplaces than others, and depending on the work that you do, there will be hazards that are more or less relevant to your business.

What are the most common workplace hazards?

There are many types of workplace hazards, which tend to come under four main categories:

- **physical hazards** – the most common workplace hazards, including vibration, noise and slips, trips and falls;
- **ergonomic hazards** – physical factors that harm the musculoskeletal system, such as repetitive movement, manual handling and poor body positioning;

- **chemical hazards** – any hazardous substance that can cause harm to your employees;
- **biological hazards** – bacteria and viruses that can cause health effects, such as hepatitis, HIV/AIDS and Legionnaire's disease.

Common health risks:

Some of the most common health risks associated with workplace hazards include:

- breathing problems;
- skin irritation;
- damage to muscles, bones and joints;
- hearing damage;
- reduced wellbeing.

How to prevent workplace hazards:

The best way to protect yourself and your employees from workplace hazards is to identify and manage them and take reasonable steps to prevent their potential to harm.

In order to control workplace hazards and eliminate or reduce the risk, you should take the following steps:

- identify the hazard by carrying out a workplace risk assessment;
- determine how employees might be at risk;
- evaluate the risks;
- record and review hazards at least annually, or earlier if something changes.

Warning Symbols:

Imperial Vs Metric System:

There are two main systems for measuring distances and weight, the Imperial System of Measurement and the Metric System of Measurement. Most countries use the Metric System, which uses the measuring units such as meters and grams and adds prefixes

like kilo, milli and cent to count orders of magnitude. In the United States, we use the older Imperial system, where things are measured in feet, inches and pounds. It might be confusing if you are living in the U.S for the first time and are not used to this system. If you ask someone for directions, they will probably tell you something is a certain number of miles away. Or you may be told to move a few feet… But, whose feet?

The Imperial System is also called The British Imperial because it came from the British Empire that ruled many parts of the world from the 16th to the 19th century. After the U.S gained independence from Britain, the new American government decided to keep this type of measurement, even though the metric system was gaining in popularity at the time.

We are one of the few countries in the world that still use this system, and first-time visitors may find it confusing. Here are a few things to remember that will come in handy day to day:

- 1 mile equals 1.6 Kilometers.
- 1 inch is about 25 millimeters or 2.54 centimeters
- A 3-foot measurement is almost exactly 1 meter
- 1 Kilogram is just over 2 pounds
- 1 pound is about 454 grams
- For British visitors, 100 pounds = 7.14 stone

Complicated measurements, used in the sciences for example, will be in the metric system so no need to worry if you are planning to do an internship in engineering or chemistry.

By the way, the temperature scales are different too. We didn't want to make things too easy for you! Though not technically part of the metric system, Americans measure temperature in Fahrenheit, not Centigrade. You may turn on the television and listen for the weather and hear that it is 70 degrees outside. No, you won't pass out and be vaporized by the sun; 70 degrees Fahrenheit is actually very pleasant, about 21 degrees Centigrade. Centigrade has been used around the world from the mid-20th century but again, Americans held fast to the original Fahrenheit system.

Here are some more handy conversions for temperature:

- 0 degrees Celsius is equal to 32 degrees Fahrenheit. (The freezing point)
- 24 degrees Celsius is equal to 75 degrees Fahrenheit. (A very pleasant day)
- To convert Celsius (c) to Fahrenheit, use the formula (c * 1.8) + 32

References:

- https://fitforwork.org/blog/identifying-workplace-hazards/
- https://www.interexchange.org/articles/career-training-usa/2012/05/24/imperial-vs-metric-system/

VIDEOS:

	Risk Assessment https://www.youtube.com/results?search_query=assessing+site+hazards

	Hazard Identification https://www.youtube.com/results?search_query=assessing+site+hazards
	How to develop safe work procedures https://www.youtube.com/results?search_query=sops+relating+to+safe+work+environment

Frequently Asked Questions:

1. What is Competency Based Training (CBT) and how is it different from currently offered trainings in institutes?	Competency-based training (CBT) is an approach to vocational education and training that places emphasis on what a person can do in the workplace as a result of completing a program of training. Compared to conventional programs, the competency-based training is not primarily content based; it rather focuses on the competence requirement of the envisaged job role. The whole qualification refers to certain industry standard criterion and is modularized in nature rather than being course oriented.
2. What is the passing criterion for CBT certificate?	You shall be required to be declared “Competent” in the summative assessment to attain the certificate.
3. What are the entry requirements for this course?	The entry requirement for this course is 8th Grade or equivalent.
4. How can I progress in my educational career after attaining this certificate?	You shall be eligible to take admission in the National Vocational Certificate Level-3 in Leather Products Development Technician (Pattern Maker). You shall be able to progress further to National Vocational Certificate Level-4 in Heavy Construction Machinery Operator Course; and take admission in a level-5, DAE or equivalent course (if applicable). In certain case, you may be required to attain an equivalence certificate from The Inter Board Committee of Chairmen (IBCC).
5. If I have the experience and skills mentioned in the competency standards, do I still need to attend the course to attain this certificate?	You can opt to take part in the Recognition of Prior Learning (RPL) program by contacting the relevant training institute and getting assessed by providing the required evidences.
6. What is the entry requirement for Recognition of Prior Learning program (RPL)?	There is no general entry requirement. The institute shall assess you, identify your competence gaps and offer you courses to cover the gaps; after which you can take up the final assessment.
7. Is there any age restriction for entry in this course or Recognition of Prior Learning program (RPL)?	There are no age restrictions to enter this course or take up the Recognition of Prior Learning program
8. What is the duration of this course?	The duration of the course work is 1,510 hrs. (11 months)
9. What are the class timings?	The classes are normally offered 25 days a month from 08:00am to 01:30pm. These may vary according to the practices of certain institutes.
10. What is equivalence of this certificate with other qualifications?	As per the national vocational qualification’s framework, the level-4 certificate is equivalent to Matriculation. The equivalence certificate can be obtained from The Inter

	Board Committee of Chairmen (IBCC).
11. What is the importance of this certificate in National and International job market?	This certificate is based on the nationally standardized and notified competency standards by National Vocational and Technical Training Commission (NAVTTC). These standards are also recognized worldwide as all the standards are coded using international methodology and are accessible to the employers worldwide through NAVTTC website.
12. Which jobs can I get after attaining this certificate? Are there job for this certificate in public sector as well?	You shall be able to take up jobs in the local or overseas construction companies in heavy machinery operator job profile.
13. What are possible career progressions in industry after attaining this certificate?	You shall be able to progress up to the level of supervisor after attaining sufficient experience, knowledge and skills during the job. Attaining additional relevant qualifications may aid your career advancement to even higher levels.
14. Is this certificate recognized by any competent authority in Pakistan?	This certificate is based on the nationally standardized and notified competency standards by National Vocational and Technical Training Commission (NAVTTC). The official certificates shall be awarded by the relevant certificate awarding body.
15. Is on-the-job training mandatory for this certificate? If yes, what is the duration of on-the-job training?	On-the-job training is not a requirement for final / summative assessment of this certificate. However, taking up on-the-job training after or during the course work may add your chances to get a job afterwards.
16. How much salary can I get on job after attaining this certificate?	The minimum wages announced by the Government of Pakistan in 2019 are PKR 17,500. This may vary in subsequent years and different regions of the country. Progressive employers may pay more than the mentioned amount. The heavy Machinery Operator normally earns 20,000 to 25,000 in the start.
17. Are there any alternative certificates which I can take up?	There are some short courses offered by some training institutes on this subject. Some institutes may still be offering conventional certificate courses in the field.
18. What is the teaching language of this course?	The leaching language of this course is Urdu and English.
19. Is it possible to switch to other certificate programs during the course?	There are some short courses offered by some training institutes on this subject. Some institutes may still be offering conventional certificate courses in the field.
20. What is the examination / assessment system in this program?	Competency based assessments are organized by training institutes during the course which serve the purpose of assessing the progress and preparedness of each student. Final / summative assessments are organized by the relevant qualification awarding bodies at the end of the certificate program. You shall be required to be declared

	"Competent" in the summative assessment to attain the certificate.
21. Does this certificate enable me to work as freelancer?	You can start your small business by purchasing your own heavy construction machine and can start earning 50,000 per month. You may need additional skills on entrepreneurship to support your initiative.

Test Yourself (Multiple Choice Questions)

MODULE	**7**	Perform Winding		
Question	**1**	What type of winding is generally used for the stators?	A	Double layer wave winding
			B	Double layer lap winding
			C	Single layer wave winding
			D	Single layer lap winding
Question	**2**	When coil sides are pole pitch apart, the DC armature winding is called as	A	Multiplex
			B	Fractional pitch
			C	Full pitch
			D	Pole pitch

Question 3 What does S.W.S stands for?

A Standard western gauge

B Swiss wire gauge

C Swiss western gauge

D Standard Wire Gauge

Question 4 Resins and varnisher are commonly used in

A Generators and Motors

B Cables

C Transformers

D Circuit breakers

Question 5 The advantage of a short pitch winding is

A Low noise

B Increased inductance

C Suppression of harmonics

D Reduced eddy currents

MODULE	**8**	Perform Test As per Specifications		
Question	**1**	A device that is used to measure current without opening the circuit is:	A	Megger test
			B	Clamp probe
			C	Ammeter
			D	multimeter
Question	**2**	A multimeter is a device that measures:	A	Voltage
			B	Current
			C	Resistance
			D	All of these.

Question 3 Frequency can be measured by:

A Hertz meter

B Ammeter

C Voltmeter

D Multimeter

Question 4 Voltage is always measured in:

A Series

B Parallel

C Combination of series and parallel

D None of these

Question 5 A device used to indicate the temperature of an item being monitored is known as:

A Tachometer

B Temperature gauge

C Multimeter

D Frequency meter

MODULE 9 Plan Work

Question 1 A hazard is....

A The likelihood of a substance person, activity or process to cause harm.

B The probability of a substance person, activity or process to cause harm

C The potential of a substance person, activity or process to cause harm

D The prospect of a substance person, activity or process to cause harm.

Question 2 What is the appropriate text for this safety sign?

A Humpty-Dumpty Lives Here

B Watch out for Pills with Wings

C Charlie Chaplin Studio

D Hard Hat Area

Question 3 What is the appropriate text for this safety sign?

A You are challenged to a duel

B Mr. Clean says Hello

C Use your other left

D Wear your gloves

Question 4 What is the appropriate text for this safety sign?

A Sunglasses are mandatory.

B Eye checkup area begins

C Safety Goggles are mandatory

D Wear prescription glasses

Question 5 What is the appropriate text for this safety sign?

A Personal headphones may be worn

B Hearing protection must be worn

C Personnel with hearing disability only.

D Eye checkup area begins

Answer Keys

MODULE 7: Q1.a Q2.c Q3.d Q4.a Q5.c

MODULE 8: Q1.b Q2.d Q3.a Q4.b Q5.b

MODULE 9: Q1.c Q2.d Q3.d Q4.c Q5.b

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