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ELECTRICAL MACHINE WINDING TECHNICIAN

LEARNER GUIDE

National Vocational Certificate Level 3

Version 1 - September, 2018

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Contents

Introduction

Welcome to your Learner's Guide for the **Electrical Machine Winding Technician** Program. It will help you to complete the program and to go on to complete further study or go straight into employment.

The**Electrical Machine Winding Technician** program is to engage young people with a program of development that will provide them with the knowledge, skills and understanding to start their career in Pakistan. The program 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**:
  - Thiscontains the summary of the modules that make up your learner's guide
- **Frequently asked questions**:
  - These have beenadded 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.

ELECTRICAL MACHINE WINDING TECHNICIAN

Module-A
LEARNER GUIDE
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Module A: 0713001129 Disassemble Machine at Workshop

Objective: This Module covers the knowledge & skills required to Disassemble Machine at Workshop through Prepare for work , Shift Machine to work Bench ,Perform marking for Positions of Parts ,Perform numbering on Machine parts as per Inventory Record ,Remove the Faulty Parts ,Ensure safe and Sequential Placing of healthy parts of Machine

Duration: 90 Hours **Theory: 18 Hours** **Practice: 72 Hours**

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1. Prepare for work to disassemble machine at workplace	**The trainee will be able to:** • Identify the required PPE's • Collect the required PPE's • Identify the required tools and equipment • Collect the required tools and equipment • Ensure functional condition of PPE's/Tools and equipment • Ensure safe working conditions ➢ Clear Passage ➢ Cleanliness ➢ Adequate light	• Recognition of required Tools/Equipment and PPEs to disassemble machine at workplace • Importance of functional conditions of required Tools, Equipment and PPEs and their use • Importance of safe working condition regarding • Clear passage • Cleanliness • Adequate light • Ventilation	**Tools** • Computer System/Laptop • Printer **Consumable Material** • Lead Pencil • Rubber • Tag Inventory register

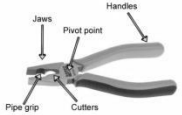
Learning Unit	Learning Outcomes	Learning Elements	Materials Required
	➢ Ventilation		
LU2. Shift Machine to work bench	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Ensure safe shifting of machine to work bench • Record shifting of machine to work bench	• Use of required PPEs • Describe procedure for safe shifting of faulty machine to work bench • Describe process for updating Inventory Record at the work bench	**Tools** • **Consumable Material** • Lead Pencil • Rubber • Tag • Inventory register
LU3. Perform marking for Positions of Parts	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Identify the parts to be marked for position marking • Perform marking for position of parts as per machine catalogue	• Selection and Use of required PPEs • Importance of marking on parts as per machine catalogue	**Tools** • Scriber • Number Punch • Hammer **Consumable Material** • Lead Pencil • Rubber • Tag • Inventory register • Sand Paper
	The trainee will be able	• Selection and Use of	**Tools**

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU4. Perform numbering on Machine parts as per Inventory Record	**to:** • Wear the required PPE's • Pick the required tools and equipment • Identify the parts of machine for allotment of specific number • Perform numbering on machine parts as per inventory record	required PPEs • Importance of numbering on parts as per inventory record for the specific machine	• Scriber • Number Punch Tool • Hammer **Consumable Material** • Lead Pencil • Rubber • Tag • Inventory register
LU5. Remove the faulty parts	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Identify faulty parts of machine • Remove the faulty parts of machine • Mark specific numbering on faulty parts of machine	• Selection and Use of required PPEs • Importance of identification of faulty parts of machine • Describe numbering procedure on faulty parts of machine	**Tools** • Scriber • Number Punch Tool • Hammer **Consumable Material** • Lead Pencil • Eraser • Tag • Inventory register

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU6. Ensure safe and Sequential Placing of healthy parts of Machine	• Wear the required PPE's • Pick the required tools and equipment • Mark specific numbering on healthy parts of machine • Place healthy parts of machine at safe place in sequential order • Record the placement/location of healthy parts	• Selection and Use of required PPEs • Importance of marking on healthy parts of machine • Importance of placing healthy parts of machine in sequential order • Importance of recording the placement/location of healthy parts	**Tools** **Consumable Material** • Lead Pencil • Eraser • Tag • Inventory register

LU1 Recognition of required Tools, Equipment and PPEs to disassemble machine at workplace

COMBINATION PLIER: Combination pliers used by electricians and other tradesmen primarily for gripping, twisting, bending and cutting wire and cable. Pliers typically are machined from forged steel and the two handles precisely joined with a heavy duty rivet that maintains the pliers' accuracy even after repeated use. Pliers usually have grips for better handling than bare metal handles; the grips may also provide insulation for protection against electric shockwhen working with live circuits, to withstand a specified voltage, e.g. 1000V.



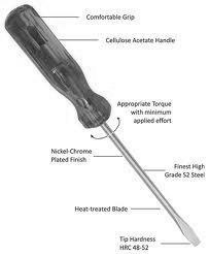
LONG NOSE PLIER: Their namesake long nose gives excellent control while the cutting edge near the pliers' joint

provides "one-tool" convenience. Because of their long shape they are useful for reaching into small areas where cables or other materials have become stuck or unreachable with fingers or other means.

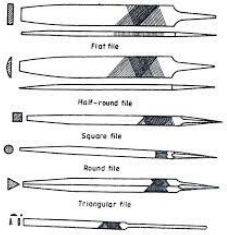
SIDE CUTTER: Diagonal pliers (or side cutters or wire cutters or diagonal cutting pliers or diagonal cutters) are pliers intended for the cutting of wire (they are generally not used to grab or turn anything). The plane defined by the cutting edges of the jaws intersects the joint rivet at an angle or "on a diagonal", hence the name. Instead of using a shearing action as with scissors, diagonal pliers cut by indenting and wedging the wire apart. The jaw edges are ground to a symmetrical "V" shape, thus the two jaws can be visualized to form the letter "X", as seen end-on when fully occluded. The pliers are made of tempered steel, and inductive heating and quenching are often used to selectively harden the jaws.

SCREW DRIVER: A screwdriver is a tool for turning (driving or removing) screws. A typical simple screwdriver has a handle and a shaft, and a tip that the user inserts into the screw head to turn it. The shaft is usually made of tough steel to resist bending or twisting. The tip may be hardened to resist wear, treated with a dark tip coating for improved visual contrast between tip and screw or ridged or treated for additional 'grip'. Handle are typically wood, or plastic and usually hexagonal, square, or oval in cross-section to improve grip and prevent the tool from rolling when set down.

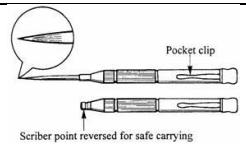
A screwdriver is classified by its tip, which is shaped to fit the driving surfaces slots, grooves, recesses, etc. on the corresponding screw head. Proper use requires that the screwdriver's tip engage the head of a screw of the same size and type designation as the screwdriver tip. Screwdriver tips are available in a wide variety of types and sizes. The two most common are the simple 'blade'-type for slotted screws, and Phillips.



FILES:A file is a tool used to shape materials, by cutting away some of it. Today, files are usually made of a steel bar that has a rough surface. By rubbing the surface against a material, some of the material is cut away. Files also make the surface of the area smooth so that when it comes to the building process there are no gaps or anything.



SCRIBER:A scriber is a hand tool used in metalworking to mark lines on work pieces, prior to machining. The process of using a scriber is called scribing and is just part of the process of marking out. It is used instead of pencils or ink lines, because the marks are hard to see, easily erased, and inaccurate due to their wide mark; scribe lines are thin and semi-permanent. On non-coated work pieces marking blue is commonly used to increase the contrast of the mark lines. They are a rod with a tip made of cast steel that has been hardened and tempered. The point is sharpened to an angle of 30 or 40 degrees. Some scribers have a point at both ends. It is used by drawing the point over the surface of the work piece to leave a shallow scratch on its surface.



HAMMER:A hammer is a tool that delivers a blow (a sudden impact) to an object. Most hammers are hand tools used to drive nails, fit parts, forge metal, and break apart objects. Hammers vary in shape, size, and structure, depending on their purposes.

Hammers are basic tools in many trades. The usual features are a head (most often made of steel) and a handle (also called a helve or haft). Some hammers have other names, such as sledgehammer, mallet and gavel.

CENTER PUNCH:A punch is a hard metal rod with a shaped tip at one end and a blunt butt end at the other, which is usually struck by a hammer. Punches are used by winder to mark spots on end plates of motor to identify their alignment position.

METAL HAND SHEER: Snips, also known as shears, are hand tools used to cut sheet metal and other tough webs.

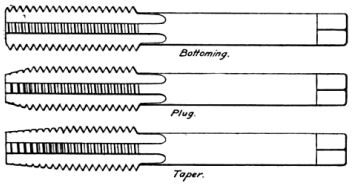
TAPS:A tap cuts a thread on the inside surface of a hole, creating a female surface which functions like a nut. The three taps in the image illustrate the basic types commonly used by most machinists:

Bottoming tap or plug taps The tap illustrated in the top of the image has a continuous cutting edge with almost no

taper between 1 and 1.5 threads of taper is typical. This feature enables a bottoming tap to cut threads to the bottom of a blind hole. A bottoming tap is usually used to cut threads in a hole that has already been partially threaded using one of the more tapered types of tap; the tapered end ("tap chamfer") of a bottoming tap is too short to successfully start into an unthreaded hole. In the US, they are commonly known as bottoming taps, but in Australia and Britain they are also known as plug taps.

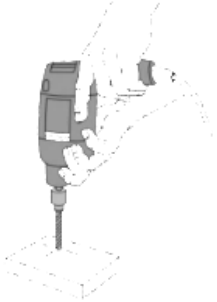
Intermediate tap, second tap, or plug tap The tap illustrated in the middle of the image has tapered cutting edges, which assist in aligning and starting the tap into an untapped hole. The number of tapered threads typically ranges from 3 to 5. Plug taps are the most commonly used type of tap. In the US, they are commonly known as plug taps, whereas in Australia and Britain they are commonly known as second taps.

Taper tap The small tap illustrated at the bottom of the image is similar to an intermediate tap but has a more pronounced taper to the cutting edges. This feature gives the taper tap a very gradual cutting action that is less aggressive than that of the plug tap. The number of tapered threads typically ranges from 8 to 10. A taper tap is most often used when the material to be tapped is difficult to work (e.g., alloy steel) or the tap is of a very small diameter and thus prone to breakage.



DRILL MACHINE:A drill is a tool fitted with a cutting tool attachment or driving tool attachment, usually a drill bit or driver bit, used for boring holes in various materials or fastening various materials together with the use of fasteners. The attachment is gripped by a chuck at one end of the drill and rotated while pressed against the target material. The tip, and sometimes edges, of the cutting tool does the work of cutting into the target material. This may

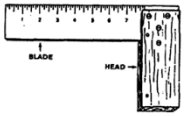
be slicing off thin shavings (twist drills or auger bits), grinding off small particles (oil drilling), crushing and removing pieces of the work piece (SDS masonry drill), countersinking, counter boring, or other operations.
Drills are commonly used in woodworking, metalworking, construction and do-it-yourself projects. Specially designed drills are also used in medicine, space missions and other applications. Drills are available with a wide variety of performance characteristics, such as power and capacity.



SCISSOR: Scissors are hand operated shearing tools. They consist of a pair of metal blades pivoted so that the sharpened edges slide against each other when the handles (bows) opposite to the pivot are closed. Scissors are used for cutting various thin materials, such as paper, cardboard, metal foil, cloth, rope, and wire. A large variety of scissors and shears exist for specialized purposes. Modern scissors are often designed ergonomically with composite thermoplastic and rubber handles which enable the user to exert either a power grip or a precision grip.

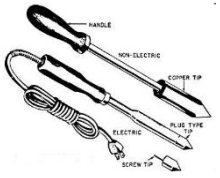
TRY SQUARE:A try square is a tool used for marking and measuring a piece of Latheroid paper. The square refers to the tool's primary use of measuring the accuracy of a right angle (90 degrees); to try a surface is to check its straightness or correspondence to an adjoining surface. A traditional try square has a broad blade made of steel that is riveted to a handle or 'stock'. Some blades also have graduations for measurement. Modern try squares may be

all-metal, with stocks that are either die-cast or extruded.



SPANNER:A wrench or spanner is a tool used to provide grip and mechanical advantage in applying torque to turn objects, usually rotary fasteners, such as nuts and boltsor keep them from turning.The most common shapes are called open-endwrench and box-end wrench. Higher quality wrenches are typically made from chromium-vanadium alloy tool steels and are often drop-forged. They are frequently chrome-plated to resist corrosion and for ease of cleaning.

SOLDERING IRON:A soldering iron is a hand tool used in soldering. It supplies heat to melt solder so that it can flow into the joint between two work pieces. A soldering iron is composed of a heated metal tip and an insulated handle. Heating is often achieved electrically, by passing an electric current (supplied through an electrical cord) through a resistive heating element. Cordless irons can be heated by combustion of gas stored in a small tank, often using a catalytic heater rather than a flame. Simple irons less commonly used than in the past were simply a large copper bit on a handle, heated in a flame. Soldering irons are most often used for installation, repairs, jointing winding wires.



HACK SAW:A hacksaw is a fine-toothed saw, originally and mainly made for cutting metal.Most hacksaws are hand saws with frame that holds a blade under tension. Such hacksaws have a handle, usually a pistol grip, with pins for attaching a narrow disposable blade. The frames may also be adjustable to accommodate blades of different sizes. A screw or other mechanism is used to put the thin blade under tension. The blade can be mounted with the teeth facing toward or away from the handle, resulting in cutting action on either the push or pull stroke. In normal use, cutting vertically downwards with work held in a bench vice, hacksaw blades are set to be facing forwards.

DIAGONAL SIDE CUTTING PLIERS: It is used to cut winding wires or wires.

NEEDLE NOSE PLIERS: Itis usedfor multiple tasks. They are great for reaching dropped screws or to hold a screw for drilling.

LOCK PLIER: It is used to tighten fittings when installing conduit. It can also be used to tighten lock nuts on various connectors. Mainly used for 2 inch conduit and smaller.

ELECTRICIAN KNIFE: This is a great addition to any tool set. It comes with 3 separate wire stripping accessories. It truly is 3 tools in one. Its heavy duty and comes with a limited lifetime warranty.

ELECTRICIAN LEVEL: Itis usedto install conduit, electrical cabinets and to check the level of machine.

MEASURING TAPE: This tape measure the distance between any two objects.

VOLTAGE DETECTOR: It is used to quickly determine if a circuit is on or off. It can carry easily on tool belt.

LOCK OUT TAG OUT KIT: This is vital for safety, have this kit and it comes with breaker locks and locks for panels. When working in an environment that people have access to panels this is a must for your safety.

DRILL BITS: These bare usedtofit in drill machine to drill holes in metal and masonry walls.

PIPE WRENCH: The pipe wrench is an adjustable wrench with hardened serrated teeth on its jaws. The hard teeth bite into the softer metal of the round pipe, and provide the grip needed to turn a pipe, even against fair resistance. The design of the adjustable jaw, which permits a certain amount of intentional play out of square, allows it to bind on the pipe, with forward pressure on the handle pulling the jaws tighter. Two leaf springs, above and below the knurled adjusting knob, help unlock the jaw when pressure on the handle of the wrench is released.

TOOLBOX:

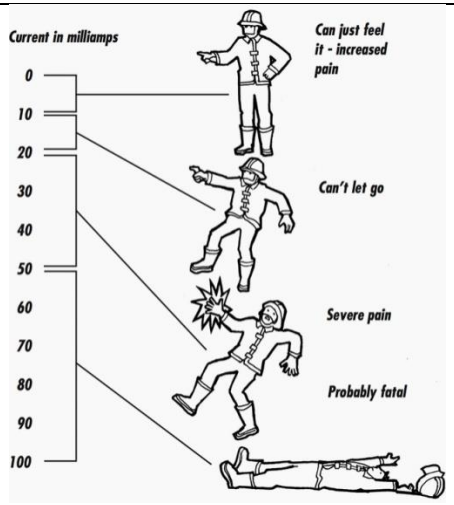
Adjustable wrench, wrench, screwdriver bits, screwdriver, tape measure, hammer, knife, socket, bull-nose pliers, needle-nose pliers, socket wrench, level, washer, nut, Allen key

- **Importance of functional conditions of required Tools, Equipment and PPEs and their use**
- **Importance of safe working condition regarding**
- **Clear passage**
- **Cleanliness**
- **Adequate light**
- **Ventilation**

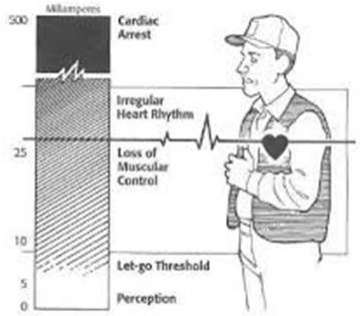
WINDING SAFETY PRECAUTION:

ELECTRIC SOCK:

- An electric shock occurs when a person comes into contact with an electrical energy source.
- Electrical energy flows through a portion of the body causing a shock.
- Exposure to electrical energy may result in no injury at all or may result in devastating damage or death.
- Many people get electric shocks obtained from man-made objects such as electrical appliances, electrical wires, and electrical circuitry.
- In addition, lightning strikes are a natural form of electric shock.
- Burns are the most common injury from electric shock and lightning strikes.



FIRST AID: The danger from an electrical shock depends on the type of current, how high the voltage is, how the current traveled through the body, the person's overall health and how quickly the person is treated.
An electrical shock may cause burns, or it may leave no visible mark on the skin. In either case, an electrical current passing through the body can cause internal damage, cardiac arrest or other injury. Under certain circumstances, even a small amount of electricity can be fatal.



When to contact your doctor: A person who has been injured by contact with electricity should be seen by a doctor.

Caution

- Don't touch the injured person if he or she is still in contact with the electrical current.

- Call 1122 or your local emergency number if the source of the burn is a high-voltage wire or lightning. Don't get near high-voltage wires until the power is turned off. Overhead power lines usually aren't insulated. Stay at least 20 feet (about 6 meters) away farther if wires are jumping and sparking.
- Don't move a person with an electrical injury unless he or she is in immediate danger.

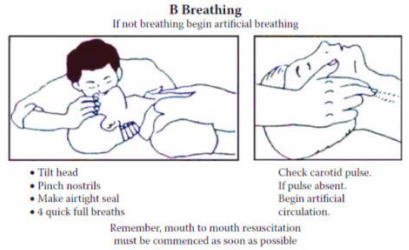
When to seek emergency care

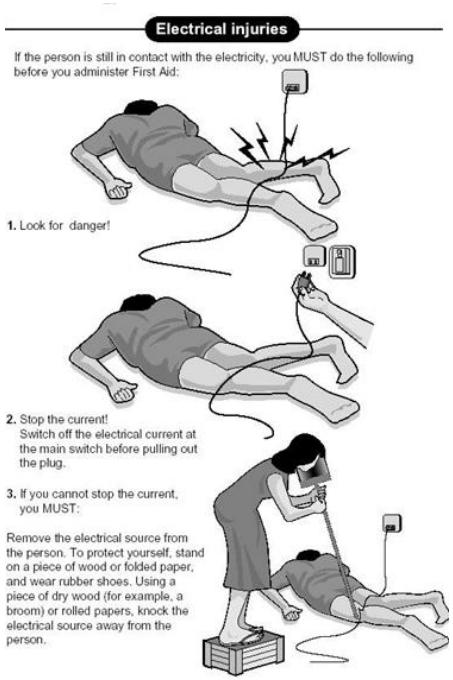
Call 1122 or your local emergency number if the injured person experiences:

- Severe burns
- Confusion
- Difficulty breathing
- Heart rhythm problems (arrhythmias)
- Cardiac arrest
- Muscle pain and contractions
- Seizures
- Loss of consciousness

Take these actions immediately while waiting for medical help:

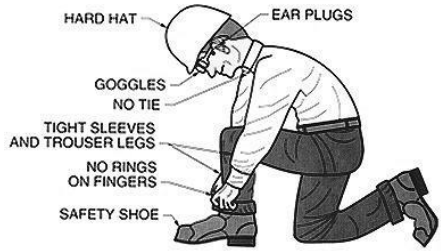
- Turn off the source of electricity, if possible. If not, move the source away from you and the person, using a dry, non-conducting object made of cardboard, plastic or wood.
- Begin CPR if the person shows no signs of circulation, such as breathing, coughing or movement.
- Try to prevent the injured person from becoming chilled.
- Apply a bandage. Cover any burned areas with a sterile gauze bandage, if available, or a clean cloth. Don't use a blanket or towel, because loose fibers can stick to the burns.





SAFETY RULES IN A WORK SHOP: Before you can use equipment and machines or attempt practical work in a workshop you must understand basic safety rules. These rules will help to keep you and others safe in the workshop. Safety in the workshops is subject to a number of various risk assessments and safe codes of working practices which have to be observed and adhered to by all workshop users and enforced by the person in charge of these areas.

Electrical danger cannot be assumed easy. The danger is difficult to trace since the flow of current cannot be seen. If the current flow in the wrong direction, the current can defect human body, cause a shock, paralyzed, fire, explosion, death and others. This accident can be prevented by observing / obeying safety procedure / rule. This safety rule is intended to protect employee, user, equipment and building from danger and risk due to electrical effect. These rules are based on IEE (Institution of Electrical Engineers) regulation and Department of Electric and Gas Supply that have been updated from to time. The following dress code must be observed for personal safety.



Workshop Safety Practice: The followings are safety procedures/ rules which must be obey:

- The floor of workplace must be free (clean) from oil, water and grease. These materials can cause the worker to slip while working there.
- Equipment used must in good and perfect condition. If not, report to officer in charge. All equipment must be kept at right and safe place so that it is easy to look for especially during emergency. After use, the equipment must be kept at its original place.
- Wear suitable clothing, not too tight and not too loose. Wear shoe having thick and all round sew sole when doing wiring work.
- Nobody is allowed to make joke or playing sharp instrument or object with friend while doing wiring work.
- Make sure the cable/conductor used fulfills its size (rating) and having suitable insulation.
- Make sure every electrical installation have effective ear thing and avoid it from rust.
- Any addition of circuit must be avoided unless there is permission from officer in charge.
- Do not dismantle electric component/device used in the experiment without the knowledge of officer in charge.
- Assistance from officer in charge must sought before testing the experiment with electrical supply,
- After using electrical machine, it must be switch off.
- In case any accident happened, officer in charge must be informed immediately.
- All electrical supply must off after finishing the job or before leaving laboratory.
- Before fitting plug to the socket, socket outlet switch must be in the off condition.
- Make sure environment around workplace is clean and systematic before and after work.

LU2. Shift Machine to work bench:

- **Use of required PPEs**
- **Describe procedure for safe shifting of faulty machine to work bench**

  Safe and secure shifting of machine to the work bench is important as any of the mishandling during

transportation of machine may cause to humane, machine or environmental damages/ loses. Select / Use the correct machine or man force required according to weight of faulty machine.

- **Describe process for updating Inventory Record at the work bench**
  - To make ready and providing accurate the existing information belonging of asset which are located in the site.
  - Physical check will cause to avoid from theft, damaged and discrepancy of asset.
  - A complete checking of organization asset to identify the current(user, department, location, condition/ status, quantity).
  - Physical check will avoid from any troubles during Handover/ Takeover of a project to other project.
  - Physical check helps you to provide your estimate Inventory list to beneficiaries.
  - Updating inventory record will facilitate you to prepare repair bill.
  - Your inventory number will show type of machine (Electric Motor abbreviated as EM), year of repair 2019 as 19, month of repair August as 8 and number of machine repaired in your workshop as 304, then your inventory number will be EM/19/8/304

LU3. Perform marking for Positions of Parts:

- **Selection and Use of required PPEs**
- **Importance of marking on parts as per inventory for the specific machine**

When you are working in workshop, you can receive more than one machines of same size, capacity and company, to distinguish between them it is necessary to mark inventory number to its all parts, after repair you can collect the same inventory numbers parts easily. This practice will facilitate you to complete your task quickly. For example if you received a motor for repair and you allotted it inventory number of EM/19/8/304, you should mark this same number on motor body, end plates, Rotor shaft, fan, terminal plate, stator core etc.

LU4. Perform numbering on Machine parts as per Inventory Record:

- **Selection and Use of required PPEs**
- **Importance of numbering on parts as per inventory record for the specific machine**

When you are working in workshop, you can receive more than one machines of same size, capacity and company, to distinguish between them it is necessary to mark inventory number to its all parts, after repair you can collect the same inventory numbers parts easily. This practice will facilitate you to complete your task quickly. For example if you received a motor for repair and you allotted it inventory number of EM/19/8/304, if there are 7 parts of machine you should mark EM/19/8/304/1/7 number on motor body, EM/19/8/304/2/7, EM/19/8/304/3/7 on end plates, EM/19/8/304/4/7 on Rotor shaft, EM/19/8/304/5/7 on fan, EM/19/8/304/6/7 on

terminal plate & EM/19/8/304/7/7 on stator core.

LU5.Remove the faulty parts:

- **Selection and Use of required PPEs**

Dismantling of Motor:

1. Remove the load - fan blades, gears, pulleys, etc. If possible, label and disconnect the power wiring as well as the motor can be totally removed to the convenience of your workbench.
2. Confirm that there are no burrs on the shaft(s) due to the set screw(s) that may have been there. For motors with plain bearings in particular, these will need to be removed to allow the shaft(s) to be pulled out without damage to the bushing. For ball bearing motors, the bearings will normally stay attached to the shaft as it is removed.
3. Use a scribe or indelible pen to put alignment marks on the covers so that they can be reassembled in exactly the same orientation.
4. Unscrew the nuts or bolts that hold the end plates together and set these aside.
5. Use a soft mallet if necessary to gently tap apart the two halves or end of the motor until they can be separated by hand.
6. Remove the end plate on the non-power shaft end (or the end of your choice if they both have extended shafts).
7. Remove the end plate or end on the power (long shaft) end. For plain bearings, gently ease it off. If there is any resistance, double check for burrs on the shaft and remove as needed so as not to damage the soft bushing.
8. Identify any flat washers or spacers that may be present on the shaft(s) or stuck to the bushings or bearings. Mark down their exact location and orientation so that they may be replaced during reassembly. Clean these and set aside. Inspect all components for physical damage or evidence of overheating or burning. Bad bearings may result in very obvious wear of the shaft or bushings or show evidence of the rotor scraping on the stator core.

8 Extended overloads, or shorted windings may result in visible or factory detected deterioration of wire insulation.

9 While it is apart, brush or blow out any built up dust and dirt and thoroughly clean the shaft, bushings.

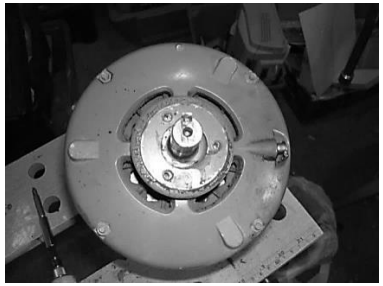
10 Re lubrication using electric motor oil for plain bearings and light grease for non-sealed ball / roller bearings.

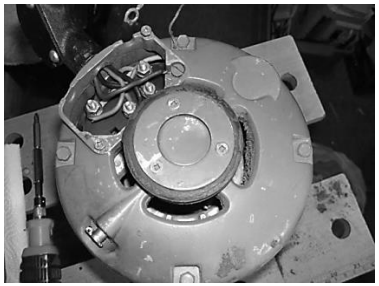
11 CAUTION: cleanliness is absolutely critical when repacking bearings or else you will be doing this again very soon.

12 Badly worn ball bearings will need replacement.

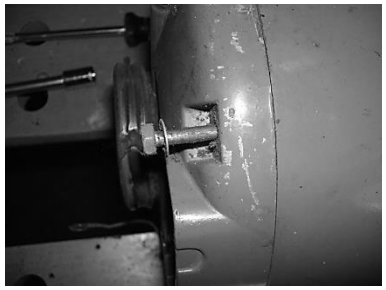
Following photos show the steps taken to split the motor apart during dismantling.

Step 1: Split the casing apart and remove the front end cap

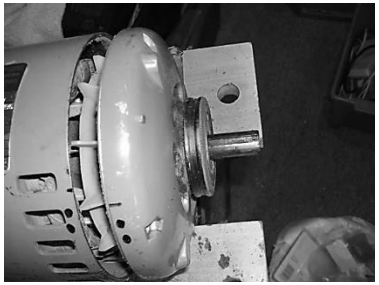


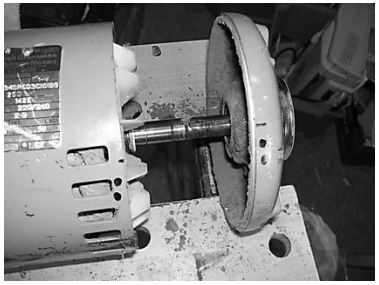


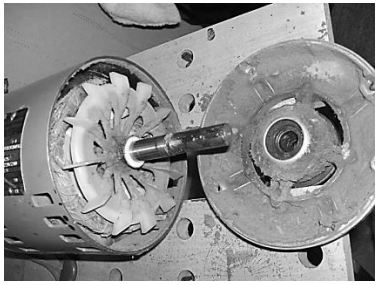
Step 2: There are 4 long nuts and bolts holding the ends together. These need removing. Marked the casing with felt-tipped pen to make sure that, you could get it back together.

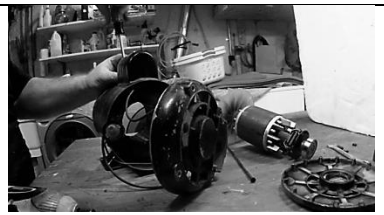


Step 3: Untied the nuts most of the way and eased a screwdriver in the join at the shaft end of the motor. Then removed all four bolts completely and took the front end casing off.









- **Importance of identification of faulty parts of machine**
  Before removing the faulty part it is necessary to identify the faulty part of machine to avoid unnecessary work, it will save your labour and time.

- **Describe numbering procedure on faulty parts of machine**
  When you are working in workshop, you can receive more than one machines of same size, capacity and company, to distinguish between them it is necessary to mark inventory number to its all parts, after repair you can collect the same inventory numbers parts easily. This practice will facilitate you to complete your task quickly. For example if you received a motor for repair and you allotted it inventory number of EM/19/8/304, if there are 7 parts of machine you should mark EM/19/8/304/1/7 number on motor body, EM/19/8/304/2/7, EM/19/8/304/3/7 on end plates, EM/19/8/304/4/7 on Rotor shaft, EM/19/8/304/5/7 on fan, EM/19/8/304/6/7 on terminal plate & EM/19/8/304/7/7 on stator core. Identify the faulty parts and place them on work bench separately from the healthy parts of machines.

LU6. Ensure safe and Sequential Placing of healthy parts of Machine:

- **Selection and Use of required PPEs**
- **Importance of marking on healthy parts of machine**
  When you are working in workshop, you can receive more than one machines of same size, capacity and company, to distinguish between them it is necessary to mark inventory number to its all parts, after repair you can collect the same inventory numbers parts easily. This practice will facilitate you to complete your task quickly. For example if you received a motor for repair and you allotted it inventory number of EM/19/8/304, if there are 7 parts of machine you should mark EM/19/8/304/1/7 number on motor body, EM/19/8/304/2/7, EM/19/8/304/3/7 on end plates, EM/19/8/304/4/7 on Rotor shaft, EM/19/8/304/5/7 on fan, EM/19/8/304/6/7 on terminal plate & EM/19/8/304/7/7 on stator core. Separate healthy parts of faulty machine from the faulty parts of machine; ensure that the parts have inventory numbers. This will facilitate you to identify and collect these parts easily and quickly when these are required to refit the machine after repair.

ELECTRICAL MACHINE WINDING TECHNICIAN

Module-B
LEARNER GUIDE
National Vocational Certificate Level 3

Version 1 - September, 2018

- **Importance of placing healthy parts of machine in sequential order**
  Health parts are safely placed in sequential order, this will facilitate you count them, and refit properly, which will save your time. If you don't observe the sequence you can miss some part to fit, and during fitting you have to disassemble the parts again to fit this part, which is of your labour and time.
- **Importance of recording the placement/location of healthy parts**
  Some repair work needs more time for repair, hence their healthy parts are required to be stored for long time and to avoid any mistake it is recommended to store these parts in a particular place and it must be recorded in inventory record. If you have stored healthy parts of EM/19/8/304 in rack number 23, you must record it in inventory register so that when you needed these parts you can trace / find them easily.

Module B. 0713001131 Diagnose Fault of Machine (Motor)

Objective: This Module covers the knowledge & skills required to diagnose fault of machine (motor) through Prepare for work, Verify pre inspection test results of machine ,Check Alignment of Rotor Shaft ,Check Bearing/ Bush of Machine ,Update Test Results of Machine ,Identify the Faulty Parts of Machine

Duration: 90 Hours **Theory: 18 Hours** **Practice: 72 Hours**

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1. Prepare for work to diagnose fault of machine (Motor)	**The trainee will be able to:** • Identify the required PPE's • Collect the required PPE's • Identify the required tools and equipment • Collect the required tools and equipment • Ensure functional condition of PPE's/Tools and equipment • Ensure safe working conditions	• Demonstration regarding selection & use of required Tools, equipment &PPEs • Importance of functional status of PPEs, Tools'& equipment / machinery • Importance of	**Tools** • Spanner Set • Screw Driver Set • Allen key Set • Clamp Meter • Safety Belt • Ladder **Consumables Items** • Hand Gloves

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
	➢ Clear Passage ➢ Cleanliness ➢ Adequate light ➢ Ventilation	conducive / ambient workplace environment ➢ Clear Passage ➢ Cleanliness ➢ Adequate light ➢ Ventilation	• Safety Shoes • Safety Goggles
LU2. Verify pre inspection test (On site test) results of machine	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Verify **/** Check numbering on machine parts as per inventory record • Perform testing with Megger ➢ Ground/Earth Fault ➢ Short Circuit ➢ Open Circuit • Record test result • Compare both the onsite and current test results	• Demonstration regarding selection &use of required Tools, equipment &PPEs • Describe verification of numbering on machine parts as per inventory record • Describe method of testing machine with Megger regarding the following: ➢ Ground / Earth Fault ➢ Short Circuit ➢ Open Circuit • State method of recording test results • State Importance of	**Tools** • Megger • Screw driver set • Spanner set • Combination plier • Ellen key set **Consumable Material** • Lead Pencil • Eraser • Paper / Performa of test results • Inventory register

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
		comparison between onsite & current test results.	
LU3. Check Alignment of Rotor Shaft	**The trainee will be able to** • Wear the required PPE's • Pick the required tools and equipment • Check alignment of rotor shaft with the help of dial gauge • Check the rotor shaft size as per bearing size • Check run out of the rotor shaft • Record result	• Demonstration regarding selection & use of required Tools, equipment &PPEs • State Importance of checking alignment of rotor shaft & method of checking. • State Importance of checking bearing size of rotor shaft & method of checking. • Describe method of checking run out of rotor shaft. • State Importance of recording test results	**Tools** • Dial Gauge • Screw driver set • Spanner set • Combination plier • Ellen key set • Outside calliper • Inside calliper • Vernier calliper **Consumable Material** • Lead Pencil • Eraser • Paper / Performa of test results • Inventory register
F4. Check Bearing/ Bush of Machine	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Inspect the bearing/bush for ➢ noise ➢ Axial/Radial Play/Looseness ➢ Stickiness	• Demonstration regarding selection & use of required Tools, equipment &PPEs • Describe techniques of inspection & checking of bearing / bush regarding ➢ Noise ➢ Axial / Radial play /	**Tools** • Screw driver set • Spanner set • Combination plier • Ellen key set • Bearing Puller • Outside calliper • Inside calliper • Vernier calliper

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
	➢ Lubrication ➢ Breakage • Check bearing / bush of machine • Record result	looseness ➢ Stickiness ➢ Lubrication ➢ Breakage • Method of recording test results	**Consumable Material** • Lead Pencil • Eraser • Paper / Performa of test results
LU5. Update Test Results of Machine	**The trainee will be able to:** • Collect onsite inspection test results of machine • Collect test results of machine conducted in workshop • Update test results of machine	• State Importance of comparison of test results • State Importance of updating test results	**Tools** **Consumable Material** • Lead Pencil • Eraser • Paper / Performa of test results
LU6. Identify the Faulty Parts of Machine	**The trainee will be able to:** ➢ Check test results of machine ➢ Identify faulty parts of machine ➢ Perform Numbering on faulty parts of machine according to inventory record ➢ Tag faulty parts of machine	➢ Describe method of detection of faulty parts of machine on the bases of test results ➢ State importance & method of numbering on the faulty parts of machine ➢ State importance & method of tagging on faulty parts of machine	**Tools** **Consumable Material** • Lead Pencil • Eraser • Paper / Performa of test results • Tags

LU1. Recognition of tools/equipment ,PPE's and their use to diagnose fault of machine (Motor)

IDENTIFICATION AND USE OF WIRE GAUGE

Wire gauge is a measurement of how large a wire is, either in diameter or cross sectional area. This determines the amount of electric current a wire can safely carry, as well as its electrical resistance and weight per unit of length.

STEP- 1 The wire gauge measures the thickness of winding wire and sheet using slots of increasing sizes.

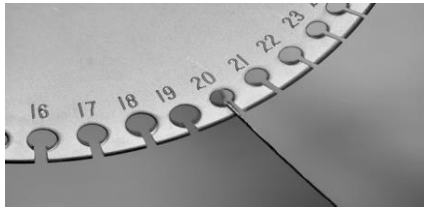
STEP- 2 One side has metal gauge sizes from 0 to 36. The reverse side of the wire gauge has the corresponding size in inches.

STEP- 3 To measure wire, slide the wire into a slot. Shown above, the wire fits loosely in the slot so it is not 12 gauge wires.

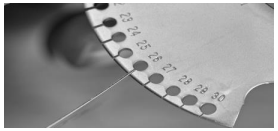
STEP- 4 Slide the wire into a smaller slot. In this case the wire does not fit into the slot so the wire is not 17 gauges.

STEP- 5 Slide the wire into a larger slot than the one in step 3. The wire fits into the slot with a tight fit. This means that our wire is 16 gauges.

STEP- 6 Measure sheet metal the same way. Slide the sheet metal into a slot. In this case the sheet metal fits loosely in the slot; it's not 20 gauge sheets.

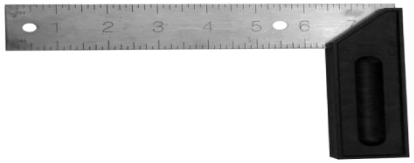


STEP- 7 Slide the sheet metal into smaller slots until the sheet metal is a tight fit. This means that this sheet metal is 26 gauge sheets.



IDENTIFICATION AND USE OF TRY SQUARE

A try square is special purpose square in wood- and metalworking used to mark or measure material. The name ‘try square’ comes from the concepts of ‘trying a surface’ (to check a surface’s straightness or correspondence to an adjacent surface) and ‘square’ (a 90°, or right, angle).Try squares generally consist of two parts. There are 3 parts to the try square. A hardwood handle or stock, a metal blade and a face plate on the handle which is usually brass. The ‘blade’ is the longer portion, usually made of metal. The ‘handle’ (or ‘stock’) is usually made of wood, plastic or metal. Try Squares from Johnson Level feature blades with hash marks for measuring short distances.



- Place the try square blade across the material you want to test or mark. The thicker part of the handle should extend over the edge of the surface, allowing the blade to lie flat across the surface.
- Hold the handle against the edge of the material. The blade is now positioned at a 90° angle compared to the edge.
- Find where you want to mark the material by adjusting the blade. Using the blade’s edge, draw a line across the material. To check the board’s square, align the blade with the end of the material. Make sure the corner of the material lines up with the corner of the try square. If there’s a gap between the try square and the material, the material isn’t square.
- The exact point at which you want the line to be is measured and marked with a pencil or marking knife on the face side.
- The pencil or marking knife is then placed on the point made.
- The try square is then clamped (with your hand) against the face edge of the timber and slid up to touch the pencil or knife.
- You can then mark the line at right angles to the face edge.
- Turn the wood and place the pencil or knife on the line you have just marked.
- The try square is this time clamped to the face side and slide up to the knife or pencil and the line is marked on the opposite edge to the face edge.

- Repeat the process for the face edge and the side opposite the face side.

Always mark from the face edge or the face side this ensures that any minor errors in the square-ness of the timber do not affect the marking out.

Inside caliper

The inside calipers are used to measure the internal size of an object.

- The upper caliper in the image requires manual adjustment prior to fitting. Fine setting of this caliper type is performed by tapping the caliper legs lightly on a handy surface until they will *almost* pass over the object. A light push against the resistance of the central pivot screw then spreads the legs to the correct dimension and provides the required, consistent *feel* that ensures a repeatable measurement.
- The lower caliper in the image has an adjusting screw that permits it to be carefully adjusted without removal of the tool from the work piece.

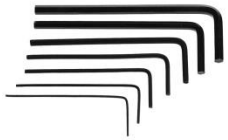
Outside caliper

Outside calipers are used to measure the external size of an object.

The same observations and technique apply to this type of caliper, as for the above inside caliper. With some understanding of their limitations and usage, these instruments can provide a high degree of accuracy and repeatability. They are especially useful when measuring over very large distances; consider if the calipers are used to measure a large diameter coil. A Vernier caliper does not have the depth capacity to straddle this large diameter while at the same time reach the outermost points of the pipe's diameter. They are made from high carbon steel.

https://www.bing.com/videos/search?q=inside+caliper&view=detail&mid=DA07A1CCE56136D02B41DA07A1CCE56136D02B41&FORM=VIRE

ELLEN KEY: These Allen keys or wrenches feature a Hex-Plus head on the short arm, and on the long arm. Hex-Plus offers a bigger contact surface in the screw head, and so reduces the chance of wear and rounding off the corners in Allen head screws. The key easily inserted into the head and permits the key to be turned at an angle, which is very useful in tight corners.



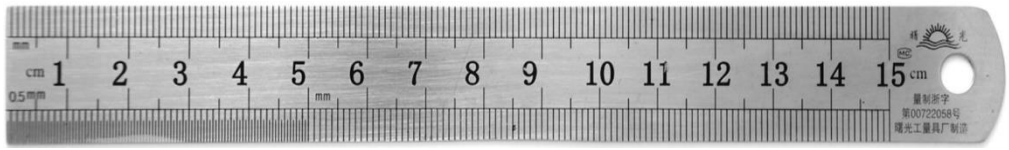
BEARING PULLER: It is used to remove bearing, gears, pulleys and flywheels. It features chrome-vanadium steel construction and reversible jaws.

IDENTIFICATION AND USE OF STEEL FOOT RULE

The simplest and most common measuring tool. The flat steel rule is usually 6 or 12 inches long, but longer sizes are available. Steel rules can be flexible or nonflexible, thin or wide. The thinner the rule, the more accurately it measures, because the division marks are closer to the work.

Generally, a steel rule has four sets of marks, two on each side of the rule. On one side are the inch marks. The longest lines are for 1-inch increments. On one edge of that side, each inch is divided into eight equal spaces of 1/8

inch each. On the other edge of that side, each inch is divided into 1/16-inch spaces. To make counting easier, the 1/4 inch and the 1/2-inch marks are normally longer than the smaller division marks. The other side of the steel rule is divided into 32 and 64 spaces to the inch. Each fourth division in the inch is usually numbered for easier reading.

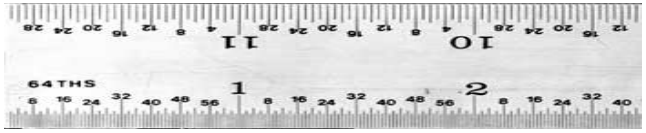


MEASURING BY STEEL FOOT RULE

Here is the correct way to measure a part with a steel rule. Notice that we are measuring from the 1" graduation on the left. (Be sure to subtract 1" from the measurement you read.) It is more accurate to measure between two graduation lines than from the end of the rule.

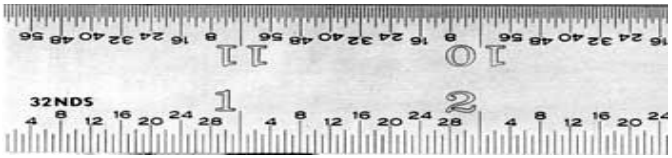
There are four basic divisions that are found on a fractional inch rule. These are: 1/64, 1/32, 1/16 and 1/8 of an inch.

- Let's look at each graduation a little closer. A 1/64" graduate scale means that in a 1-inch length, there are 64 lines dividing that inch.



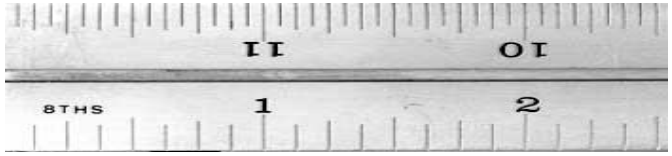
These are the smallest graduations on the rule, therefore making the accuracy of a steel rule 1/64". This is sometimes argued by some of the metal workers who say they can measure to within ±.003 with the rule. They are right for they have worked with it a long time and have become masters at reading the graduations. However, the rule is only intended to measure to 1/64" accuracy, and other instruments are used to measure to closer tolerances.

- The next set of graduations is the 1/32" scale, which divides a 1-inch length into 32 divisions. A 1/32 division is equal to 2/64 divisions.



- The 1/16" scale divides a 1-inch length into 16 divisions and is a total of 4/64 or 2/32 graduations.

❖ The 1/8" scale divides a 1-inch length into 8 equal divisions and is a total of 8/64, 4/32, or 2/16 graduations.



HOW TO USE STEEL FOOT RULE

➢ To get the full accuracy out of a rule, it is important to use it correctly. Never use the end of the rule to align with the edge of the work for a measurement (Figure 1). The end of a rule is often rounded off from misuse, and a true measurement will not be made.

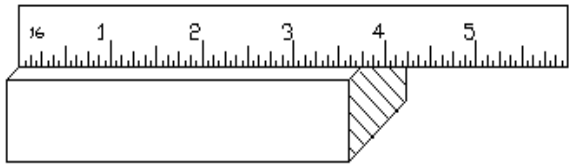


Fig. 1

➢ Even if the work piece is held firmly against a reference surface, such as an angle plate (Figure 2), this will not assure an accurate measurement if the end of the rule is worn off.

Fig. 2

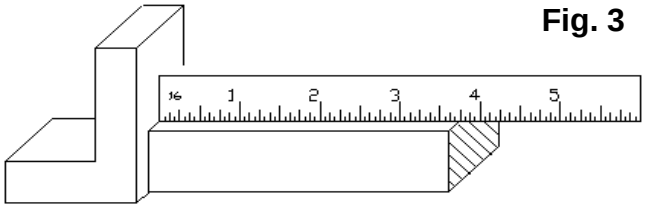
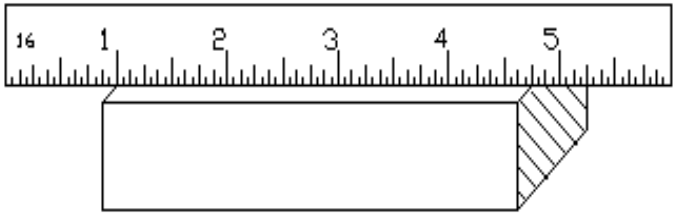
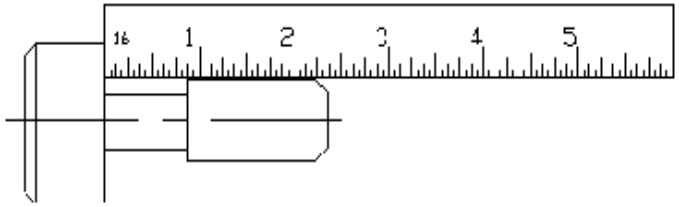


Fig. 3



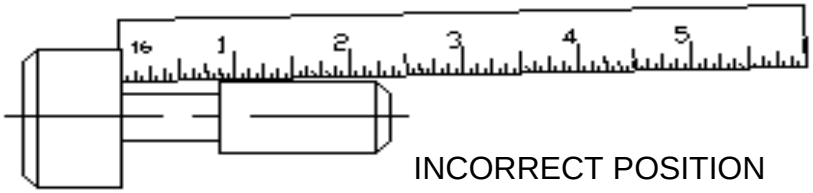
➢ To offset this, use an inch graduation as a reference point on the rule (Figure 3). Precision and reliable measurements are possible this way. With the graduation directly on the edge of the work, and by not using the end of the rule, wear is inconsequential.

1. When measuring a length, the rule must be kept in a straight line parallel to the centerline of the work. If it is tilted, the measurement will be longer than the actual part.



CORRECT POSITION

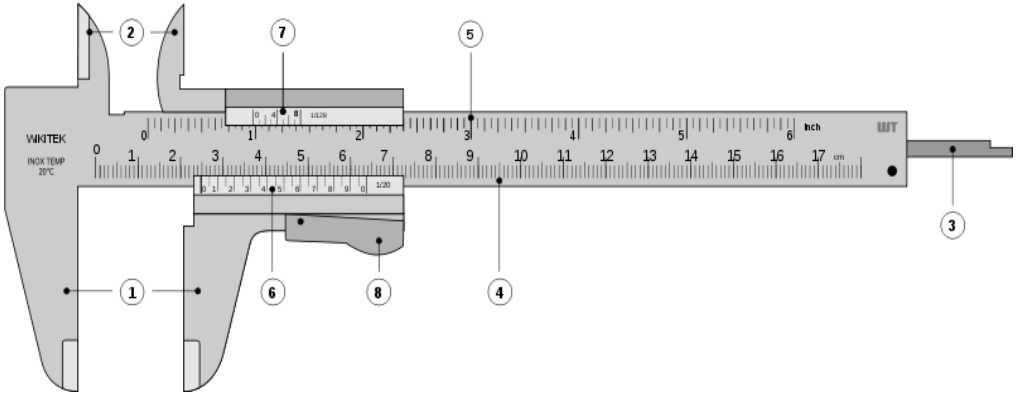
2. One other important factor in using the rule is to be aware of parallax. This is an observation error from the person measuring or holding at the part in relation to the part being held.



INCORRECT POSITION

IDENTIFICATION OF VERNIER CALIPER AND USES

Vernier caliper is a measuring tool used to measure length. It is more accurate than meter rule. It can measure length with accuracy up to 0.01cm.The Vernier Caliper is a precision instrument that can be used to measure internal and external distances extremely accurately. Measurements are interpreted from the scale by the user.



PARTS OF VERNIER CALIPER & THEIR USES

1. **OUTSIDES JAWS:**

Used to measure external diameter or width of an object.

2. **INSIDE JAWS**: Used to measure internal diameter of an object.
3. **DEPTH PROBE**: Used to measure depth of an object or hole.
4. **MAIN SCALE**: Scale marked every mm.
5. **MAIN SCALE:** Scale marked in inches and fractions.
6. **VERNIER SCALE**: Gives interpolated measurements to 0.1mm or better.
7. **VERNIER SCALE:** Gives interpolated measurements in fractions of an inch
8. **RETAINER:** Used to block moveable part to allow the easy transferring of a measurement.

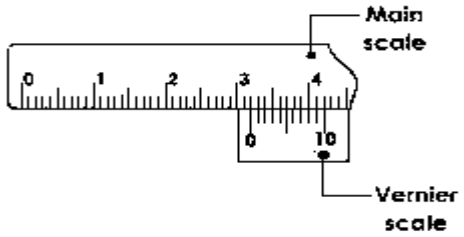
MEASUREMENT APPLICATIONS OF VERNIER CALIPER

These kinds of measurements can be taken by a Vernier caliper:

1. outside measurement
2. inside measurement
3. Step measurement
4. Depth measurement

HOW TO TAKE READING

First read the main scale, and note down the reading before the 0 on the Vernier scale, as shown in the diagram below. The reading on it is 2.8 cm, as the .8 after the 2 on the main scale is before the 0 on the Vernier scale. For the second place of decimal, look at the Vernier scale. Find a marking on the Vernier scale that coincides exactly with the reading on the main scale.



TAKING READING FROM AVERNIER CALIPERS:

1. A Vernier caliper has 2 scale, namely the main scale and the Vernier Scale.
2. The main scale is read at the zero mark of the Vernier scale.
3. The Vernier scale is read at the point where it's scale coincide with the Main scale.
4. Reading of Vernier caliper = Reading of main scale + reading of Vernier scale.
5. The Vernier scale is 9mm long, divided into 10 divisions.

INSTRUCTIONS ON USING

- The Vernier caliper is an extremely precise measuring instrument; the reading error is 1/20 mm = 0.05 mm.
- Close the jaws lightly on the object to be measured.
- If you are measuring something with a round cross section, make sure that the axis of the object is perpendicular to the caliper. This is necessary to ensure that you are measuring the full diameter and not merely a chord.
- Ignore the top scale, which is calibrated in inches.
- Use the bottom scale, which is in metric units.
- Notice that there is a fixed scale and a sliding scale.
- The boldface numbers on the fixed scale are centimeters.
- The tick marks on the fixed scale between the boldface numbers are millimeters.
- There are ten tick marks on the sliding scale. The left-most tick mark on the sliding scale will let you read from the fixed scale the number of whole millimeters that the jaws are opened.

EXAMPLE:

Reading of main scale = 2.2cm

Reading of Vernier scale = 0.07cm

Reading of the Vernier caliper = 2.27cm

ZERO ERROR OF VERNIER CALIPER

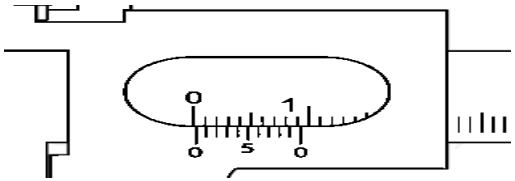
1. The zero error is determined by tightening the jaws of the Vernier Calipers.
2. Zero error must be eliminated from the reading.

Actual Reading = Reading of Vernier Caliper - Zero Error

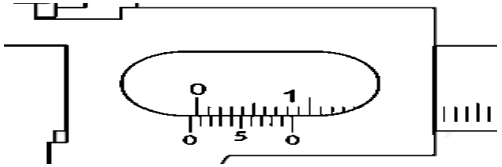
EXAMPLE

Images below show the reading of 3 Vernier calipers when their jaws are tightly closed. Find the zero error of each caliper.

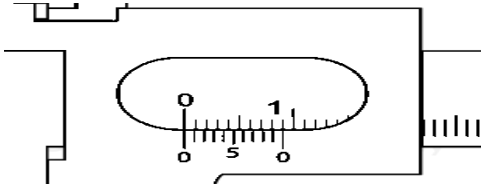
Zero error = 0.02 cm



A) Zero error = -0.06cm



B) Zero error = 0 cm (No zero error)



HOW TO AVOID ZERO ERROR

Before using Vernier caliper you should close it to find whether a zero error exists or not.

IDENTIFICATION VERNIER HEIGHT GAUGE

VERNIERHIEGHT GAUGE

This is also a sort of Vernier caliper equipped with a special base block & other attachments which makes the instruments suitable for height measurements. Along with the sliding jaw assembly, arrangement is provided to carry a removable clamp. The Vernier height gauge is mainly used in the inspection of parts and layout work. This can also be used as scribing instrument.

A Vernier height gauge is typically used to take precise vertical measurements of various objects. It is possible to measure many different things with the gauge, but they are most often used in metalworking and other related industries. They often have a scribing tool as the measurement level, allowing the operator to repeatedly mark vertical

distances on pieces of metal that can then be worked on. Heights or vertical distances may also be measured using the bottom of the scribe.

When used in metalworking and other related industries, a Vernier height gauge is typically equipped with a scribing tool. This will often take the form of adjustable level so that it can be set to particular heights and then used to scribe marks on a piece of metal. Operators may use this functionality to mark many pieces of metal with identical and precise measurements. The bottom side of the scribing tool can also be used to measure vertical distances, rather than inscribing height markings.

In order to ensure the continued accuracy of a gauge, it is typically possible to adjust the level. This may be necessary if the scribing tool becomes worn or damaged, and is often adjusted through the use of a feed screw. It may be possible to make fine adjustments using the feed screw if the height gauge is out of calibration.

Vernier height gauges are one of the two main types of tools used to make accurate vertical measurements. The other type is typically referred to as an electronic height gauge. Rather than a Vernier scale, these gauges have a digital readout. Digital height gauges may be more expensive than their Vernier counterparts, but typically take less training or expertise to read correctly.

SPECIFICATION OF VERNIER HEIGHT GAUGES:

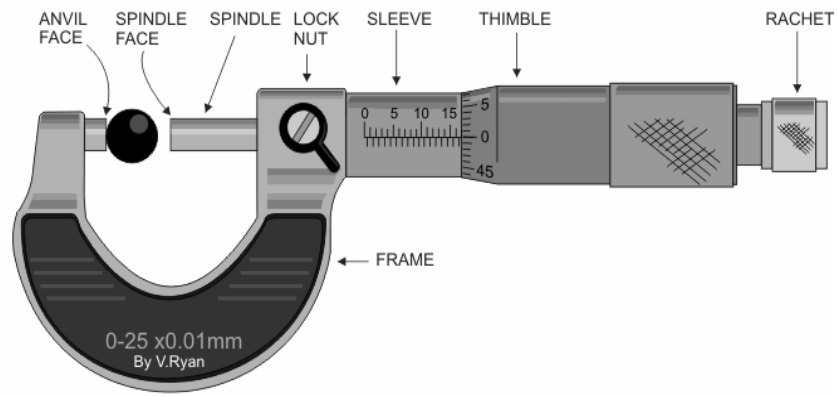
For specifying the Vernier height gauge, one has to specify clearly the range of measurement, the type of scales desired, and any particular requirements in regard to the type of Vernier desired. Generally, all the parts of the height gauges are made of good quality steel, or stainless steel also in certain cases. At the time of fabrication, the blanks:

- Storage of upon 400 dimensions.
- Data retention on failure of electric power.
- Automatic entry of data as component is measured.
- Entry of data via the custom touch key- pad.
- Calculation of capability indicates for quick and easy assessment of machine/ plant or process capability.
- Easy identification of component features out of tolerance.
- Calculation of mean, standard deviation and range.
- Assessment of 2- sigma, 3- signal, and 4- sigma confidence intervals.
- Comprehensive print- out of statistical data including histograms.
- Each sequence of measurement is recorded in numerical order and can be recalled subsequently and printed out in the format required.

IDENTIFICATION AND USE OF MICRO METER

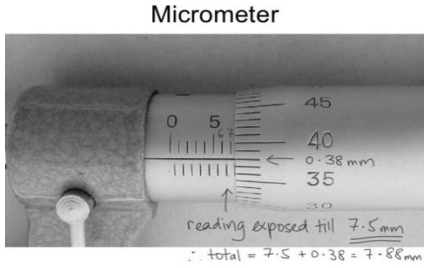
Micrometer, in full Micrometer Caliper is an instrument for making precise linear measurements of dimensions such as diameters, thicknesses, and lengths of solid bodies; it consists of a C-shaped frame with a movable jaw operated by an integral screw.

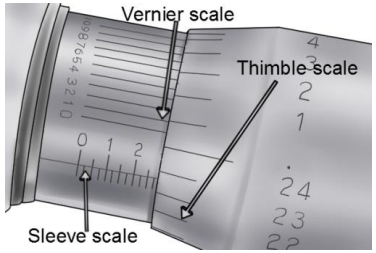
The fineness of the measurement that can be made depends on the lead of the screw—i.e., the amount the spindle moves toward or away from the anvil in one revolution and the means provided for indicating fractional parts of a revolution. The accuracy of the measurements depends on the accuracy of the screw-nut combination.



HOW TO TAKE READING

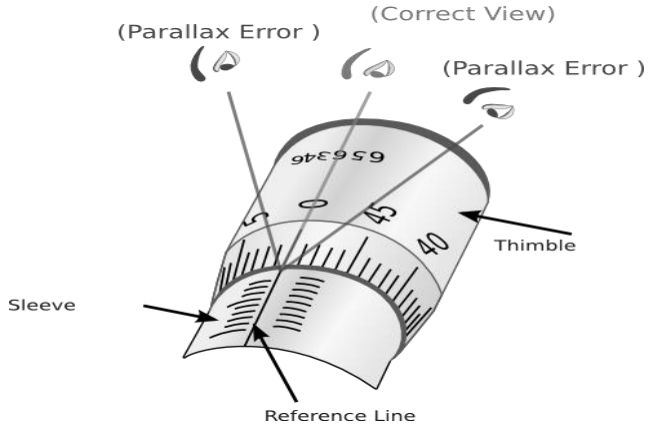
- Turn the thimble until the object is gripped gently.
- Read the main scale on the sleeve. This reading would be in millimeters. In the diagram below, the reading is 5.5mm
- Then read the line on the circular scale that coincides with the line on the main scale. In the diagram below, the 28th line on the circular scale coincides with the line. So, the reading would be 0.28mm.
- Then add 5.5 with 0.28 and you will obtain your answer in millimeters.





PARALLAX ERROR

For accurate measurement, the eye must always be placed vertically above the mark being read. This is to avoid parallax errors which will give rise to inaccurate measurement.



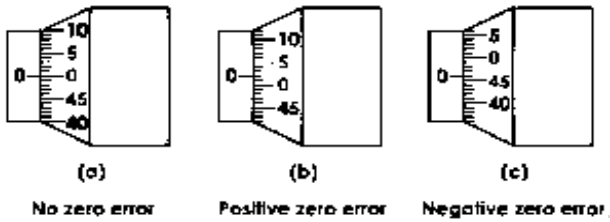
Parallax errors effect the accuracy of the measurement. If you consistently used the incorrect angle to view the markings, your measurements will be displaced from the true values by the same amount. This is called systematic error.

However, if you used different angles to view the markings, your measurements will be displaced from the true values by different amounts. This is called random error.

TYPES OF ERROR IN MICROMETER SCREW GAUGE READING

Every micrometer prior to its use should be thoroughly checked for backlash error or zero error.

- **BACKLASH ERROR**: Sometimes due to wear and tear of the screw threads, it is observed that reversing the direction of rotation of the thimble, the tip of the screw does not start moving in the opposite direction immediately, but remains stationary for a part of rotation. This is called back lash error.
- **ZERO ERROR**: If on bringing the flat end of the screw in contact with the stud, the zero mark of the circular scale coincides with the zero mark on base line of the main scale, the instrument is said to be free from zero error. Otherwise an error is said to be there. This can be both positive and negative zero error



❖ **POSITIVE ZERO ERROR**

If the zero marking on the thimble is below the datum line, the micrometer has a positive zero error. Whatever reading we take on this micrometer we would have to subtract the zero correction from the readings.

❖ **NEGATIVE ZERO ERROR**

If the zero marking on the thimble is above the datum line, the micrometer has a negative zero error. Whatever readings we take on this micrometer we would have to add the zero correction from the readings.

CALCULATING MICROMETER SCREW GAUGE READING:

Total observed reading = main scale reading + (circular scale division coinciding the base line of main scale) x least count

- True diameter = observed diameter – zero error
- Example, main scale reading = 2mm or 0.2cm
- Circular scale reading = 56, so 56 x 0.001 = 0.056cm
- So observed reading = 0.2 + 0.056 = 0.256cm

STRIPPING OF WIRES:

Cutting and Stripping a wire with wire stripper pliers is an important skill. Safe, durable electrical connections begin with clean, accurate wire stripping. Removing the outer layer of plastic without nicking the wires underneath is critical. If a wire does get nicked, the connection may break or an electrical short may occur.

Wire Stripper

A simple manual wire stripper is a pair of opposing blades much like scissors. There are several notches of varying size. This allows the user to match the notch size to the wire size, which is very important for not damaging the wires.

WARNING:

Many wire strippers found at the hardware store do not strip small gauge wire (22 to 30). When getting into prototyping, be sure to get a tool that is capable of stripping 22 AWG and smaller. Being able to strip very small 30 AWG wire (also known as wire wrap wire) is a plus.

Although a knife would also strip the wires, it may also damage the wire by nicking the metal or cutting into it. Using a knife to strip wire is also really dangerous! The knife can easily slip and cause wicked injuries.

STRIPPING THE WIRE:

If you do not have a wire stripper with different-sized teeth, or if you're using a pair of pliers with a wire stripper notch, you will have to go by feeling.

STEP 1 CUT THE COATING:

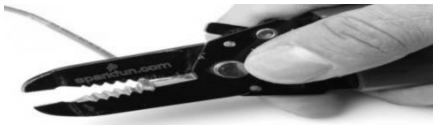
Stick the wire into the notch on the wire stripper and gently squeeze the handles together. The stripper will cut through the rubber insulation.

STEP 2 SPIN THE WIRE STRIPPER:

Spin the wire stripper around the wire once it has cut through the rubber insulation to ensure the insulation has been cut all the way through and all the way around the wire.

STEP 3 STRIP THE WIRE:

Pull the stripper toward the end of the wire to strip the rubber insulation from the wire.



By simply squeezing the handles about ¼" from the end of the wire or the desired length, using the correct notch on the tool, and then twisting it slightly, the insulation will be cut free.

Then by pulling the wire strippers towards the end of the wire, the insulation should slide right off of the wire.

TIPS, TRICKS, AND HINTS:

It is important to match the size of wire to the correct notch in the stripper. If the notch is too large, the wire will not get stripped. If the notch is too small, there is a risk of damaging the wire. Using an undersized notch means the strippers will close too far, digging into the wire underneath. With stranded wire, the tool will cut off the outer ring of wires, decreasing the total diameter of wire and reduce the strength of the wire. A nick in solid core wire will severely reduce

the strength and flexibility of the wire. The likelihood of the wire breaking upon being bent increases significantly.

This wire was not stripped properly; there are gouges and missing standards. If a wire does accidentally get a nick in it, the best plan of action is to cut the damaged part of the wire off and try again.

BENDING OF WIRES:

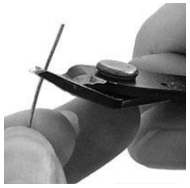
Bending of wires mean to bend a wire according to given circuit diagram. To make a circuit as per given diagram it is essential to laying the wires according to given diagram. For this purpose first need to straight the wires and cut it according to need and bend it where needed then make connections to complete wiring circuit. It will look beautiful, safe and very easy to repair whenever fault occurs in this circuit.

Laying and bending especially used in big panels / motors where so many wires are used their so laying and proper bending of wires can make it easy to install and repair.

MAKING OF EYES:

Eye pins should be made with half-hard wire to make sure they hold their shape. 22-gauge will fit through most beads, with the exception of many semi-precious stones. Most Czech glass beads and 4mm crystals will fit on 20-gauge wire.

The length used for the eye loop depends on how big you want the loop. Here we will use 3/8 inch for a moderate size loop. Flush trim end of wire.



Using chain-nose pliers, make a 90-degree bend 3/8 inch from end of wire.

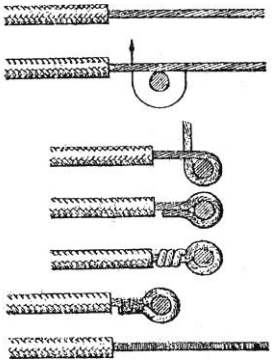
Using round-nose pliers, grasp the end of the wire so no wire sticks out between pliers' blades.

Without removing pliers from loop, open plier's blade slightly and pivot pliers back toward your body clockwise about 1/4 turn.

Close pliers onto the wire and roll the loop until it comes around, next to the 90-degree bend.

Without removing pliers from loop, open plier's blade slightly and pivot pliers back toward your body clockwise about 1/4 turn. Close pliers onto the wire and roll the loop until it comes around, next to the 90-degree bend.

Open and close eye-pin loops the same way as jump rings, by pushing open front to back.



- **Importance of functional status of PPEs, Tools'& equipment / machinery**
- **Importance of conductive / ambient workplace environment**
  - **Clear Passage**
  - **Cleanliness**
  - **Adequate light**
  - **Ventilation**

LU2. Verify pre inspection test (On site test) results of machine

- **Demonstration regarding selection &use of required Tools, equipment &PPEs**
- **Describe verification of numbering on machine parts as per inventory record**

ELECTRIC MOTORS:

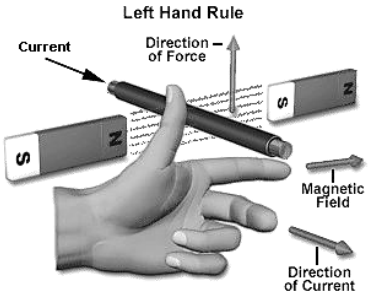
A motor is an electro-mechanical device that converts electrical energy to mechanical energy. There are different types of motor have been developed for different specific purposes.

WORKING PRINCIPLE:

In simple words we can say a device that produces rotational force is a motor. The very basic principal of functioning of an electrical motor lies on the fact that force is experienced in the direction perpendicular to magnetic field and the

current, when field and current are made to interact with each other.

LEFT HAND RULE:



Fleming's left hand rule says that if we extend the index finger, middle finger and thumb of our left hand in such a way that the current carrying conductor is placed in a magnetic field (represented by the index finger) is perpendicular to the direction of current (represented by the middle finger), then the conductor experiences a force in the direction (represented by the thumb) mutually perpendicular to both the direction of field and the current in the conductor.

TYPES OF MOTOR (AC & DC):

AC Motors:

- Three phase motor
  - Synchronous motor
  - Asynchronous / induction motor
    - Squirrel cage motor
    - wound rotor / slip ring motor
- Single Phase motor
  - Split phase induction motor
    - Capacitor start motor
    - Capacitor run motor
    - Capacitor start & capacitor run motor
      - With single capacitor
      - With double capacitor
  - Shaded pole motor
  - Hysteresis motor

- Reluctance motor
- AC series motor
- Universal motor

DC Motors:

- Series motor
- Shunt motor
- Compound motor (Cumulative & Differential compound motor
  (Short shunt & Long shunt)
- **Describe method of testing machine with Megger regarding the following:**
  - **Ground / Earth Fault**
  - **Short Circuit**
  - **Open Circuit**

MAKING OF TEST BOARD:

Test boards are designed to check short circuit, open circuit or continuity test of different electrical equipment's. These are of different types e.g. series or series parallel test board. The main advantage of series-parallel board is that full voltage may also be applied to machine after testing it.

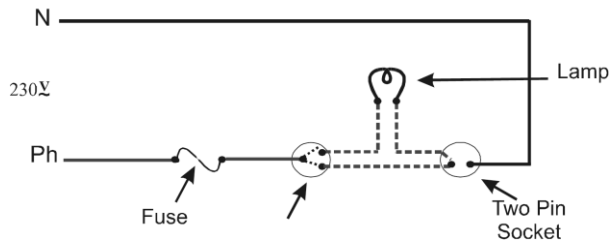
PROCEDURE:-

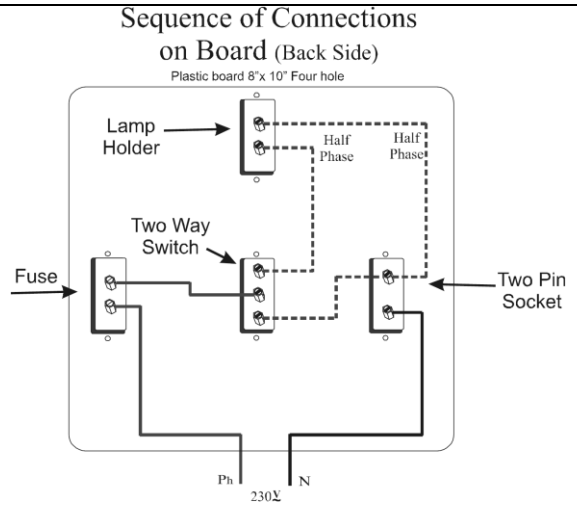
- Make a list of required accessories and tools for practical and draw all these items from store after submitting names of your group members.
- Place all the items on workbench with proper arrangement.
- Make the wire terminals after cutting proper pieces of wire.
- Make two holes in bottom side of plastic board with the help of drill machine and enter the phase (Red) and neutral (Black) wire through them.
- Fit two pin socket, lamp holder and two way switch on the board according to diagram and tighten all the nuts and bolts.
- Complete the connections according to circuit shown.
- Check this circuit to your instructor and then connect it to supply.
- Deposit all the accessories and tools in the store after dismantling the circuit with great care.

PRECAUTIONS:-

- Use the proper wire in fuse.
- Use electrician knife instead of electrician plier for making of wire terminals.
- The direction of electrician knife should be outward at the time removing insulation and there should be no student in front of you.
- Insert the wire conductor in terminal so that insulation does not come between screw and conductor.
- Always use switch with live wire.
- Do not left the screw terminals so loose or tighten that they get free or break the conductor.
- Remove the conductor insulation up to proper length.
- Make sure the use of proper tools and never use the tool instead of other.
- Make sure the use of proper screw driver according to size of screw.
- Avoid from joints if a cable of proper size is available.
- If the joint is necessary then make sure the use of PVC tape on joints.
- Do not provide the supply to circuit before checked by instructor.
- Always use the out of order tools or machines in series for checking purpose.
- Do not use bulb of power ratings below 200W.

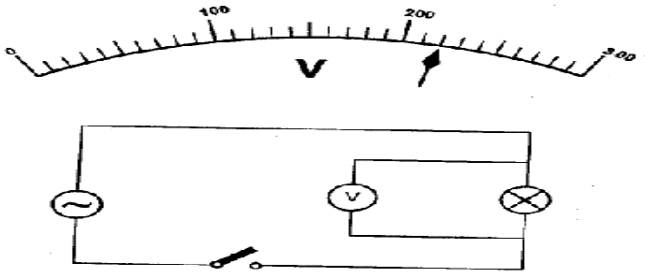
Circuit Diagram



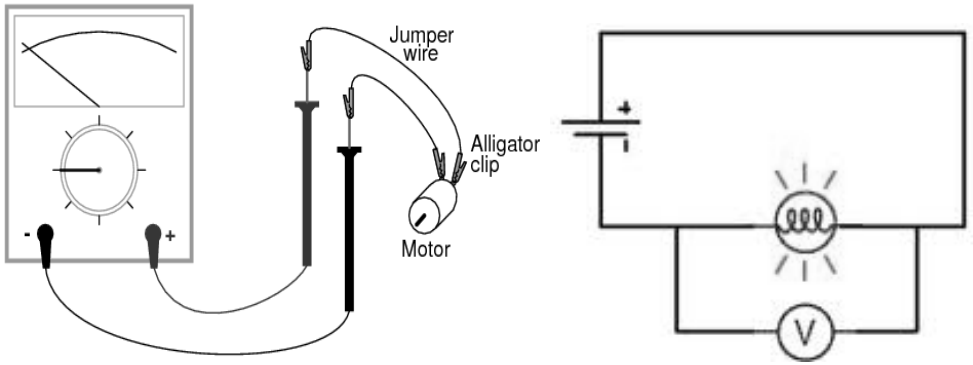


USE OF VOLT METER:

Volt meter is a measuring device which can measures electric pressure in an electric circuit. To measure electric pressure in an electric circuit connect a volt meter parallel across the load in electric circuit. It is shown in diagram below how to connect a volt meter in a circuit.



Measurement with Volt Meter is as under.



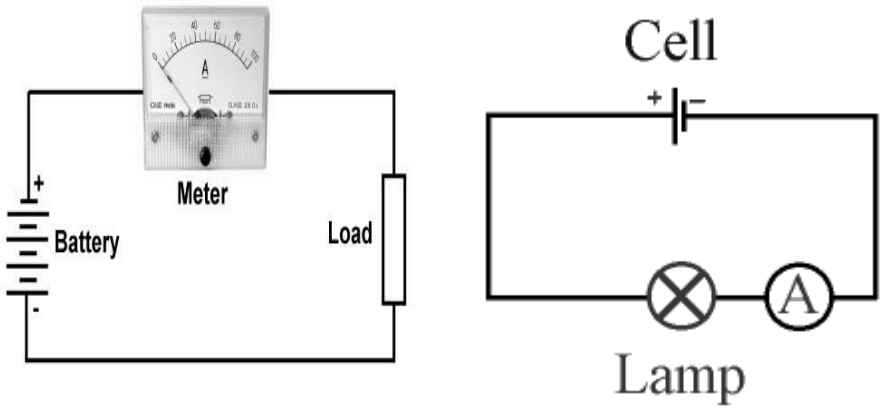
Take different readings and record them in table shown below.

Sr. #	Reading of Voltmeter
1	
2	
3	
4	
5	

USE OF AMPERE METER:

An ammeter is a measuring instrument used to measure the electric current in a circuit. Electric currents are measured in amperes (A), hence the name. Instruments used to measure smaller currents, in the mill ampere or microampere range, are designated as milli ammeters or micro ammeters. By the late 19th century, improved instruments were designed which could be mounted in any position and allowed accurate measurements in electric power systems. The ammeters are connected in series with the circuit carrying the current to be measured

Measurement with Ampere Meter is as under.



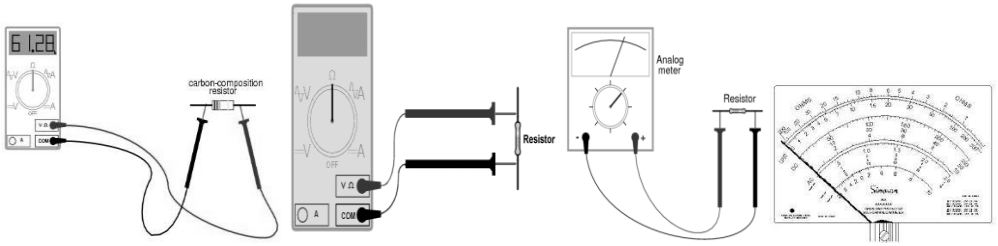
Take different readings and record them in table shown below.

Sr. #	Reading of Ammeter
1	
2	
3	
4	
5	

USE OF Ohm's Meter:

An ohm's meter is an electrical instrument used to measure electrical resistance, the opposition to an electric current. The unit of measurement for resistance is ohms (Ω). In ohmmeter a small battery is used to apply a voltage to a resistance via a galvanometer to measure the current through the resistance. The scale of the galvanometer was marked in ohms, because the fixed voltage from the battery assured that as resistance is decreased, the current through the meter would increase. Ohmmeters form circuits by themselves; therefore they cannot be used within an assembled circuit. The meter needs to be zeroed by shorting the measurement points together and performing an adjustment for zero ohms indication prior to each measurement. This is because as the battery voltage decreases with age, the series resistance in the meter needs to be reduced to maintain the zero indication at full deflection.

Measurement with Ampere Meter is as under.

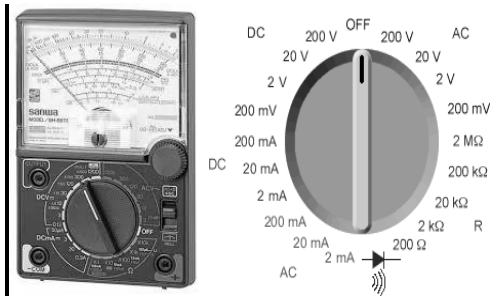


Take different readings and record them in table shown below.

Sr. #	Reading of Ohmmeter
1	
2	
3	
4	
5	

USE OF MULTIMETER:

A multi-meter or a multi tester, also known as a VOM (Volt-Ohm meter), is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter would include basic features such as the ability to measure voltage, current, and resistance. Analog multimeter use a micro ammeter whose pointer moves over a scale calibrated for all the different measurements that can be made. Digital multimeter (DMM, DVOM) display the measured value in numerals, and may also display a bar of a length proportional to the quantity being measured. Digital multimeter are now far more common than analog ones, but analog multimeter are still preferable in some cases, for example when monitoring a rapidly varying value.

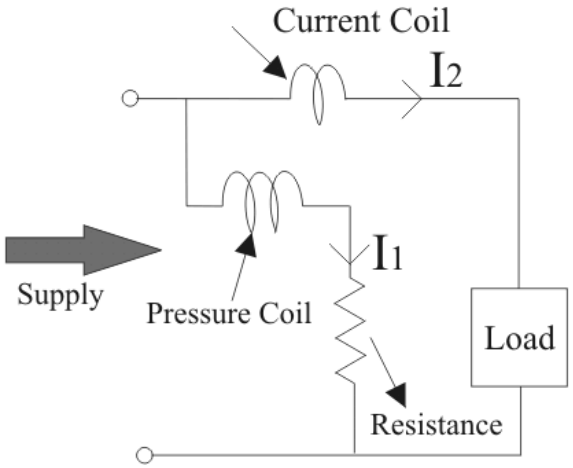


Take readings of voltage current and resistance and record them in table below.

Sr. #	Reading of Voltmeter	Reading of Ammeter	Reading of Ohmmeter
1			
2			
3			
4			
5			

USE OF WATT METER:

Wattmeter is used to measure the power of the circuit. To measure power, connect the wattmeter as shown below. Switch on power supply, take the readings by changing different loads and record them in the table. Read multiplying factor of meter and calculate actual reading by multiplying reading with multiplying factor.



Sr. #	Reading on wattmeter scale	Multiplying factor	Actual Reading
1			
2			
3			
4			
5			

USE OF TACHOMETER:

Tachometer is an instrument used to measure the speed of rotation of motor in revolution per minute (RPM). They are made contact type and non-contact type. Method of using both types is shown in figure. When using the non-contact mode, rotational speed (RPM) is measured using a visible beam of light. The tachometer is kept up to 24 inches away from the small piece of reflective tape that is affixed to the rotating element. In the contact operating mode, the speed is sensed by directly contacting rotating device using one of the contact adapters supplied with the instrument.

Take readings of different motors and record them in the table shown below.

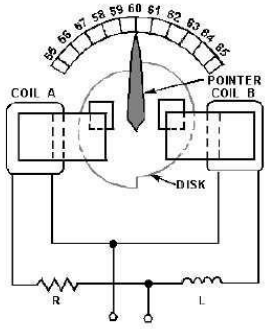
Sr. #	Reading of tachometer in RPM
1	
2	
3	
4	
5	

USE OF FREQUENCY METER:

A frequency meter is an instrument that displays the frequency of a periodic electrical signal. Frequency meters can be classified by type. Two broad classes of meter include deflection meters and resonant reed meters.

Deflection Meters

There are two basic types of deflection meters: moving-coil meters and ratio meters. Moving-coil meters are electrically resonant circuits that consist of two coils tuned to different frequencies and connected at right angles to one another. Frequencies in the middle of the range equalize the currents in the two coils and allow the needle or pointer to indicate the midpoint of the scale. Changes in frequency create an imbalance between these currents, causing the coils and the needle or pointer to move. Ratio meters use two frequency inputs: a known standard and an unknown amount.

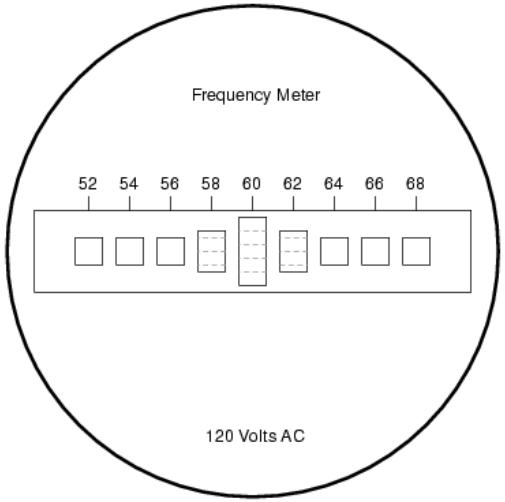


Resonant Reed Meters

Resonant reed meters typically operate at lower frequencies and so are rarely used in RF applications. Their low

frequencies, however, make them suitable for tuning motors and other devices which use applied AC power. Due to their simple, mechanical operation, resonant reed meters are less accurate than deflection types but are rugged enough to be used for field measurements.

Reed meters simply consist of a series of metal reeds tuned to different frequencies. When AC power is applied to the meter, the reed closest in frequency to the signal will vibrate more than the others, causing an audible tone at that frequency. This is shown in the image below. Because the applied 120V AC power is properly tuned to 60 Hz, the 60 Hz center reed is shown vibrating more than the others.



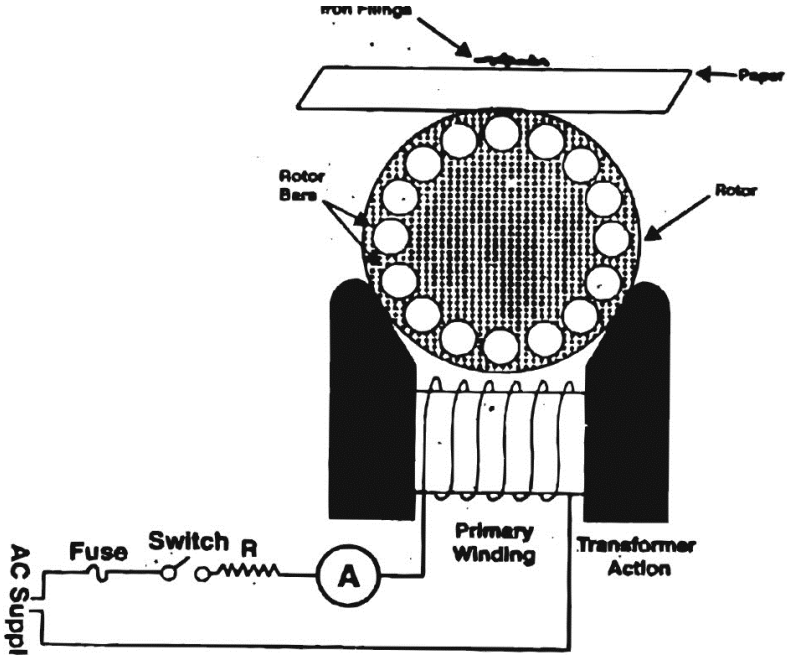
Frequency meter is connected in parallel with the supply as voltmeter. Take readings and record them in table shown below.

Sr. #	Reading of Frequency meter in Hz or C/S
1	
2	
3	

4	
5	

USE OF GROWLER:

A growler is an electrical device used for testing insulation of a motor for shorted coils. A growler consists of a coil of wire wrapped around an iron core and connected to a source of AC current. When placed on the armature or stator core of a motor the growler acts as the primary of a transformer and the armature coils act as the secondary. A "feeler", a thin strip of steel (hacksaw blade) can be used as the short detector.



MOTOR TESTING:

The alternating magnetic flux set up by the growler passes through the windings of the armature coil, generating an alternating voltage in the coil. A short in the coil creates a closed circuit that will act like the secondary coil of a transformer, with the growler acting like the primary coil. This will induce an alternating current in the shorted armature that will in turn cause an alternating magnetic field to encircle the shorted armature coil. A flat, broad, flexible piece of metal containing iron is used to detect the magnetic field generated by a shorted armature. A hacksaw blade is commonly used as a feeler. The alternating magnetic field induced by a shorted armature is strong at the surface of the armature, and when the feeler is lightly touched to the iron core of an armature winding, small currents are induced in the feeler that generate a third alternating magnetic field surrounding the feeler.

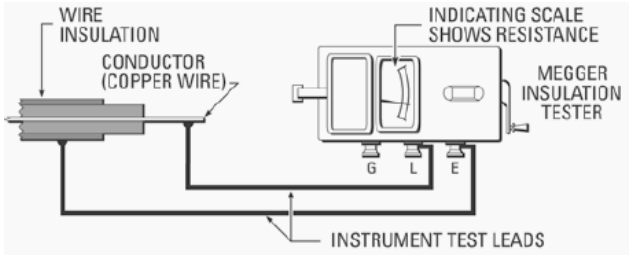
With the growler energized, the feeler is moved from slot to slot. When the feeler is moved over a slot containing the shorted coil, the alternating magnetic field will alternately attract and release the feeler, causing it to vibrate in synch with the alternating current. A strong vibration of the feeler accompanied by a growling noise indicated that the coil is shorted.

Sr. #	Reading of growler Ammeter in Ampere
1	
2	

3	
4	
5	

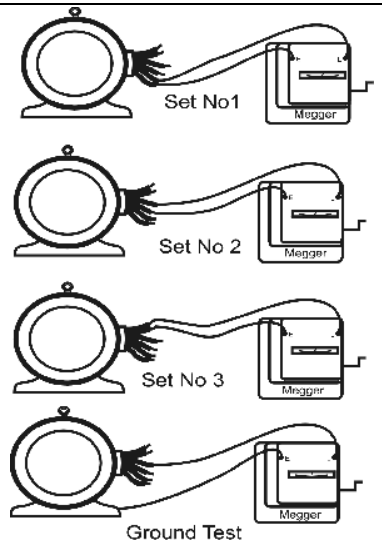
USE OF MEGGER:

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 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.



Procedure:-

1. Separate set of three windings of motor by opening the connection box of three phase induction motor.
2. Now connect the Megger lead with one end of winding set and the other lead with end of other set of winding.
3. Now rotate the handle of earth tester at 60RPM and note the reading from dial.
4. Similarly note the insulation of all three sets with respect to each other.
5. Now connect E terminal of Megger with motor body and L terminal with one wire from three sets (all sets will be checked) to find out phase to ground insulation.



Precautions:-

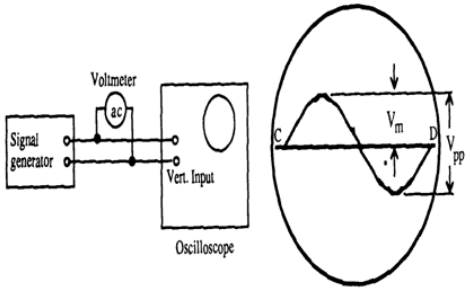
1. Prevent the Megger from shocks during use.
2. Make neat, strong and clean connections.
3. Switch off the supply before checking insulation of appliances.
4. Do not rotate the Megger handle slowly.
5. Use the Megger of double rating according to voltage of machine or installation whose test is to be performed.
6. Phase to Phase insulation resistance should be double from phase to ground insulation resistance.

Take readings of insulation resistance of different motors and record them in table shown.

Sr. #	Reading of Megger in MΩ
1	
2	
3	
4	
5	

MEASUREMENT WITH OSCILLOSCOPE:

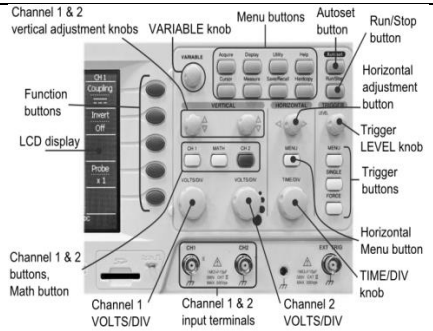
Consider the circuit in Figure. The signal generator is used to produce a 1000 hertz sine wave. The AC voltmeter and the leads to the vertical input of the oscilloscope are connected across the generator's output. By adjusting the Horizontal Sweep time/cm and trigger, a steady trace of the sine wave may be displayed on the screen. The trace represents a plot of voltage vs. time, where the vertical deflection of the trace about the line of symmetry CD is proportional to the magnitude of the voltage at any instant of time.



To determine the size of the voltage signal appearing at the output of terminals of the signal generator, an AC (Alternating Current) voltmeter is connected in parallel across these terminals. The AC voltmeter is designed to read the dc "effective value" of the voltage. This effective value is also known as the "Root Mean Square value" (RMS) value of the voltage.

The peak or maximum voltage seen on the screen is V_m volts and is represented by the distance from the symmetry line CD to the maximum deflection. The relationship between the magnitude of the peak voltage displayed on the scope and the effective or RMS voltage (V_{RMS}) read on the AC voltmeter is

$V_{RMS} = 0.707\ V_m$ (for a sine or cosine wave).

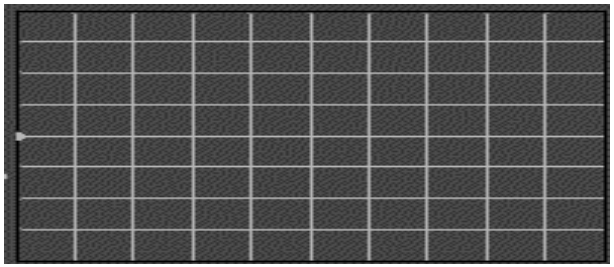


SINE WAVE:

You can show a sine signal on the oscilloscope screen with the following characteristics

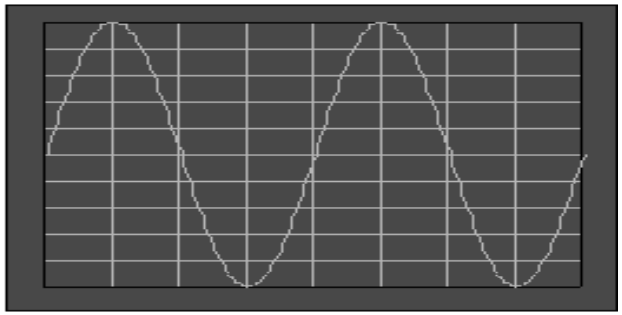
- 1 volt (2v peak-to-peak) signal. In other words, it has a positive peak of +1 volt and a negative peak at -1 volt.
- A frequency of 1000 Hz (i.e. 1 KHz).
- A sinusoidal signal. In other words, it looks like a familiar sine wave.

The oscilloscope has an illuminated dot that moves across the screen. With no signal, it would look like the following.



If you have a sinusoidal signal that repeats every half millisecond - a frequency of 2 kHz - you would get a picture like

this one. It would appear to be stationary on the oscilloscope screen, but it really isn't. It's just that it repeats so frequently that you see it as a constant image.

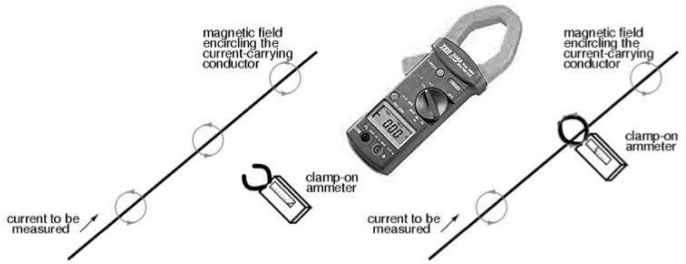


To draw sine wave on graph paper

1. Fix the Graph paper of 6 x 12 inch on Drawing board with the help of Tape.
2. Now draw a circle with compass as shown in figure below.
3. Divide this circle in equal 8 or 12 portions like figure. And like this divide your graph for sine wave in 8 or 12 equal portions as shown in figure.
4. If you will divide in 8 portions, then each angle will be $45^{0,}$ but in case of 12 portions, each angle will be 30^{0}. (we know circle's angles are 360^{0}. so in case of 8 portions angle will be = 360/8 = 45^{0} and in case of 12, 360 / 12 = 30^{0})
5. Mark dots on divided angles.
6. Draw straight dotted lines from divided portions of circle to X-Y portions of graph.
7. Now draw the sine wave following dots.

USE OF TONGUE TESTER:

This instrument is used to measure current of a circuit / motor without breaking its circuit. The wire / cable are inserted by opening the jaws with knob. Tongue tester can also measure voltage and ohm, so basically it is also a type of multimeter. These are available in analog and digital form. Analog meters have all three scales, and position of pointer indicates the value of relative quantity. Use of meter (Use as Ammeter, Voltmeter or Ohm meter) is determined with the position of selector switch.

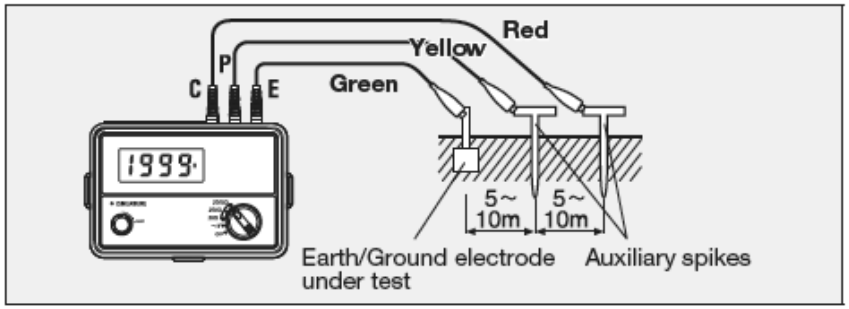


Sr. #	Reading of Tong Tester in Ampere
1	
2	
3	
4	
5	

USE OF EARTH TESTER:

Connect the earth / ground electrode (E) and auxiliary spikes (P, C) to the main body using the accessory test lead. Put apart 5 to 10 m between E and P, and P and C, respectively. E, P, and C should be approximately in a line. Select the multiplying factor with selector switch and switch ON the supply, take reading and note in table below. Repeat the test

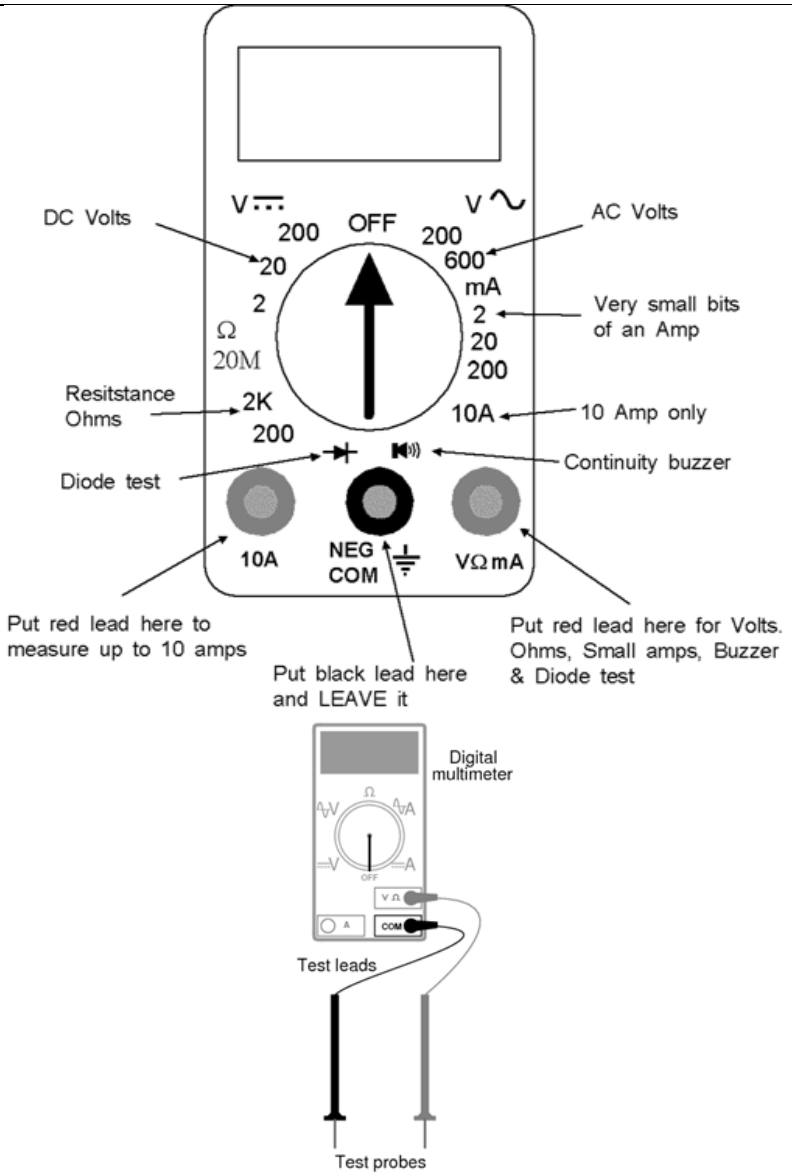
by changing the positions of spikes.



Sr. #	Reading of Earth Tester in Ω
1	
2	
3	
4	
5	

USE OF DIGITAL MULTI METER:

Digital multimeter displays the measured value in numerals. Digital Multimeter is now far more common in use than analog ones.



Take readings of voltage current and resistance and record them in table below.

Sr. #	Reading of Voltmeter	Reading of Ammeter	Reading of Ohmmeter
1			
2			
3			
4			
5			

- **State method of recording test results**

TESTING OF WINDING

Begin to check the bearings of the motor. Many electric motor failures are caused by bearing failures. The bearings allow the shaft or rotor assembly to turn freely and smoothly in the frame. Bearings are located at both ends of the motor which are sometimes called "bell housings" or "end bells".

There are several types of bearings used. Two popular types are brass sleeve bearings and steel ball bearings. Many have fittings for lubrication while others are permanently lubricated or "maintenance free".

Perform a check of the bearings. To perform a cursory check of the bearings, place the motor on a solid surface and place one hand on the top of the motor, spin the shaft/rotor with the other hand. Closely watch, feel, and listen for any indication of rubbing, scraping, or unevenness of the spinning rotor. The rotor should spin quietly, freely and evenly.

Next, push and pull the shaft in and out of the frame. A small amount of movement in and out (most household fractional horsepower types should be less than 1/8" or so) is permitted, but the closer to "none" the better. A motor that has bearing-related issues when run will be loud, overheat the bearings, and potentially fail catastrophically.

SHORT CIRCUIT TEST:

Check the windings for short circuiting to the frame. Most household appliance motors with a shorted winding will not run and will probably open the fuse or trip the circuit breaker instantly (600 volt systems are "ungrounded," so a 600 volt motor with a shorted winding may run and not trip a fuse or circuit breaker).

Use an ohmmeter to check resistance value. With an ohmmeter set to the Resistance or Ohms test setting, place test probes into the appropriate jacks, usually the "Common" and "Ohms" jacks. (Check the meter's operation manual if necessary) Choose the highest scale (R X 1000 or similar) and zero the meter by touching both probes against each other. Adjust the needle to 0 if possible. Locate a ground screw (often a green, hex head type) or any metal part of the frame (scrape away paint if needed to make good contact with metal) and press a test probe to this spot and the other test probe to each of the motor leads, one at a time. Ideally, the meter should barely move off the highest resistance indication. Make sure your hands are not touching the metal probe tips, as doing so will cause the reading to be inaccurate.

It may move a fair amount, but the meter should always indicate a resistance value in the millions of ohms (or "mega ohms"). Occasionally, values as low as several hundred thousand ohms (500,000 or so), may be acceptable, but a higher number is more desirable.

Many digital meters do not offer the ability to zero, so skip the "zeroing" information above if yours is a digital meter.

OPEN CIRCUIT TEST:

Check that the windings are not *open* or *blown*. Many simple "across the line" single-phase and 3 phase motors (used in household appliances and industry respectively) can be checked simply by changing the range of the ohm meter to the lowest offered (R X 1), zeroing the meter again, and measuring the resistance between the leads of the motor. In this case, consult the wiring diagram of the motor to be sure that the meter is measuring across each winding.

Expect to see a very low value of resistance in ohms. Low, single digit resistance values are expected. Make sure your hands are not touching the metal probe tips, as doing so will cause the reading to be inaccurate. Values greater than this indicate a potential problem and values significantly greater than this indicate the winding has failed opened. A motor with high resistance will not run - or not run with speed control (as is the case when a 3-phase motor winding opens while running).

EARTH TEST:

Using Ohm meter: Disconnect all power from machine. Check all three wires singly T1, T2, T3 (all three phases) to the ground wire. Readings should be infinite. If it is zero or reads any continuity at all, then a problem exists with either the motor or cable. If it is go directly to the motor and disconnect from cable and check motor and the cable separately. Be sure to make sure leads on both ends are not touching anything including the other leads. Most servo motor shorts can be read with a regular quality meter. Make sure you use quality meter going up to at least 10 mega ohms.

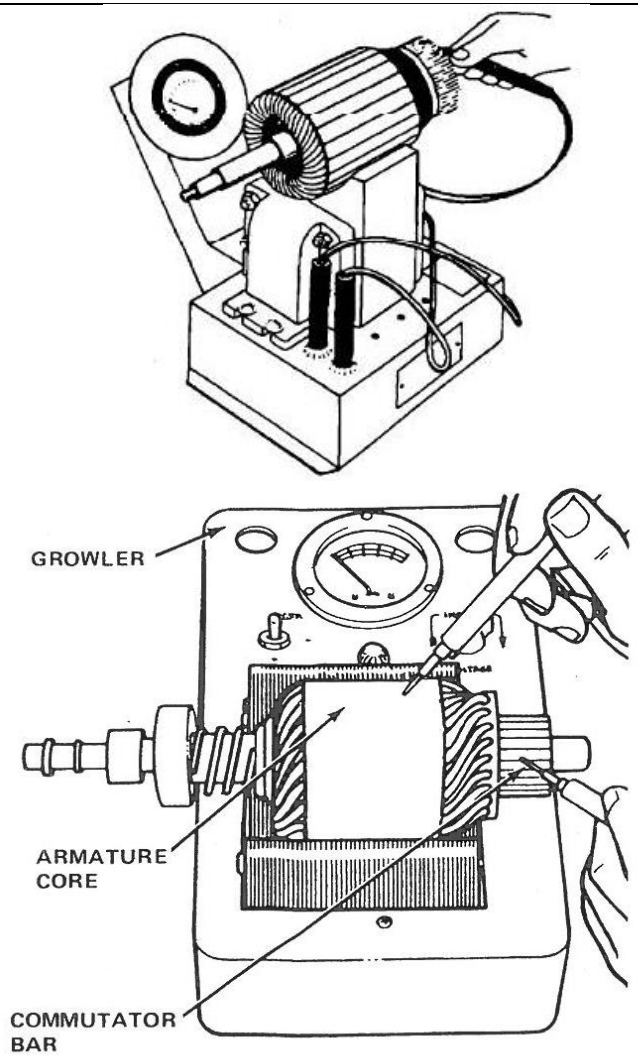
Using Mega ohm meter: Disconnect all power from machine. Check all three wires separately T1, T2, T3 (all three phases) to the ground wire. Readings are usually in a range from 600-2000 Mega ohms. Most shorts will be below 20 mega ohms. Be careful not to touch the leads or the wires to anything when taking the reading.

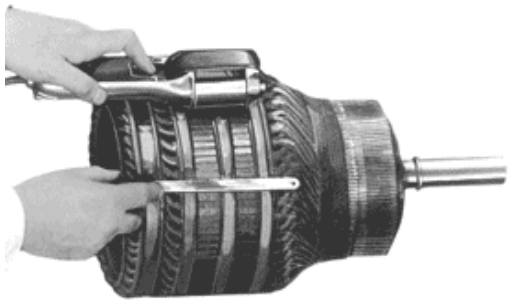
GROWLER TEST:

When an alternating current is passed through a Growler, it sets up a magnetic flux in the iron of the armature or stator spanned by the jaws of the Growler.

As this flux passes through any coil, it induces a potential. A current will flow if the coil is short-circuited. When current flows, it sets up a magnetic field around the shorted coil which can be detected with an iron feeler. (The increased load on the Growler sometimes changes the tone of the hum; hence the name "Growler".) In many cases a meter can be used to measure a change in magnetic flux, or to measure the increased current requirements of the Growler.

The most common way of using a Growler is the "feeler method" in which the Growler spans a slot containing a coil, and a "feeler" or iron, such as a hack-saw blade is held about 1/4" above the slot containing the other side of the same coil.


GROWLER
ARMATURE
CORE
COMMUTATOR
BAR



If the coil is shorted the feeler will be pulled down to the slot and will stick and vibrate. The action is very positive and is recognized instantly.
The feeler can also be used on the same side of the coil that is spanned by the Growler, either a separate feeler.

Open Circuits

Open circuits can be detected by shorting adjacent commutator bars with a screw driver, or any other piece of metal. Good coils will spark as the bars are shorted. No sparks indicate the coil is open. Test field coils by shorting lead wires. Another way is to use a continuity tester such as the ones shown in our catalog. Grounds can also be detected with a continuity tester.

RECORD KEEPING OF WINDING:

Taking Data, the key objective is to accurately determine winding data for rewinding of 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.

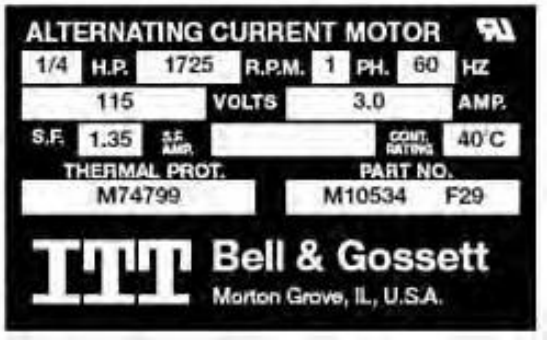
The following data you need to record for rewinding?	
Line to line voltage (V)	
Frequency (Hz)	
Star or delta connection	
Number of poles & rpm	
Number of stator slots	

Core internal diameter (mm)	
Core external diameter (mm)	
Core length in mm	
Number and width of air vents if exist	
Back-iron (mm)	
Tooth-width (mm)	
Pole pitch	
Number of coils	
Winding wire size	
Number of turns in each coil	
Number of sets of coils	
Horse power	
Current	

Check the nameplate on the motor. The nameplate is a metal or other durable tag or label that is riveted or otherwise affixed to the outside of motor housing called the '"stator" or "frame". Important information about the motor is on the label; without it, it will be difficult to determine its suitability to a task. Typical information found on most motors includes (but not limited to):

- Manufacturer's Name; the name of the company the made the motor
- Model and Serial Number; information that identifies your particular motor
- RPM; the number of revolutions the rotor makes in one minute
- Horsepower; how much work it can perform
- Wiring diagram; how to connect for different voltages, speeds and direction of rotation
- Voltage; voltage and phase requirements
- Current; amperage requirements
- Frame Style; physical dimensions and mounting pattern
- Type; describes if frame is open, drip proof, total enclosed fan cooled, etc.

- Full-load efficiency
- Power factor



DEFINITION OF WINDING*:*

Material (as wire) wound or coiled about an object (as an armature) even a single turn of the wound material is called winding. Coil winding can be defined as a process to make an electromagnetic coil with the help of a series of loops, which is used for a variety of applications in different industrial sectors. Ideally coil winders are used in components like relays, chokes, solenoids, transformers, resistors, inductors, electric motors and generators. The winding is composed of a large number of wires, called inductors, in which an electromotive force (emf.) or electrical pressure is induced when there is a relative movement of these inductors with reference to the magnetic field of the machine.

State Importance of comparison between onsite & current test results.

Comparison between results of onsite and test performed in workshop will confirm the nature of fault and you can avoid unnecessary labour and time wastage.

LU3. Check Alignment of Rotor Shaft

- **Demonstration regarding selection & use of required Tools, equipment &PPEs**
- **State Importance of checking alignment of rotor shaft & method of checking.**

The main purpose of shaft alignment is to make sure that the center line of the motor rotor shaft coincides with the center line of the driven machinery i.e., pump or a generator. Shaft misalignment is responsible for as much as 50 percent of all costs related to rotating machinery breakdowns. Accurately aligning shafts can prevent a large number of machinery breakdowns Thus, alignment is necessary because;

- Increased friction, resulting in excessive wear, excessive energy consumption, and the possibility of premature breakdown of equipment

- Excessive wear on bearings and seals, leading to premature failure
- Premature shaft and coupling failure
- Excessive seal lubricant leakage
- Failure of coupling and foundation bolts
- Increased vibration and noise

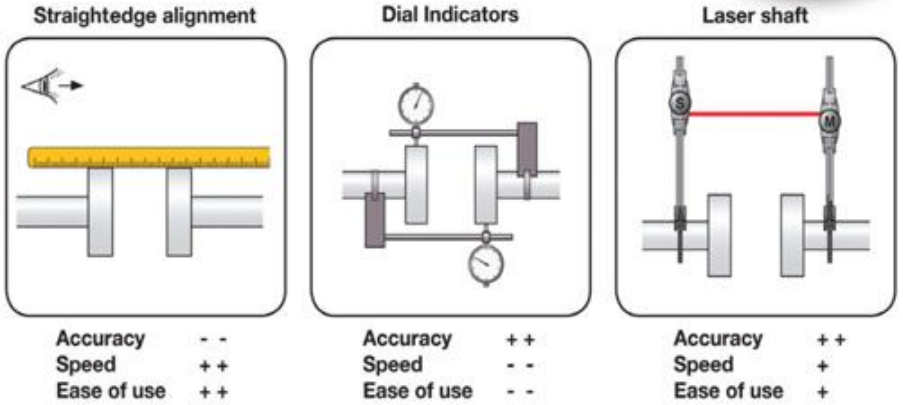
Describe different methods for checking alignment of motor couplings

Traditional alignment methods; still in common use today include visual inspection combined with a straightedge or ruler. The straightedge is positioned on two bearings supporting one or more shafts, while the maintenance inspector visually assesses whether or not the components are properly aligned. While such rough alignment methods have the advantage of being quick and relatively easy, they are also highly inaccurate and do not produce the exacting degree of accuracy required by today's precision machinery.

Dial indicators; represent another traditional method of measuring misalignment. But while dial indicators do offer a higher degree of accuracy, they also present certain problems. Not only do they require a high level of technical skill to be used properly, but the effort is also generally quite time-consuming

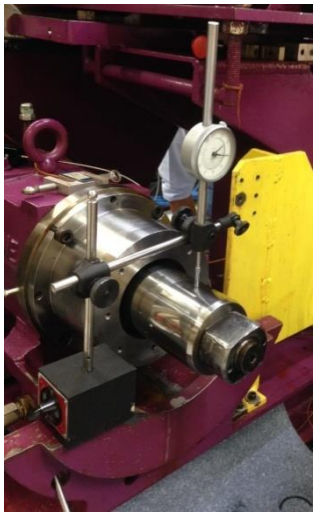
Laser-guided tools; are quick, accurate, easy-to-use, and require only a single installation. In addition, they deliver consistently better accuracy than dial indicators and they do not require special skills to obtain accurate results virtually every time. Shaft alignment laser-guided tools typically consist of two units, each capable of emitting a precise laser beam and detecting a laser beam from its mate, plus a handheld control device.

The units securely mount to shafts via magnetic brackets and/or a magnetic chain. To run them, the operator activates the instrument via the handheld control device and each unit emits a precise laser line projected onto the other unit's detector. A display on the handheld device provides real-time coupling and feet values during the alignment process, avoiding the need to remove and reinstall the measuring units after each alignment adjustment. In addition, the laser system tool documents the values, which can be downloaded to a computer and used as a benchmark for future alignment inspection



- **State Importance of checking, bearing size of rotor shaft & method of checking.**
- **Describe method of checking run out of rotor shaft.**

A dial indicator mounted on a magnetic base is being used to measure shaft runout as the shaft is being turned slowly. The runout measurement is reported in terms of the total movement of the indicator needle. Runout measurements in actual operating conditions may be impractical to measure, and are likely to be far greater than measurements taken while rotating the shaft slowly, without actual operational loads. When space is restricted, a dial test indicator can be used in place of the illustrated dial indicator.



- **State Importance of recording test results**

Test are conducted to establish an opinion about the nature of fault, the results of these tests are recorded to compare with the test results carried out on site, this practice will confirm the nature of fault to facilitate the repair work to be done accurately and quickly. Details to be recorded to relate to visual inspection, analysis testing, functional operation & measurement. These test reports to be presented oral, written & electronics to the appropriate person such as team leader, production / repair supervisor or quality control supervisor.

LU4. Check Bearing/ Bush of Machine

- Demonstration regarding selection & use of required Tools, equipment &PPEs
- Describe techniques of inspection & checking of bearing / bush regarding
  - Noise
  - Axial / Radial play / looseness
  - Stickiness
  - Lubrication
  - Breakage

Table 2 - Causes of and Countermeasures for Operating Irregularities

Irregularities		Possible Causes	Countermeasures
Noise	Loud Metallic Sound (1)	Abnormal Load	Improve the fit. internal clearance. preload, position of housing shoulder. etc.
		Incorrect mounting	Improve the machining accuracy and alignment of shaft and housing. accuracy of mounting method.
		Insufficient or improper Lubricant	Contact of rotating parts
		Replenish the lubricant or select another lubricant.	Modify the labyrinth seal. etc.
	Loud Regular Sound	Flaws.corrosion,or scratches on raceways	Replace or clean the bearing, improve the seals. and use clean lubricant.
		Brinelling	Replace the bearing and use care when handling bearings.
		Flaking on raceway	Replace the bearing.
	Irregular Sound	Excessive clearance	Improve the fit. clearance and preload.
		Penetration of foreign particles	Replace or clean the bearing, improve the seals. and use clean lubricant.
		Flaws or flaking on balls	Replace the bearing.
Abnormal Temperature Rise		Excessive amount of lubricant	Reduce amount of lubricant. select stiffer grease.
		Insufficient or improper lubricant	Replenish lubricant or select a better one.
		Abnormal load	Improve the fit. internal clearance. preload, position of housing shoulder.
		Incorrect mounting	Improve the machining accuracy and alignment of shaft and housing, accuracy of mounting, or mounting method.
		Creep on fitted surface. excessive seal friction	Correct the seals. replace the bearing. correct the fitting or mounting.
		Brinelling	Replace the bearing and use care when handling bearings.
		Flaking	Replace the bearing.
Vibration (Axial runout)		Incorrect mounting	Correct the squareness between the shaft and housing shoulder or side of spacer.
		Penetration of foreign particles	Replace or clean the bearing. improve the seals.
Leakage or Discoloration of Lubricant		Too much lubricant, Penetration by foreign matter or abrasion chips	Reduce the amount of lubricant. select a stiffer grease. Replace the bearing or lubricant. Clean the housing and adjacent parts.

- **Method of recording test results**

Record the test result of bearing and locate the fault from the above given chart of possible causes to decide the repair

work of replacement of bearing.

LU5. Update Test Results of Machine

State Importance of comparison of test results

Comparison of test results carried out at onsite test and test carried out in workshop will help you judge the nature of fault and cause of fault. This will facilitate you to perform repair work quickly and effectively.

- **State Importance of updating test results**

Keeping accurate and up-to-date test records is vital to the success of your workshop. You must realise that records kept will be one of the most important management tools it possesses and, therefore, it should be allocated due importance. Many workshop owners invest a lot of time and effort into the running of their workshop and yet fail to realise the importance of maintaining good documentation. The workshop owner is looking for the maximum return from their investment and the maintaining of good records is part of that equation.

Any test record keeping system should be accurate, reliable, easy to follow, consistent as to the basis used and be very simple. Updated test record keeping is vital in regards to meeting the commitments of repairing the machines in time and providing information on which decisions for the repair or replacement can be based.

LU6. Identify the Faulty Parts of Machine

- Describe method of detection of faulty parts of machine on the bases of test results
- State importance & method of numbering on the faulty parts of machine
- State importance & method of tagging on faulty parts of machine

Faulty parts of machines are Identified on the bases of test results (By visual / physical inspection, open circuit test, short circuit test and ground fault test), after identification parts are marked with numbers according to inventory record and also are tagged properly. Prepare a list of faulty parts, indicating name of machine, inventory #, name of part, nature of fault, brief of required repair / replacement.

Inventory # such as IM/19/8/304			**Machine Detail such as Three phase SCI motor 50HP**	
Sr. #	**Name of faulty part**	**Part #**	**Brief of required repair**	**Material required for repair**
1	Motor stator	IM/19/8/304/1/3	Rewinding	Winding wire 18 SWG, Latheroid paper # 10, Sleeve # 1,2 & 4, cotton tape ¾", Thread, Varnish, Solder, Insulation Tape
2	Ball Bearing	IM/19/8/304/2/3	Must be Replaced	Ball Bearing ZZ 6004
3	Rotor shaft	IM/19/8/304/3/3	Required alignment	-
4				

ELECTRICAL MACHINE WINDING TECHNICIAN

Module-C
LEARNER GUIDE
National Vocational Certificate Level 3

Version 1 - September, 2018

Module C: 0713001130 Estimate Repair/Replacement Cost

Objective: This Modulecovers the knowledge & skills required to Estimate Repair/Replacement Cost through Prepare for work , Estimate Cost of the required Materials , Estimate Transportation Charges , Estimate Labour Cost of the materials , Calculate accumulative cost of the materials , Liaise with client/customer on repair cost , Order parts , Arrange the required Materials/Parts ,

Duration: 50 Hours **Theory: 10 Hours** **Practice: 40 Hours**

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1. Prepare for work to estimate repair/replacement cost	**The trainee will be able to:** • Identify the required stationary, equipment, software and materials • Collect the required stationary, equipment, software and materials	• Recognition of the required stationary materials, equipment, and software • Importance of estimate preparation for repair/replacement cost. • Importance of safe working condition regarding • Adequate light • Ventilation	**Tools Consumables:** • Computer & printer • Lead Pencil • Eraser • Paper / Performa of estimation Calculator
LU2. Estimate Cost of the required Materials	**The trainee will be able to:** • Prepare list of the materials/parts required for repair/replacement • Estimate quantity of	• Describe procedure for estimation of repair / replacement of faulty parts of machine: ➢ Materials / parts	**Tools Consumable Material** • Computer &printer • Lead Pencil

	materials/faulty parts of machine • Estimate cost of the required material/parts	➢ Quantity of materials / parts ➢ Cost of the required materials / parts	• Eraser • Paper / Performa of estimation • Calculator
LU3. Estimate Transportation Charges	**The trainee will be able to:** • Estimate transportation charges of pick and drop of machine • Estimate transportation charges on collection/purchase of material/parts of machine	• Describe procedure for estimation of transportation charges for: ➢ Pick & drop of the machine ➢ Collection / purchase of materials / parts	**Tools** **Consumable Material** • Computer & printer • Lead Pencil • Eraser • Paper / Performa of estimation • Calculator
LU4. Estimate Labour Cost of the materials	**The trainee will be able to:** • Estimate man hours for pick and drop of machine • Estimate man hours for arrangement of material/parts • Estimate man hours required for repair work	• Describe procedure for estimation of man / work hour (labour cost) for repair of machine: ➢ Pick & drop of the machine ➢ Collection / purchase of materials / parts ➢ Repair work	**Tools** **Consumable Material** • Computer & printer • Lead Pencil • Eraser • Paper / Performa of estimation • Calculator
LU5. Calculate accumulative cost of the materials	**The trainee will be able to:** • Calculate the estimated costs: ➢ Material Cost ➢ Transportation Cost ➢ Labour Cost ➢ Overhead Charges	• Describe procedure for estimation of accumulative cost for repair of machine: ➢ Material cost ➢ Transportation cost ➢ Labour cost ➢ Overhead charges	**Tools** **Consumable Material** • Computer & printer • Lead Pencil • Eraser • Paper / Performa

	➢ Set the profit margin • Calculate the accumulative cost	➢ Profit margin	of estimation • Calculator
LU6. Liaise with client /customer on repair cost	**The trainee will be able to:** • Inform the client/customer about total cost • Negotiate with the client/customer about total cost • Finalize the total cost • Make agreement with the client/customer	• Describe importance of Liaising with the client / customer • Describe procedure for making written agreement with the client /customer	**Tools** **Consumable Material** • Computer & printer • Lead Pencil • Eraser • Paper / Performa of estimation • Calculator
LU7. Arrange the required Materials / Parts	**The trainee will be able to:** • Collect list of the estimated material/parts for repair • Check availability of the required parts/material in the store • Place purchase order for the deficient parts/materials • Collect the required parts/materials from the store	• Describe method of issuing purchase order • Fill in documents of purchase order	**Consumable Material** • Lead Pencil • Eraser • Paper / Performa of estimation • Calculator

LU1. Prepare for work to estimate repair/replacement cost

- Recognition of the required stationary materials, equipment, and software like, Computer & printer, Lead Pencil , Eraser, Paper / Performa of estimation, Calculator
- Importance of estimate preparation for repair replacement cost.
- Importance of safe working condition regarding
- Clear passage
- Cleanliness
- Adequate light
- Ventilation

LU2. Estimate Cost of the required Materials

- Describe procedure for estimation of repair / replacement of faulty parts of machine:
  - Materials / parts
  - Quantity of materials / parts
  - Cost of the required materials / parts

Method for estimating a quantity and cost of repair / replacement of faulty parts needed for a machine, the method comprising:

(a) Receiving life data for a number of parts of a machine for replacement and duration for the life cycle of the machine;
(b) Calculating quantity of material required for repair
(c) Calculating quantity of replacement parts
(d) Receiving a unit price for each of the corresponding material / parts
(e) Calculating estimated cost for repair / replacement parts
(f) Preparing an estimated budget report of the quantity and cost of the corresponding parts based on the estimated cost

Sr. #	Specifications of required material	Required Quantity	Measuring Unit	Rate / Unit	Cost
1	Enameled copper winding wire 16 SWG	5	Kg	1500/-	7500/-
2	Latheroid paper # 10	8	Ft.	250/-	2000/-
3	Cotton Tape	4	Roll	50/-	200/-

4	Thread	1	Roll	100/-	100/-
5	Varnish	2	Quarter	300/-	600/-
6	Ball bearing ZZ6002	2	Nos.	850/-	1700/-
Grand Total					**12100/-**

LU3.Estimate Transportation Charges

- Describe procedure for estimation of transportation charges for:
- ➢ Pick & drop of the machine
- ➢ Collection / purchase of materials / parts

Transportation is simply moving machines and materials from one place to another. This includes movement of faulty machines / materials from workplace to workshop and movement of repaired machine to the workplace / customer. Transportation also includes the movement of purchased material / parts to assembly area / workshop. This includes overseeing transportation, as well as storage of materials, packaging of machine for storage and for safe transportation.

Sr. #	Detail of Transportation charges	Amount
1	Movement of faulty machines / materials from workplace to workshop	2500/-
2	Movement of repaired machine to the workplace / customer	2500/-
3	Movement of purchased material / parts to assembly area / workshop	550/-
4	Storage of materials, packaging of machine for storage and for safe transportation	450/-
Grand Total		**6000/-**

LU4. Estimate Labour Cost of the materials

- Describe procedure for estimation of man / work hour (labour cost) for repair of machine:
- ➢ Pick & drop of the machine
- ➢ Collection / purchase of materials / parts
- ➢ Repair work

Estimation of labour cost of material includes;

1- Estimation of labour work hours utilized for loading of faulty machine from workplace
2- Estimation of labour work hours utilized for unloading of faulty machine at workshop
3- Estimation of labour work hours utilized for loading of repaired machine from workshop
4- Estimation of labour work hours utilized for unloading of repaired machine at workplace

5- Estimation of labour work hours utilized for purchasing of material / parts from market

6- Estimation of

7- Calculate all labour work hours

8- Calculate labour cost based on above data

Sr. #	Detail of labour hours	Hours	Rate / hour	Amount
1	Labour work hours utilized for loading of faulty machine from workplace	6	250/-	1500/-
2	Labour work hours utilized for unloading of faulty machine at workshop	4	250/-	1000/-
3	Labour work hours utilized for purchasing of material / parts from market	2	300/-	600/-
4	Labour work hours utilized for repair of faulty machine at workshop	40	200/-	8000/-
5	Labour work hours utilized for loading of repaired machine from workshop	6	250/-	1500/-
6	Labour work hours utilized for unloading of repaired machine at workplace	4	250/-	1000/-
Grand Total				**13600/-**

LU5. Calculate accumulative cost of the materials

- Describe procedure for estimation of accumulative cost for repair of machine:
  - Material cost
  - Transportation cost
  - Labour cost
  - Overhead charges
  - Profit margin

Estimation of accumulative cost for repair of machine includes;

Sr. #	Detail of cost	Amount
1	Material cost	12100/-
2	Transportation cost	6000/-
3	Labour cost (Services)	13600/-
4	Overhead charges	1250/-
5	Profit margin	4500/-
6	Income tax at services @ 17%	2312/-
7	Sales tax at material cost @ 17.5%	2118/-

Total claim	41880/-

LU6. Liaise with client /customer on repair cost

- **Describe importance of Liaising with the client / customer**

Liaising with customers means to communicate back and forth with customers. Liaising is an essential key for displaying satisfactory customer service skills. If you delight your customers, you have probably exceeded their expectations. The more customers that are served will mean a higher profit for the company as well as bigger business. The more customers served will mean more customers in the future. Customer satisfaction means providing service to the customer's expectation. Negotiate for variations in repair cost, delivery with clients.

- **Describe procedure for making written agreement with the client /customer**

You will normally need to make a written agreement with your client. This is called a service / repair Agreement. Service Agreements should be simple and set out how and when your supports will be delivered. When making a Service Agreement, you should take a copy**.** In this written agreement you write the following information's;

- What services you agrees to provide.
- The cost of those services.
- How, when and where you would like your services to be provided.
- How long you need the services to be provided.
- When and how your service agreement will be reviewed.
- How any problems or issues that may arise will be handled?
- Your responsibilities under the service agreement.
- Make sure you have read the service agreement carefully before you sign it and keep a copy in a safe place.

LU7.Arrange the required Materials / Parts

- Describe method of issuing purchase order

A purchase order is the official confirmation of an order. It is a document sent from a purchaser to a vendor that authorizes a purchase. While some information may vary, purchase orders generally include the name of the company purchasing the goods, date, the description and quantity of the goods, price, a mailing address, payment information, invoice address, and a purchase order number. The following are the steps in the purchase order process.

- Fill in documents of purchase order

Order Form

From:

			Customer No.:
			Terms:
Ship To:			**Salesperson:**
			Ship Week Of:
Order No:	**Delivery Via :**		**Routing :**

Item	**Quantity Ordered**	**Description**	**Unit Count**	**Unit Price**	**Total**

	Total					
	Note / Comments:	**Date:**		**Approver's Signature:**		
		Purchaser:				
		Title:				

ELECTRICAL MACHINE WINDING TECHNICIAN

Module-D
LEARNER GUIDE
National Vocational Certificate Level 3

Version 1 - September, 2018

Module D*: 0713001132 Perform Motor Rewinding*

Objective:This Modulecovers the knowledge & skills required to Perform Motor Rewinding through Prepare for work , Shift Faulty part of Motor to work Bench , Remove the Winding Coils , Collect the required Materials for Rewinding , Prepare Core for Rewinding , Interpret Wiring Diagram , Make a Former for Coil Winding , Prepare Coil Winding Machine for Rewinding , Set the Coils in the Core slots , Interlink Coils as per number of Poles , Perform Winding Tests , Perform Binding of Coils , Conduct Baking of Winding , Verify Winding Tests ,

Duration: 110 Hours **Theory: 22 Hours** **Practice: 88Hours**

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1. Prepare for work to perform motor rewinding	**The trainee will be able to:** • Identify the required PPE's • Collect the required PPE's • Identify the required tools and equipment • Collect the required tools and equipment • Ensure functional condition of PPE's/Tools and equipment • Ensure safe working conditions ➢ Clear Passage ➢ Cleanliness ➢ Adequate light ➢ Ventilation	• Recognition of required Tools, Equipment and PPEs for performing motor rewindin**g** • Importance of functional conditions of required Tools, Equipment and PPEs and their use • Importance of safe working condition regarding • Clear passage • Cleanliness • Adequate light • Ventilation • Define insulator and types of insulating material used in motor for insulations	**Tools** • Spanner Set Screw Driver Set • Allen key Set • Clamp Meter • Safety Belt • Ladder **Consumables Items** • Hand Gloves • Safety Shoes • Safety Goggles

LU2. Shift Faulty part of Motor to work Bench	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Locate faulty parts of motor • Perform shifting of faulty parts of motor to work bench	• Demonstration regarding selection & use of required Tools, equipment & PPEs • State method of safe shifting of faulty parts of motor to work bench	**Tools** • Use Appropriate means of shifting **Consumable Material** • Hand gloves • Cotton waste
LU3. Remove the Winding Coils	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Perform marking at motor body for correct re-fitting at both ends • Dis-assemble motor • Store rotor and stator after appropriate tagging • Cut fastening threads • Record the connection details of stator coils • Locate faulty winding coils • Cut faulty winding coils from both ends of stator core • Remove faulty coils from stator core • Count / measure and	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe methods and advantages of exact marking at motor body • Explain dis assembling procedure of motor • State importance of tagging • Describe the procedure to remove the faulty coils/windings: ➢ Cutting of coil fastening threads ➢ Recording of connection details of stator coils ➢ Locating of faulty winding coils	**Tools** • Spanner set • Screw driver set • Combination plier • Wire cutter • Scissor • Sheet cutter • Standard wire gauge • Micro meter • Weight scale • Wooden Hammer • Hacksaw • Heat Gun • Iron Tray **Consumable Material** • Hand gloves • Cotton waste • Pencil • Paper

	record: ➢ Number of turns of each coil ➢ Pole pitch ➢ Coil span ➢ Weight of each coil ➢ Size of winding wire of each coil	➢ Cutting of faulty winding coils from both ends of stator core ➢ Removing faulty coils from stator core • Counting / measuring and recording ➢ Number of turns of each coil ➢ Number of poles ➢ Pole pitch ➢ Coil span ➢ Weight of each coil ➢ Measurement of size of winding wire of each coil	
LU4. Collect the required Materials for Rewinding	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Estimate total weight of wire required for rewinding • Verify size of winding wire • Estimate length of required latheroid paper • Prepare list of material required for rewinding	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe importance of estimation of winding wire and other required related winding materials • State importance of verification of winding wire size • State method of arranging	**Tools** • Standard wire gauge • Micro meter • Weight scale • Iron Tray **Consumable Material** • Hand gloves • Cotton waste • Pencil • Paper

	• Collect the required material for rewinding • Update record	required winding materials	• Motor stator having burnt winding
LU5. Prepare Core for Rewinding	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Clean laminations of the core • Set laminations of the core • Perform marking on latheroid paper according to size of core slots • Perform cutting of latheroid paper according to marking • Insert latheroid paper into core slots	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe importance and method of cleaning laminations of stator core • State method of setting laminations of stator core • Describe method of Laying latheroid paper in stator slots: ➢ Measuring size of stator slot ➢ Marking on Latheroid paper sheet as per slot size ➢ Cutting of latheroid paper ➢ Inserting procedure of latheroid paper in stator slots	**Tools** • Steel Rule • Scissor • Motor stator core without winding **Consumable Material** • Hand gloves • Latheroid paper sheet (Size & measurement) as per requirement • Pencil
LU6. Interpret Winding Diagram	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe importance of	**Tools** • Different types Motor winding diagrams

	• Collect winding data • Interpret winding diagram	winding diagram: ➢ Winding symbols ➢ Types of winding ➢ Types of connections	**Consumable Material**
LU7. Make a Former for Coil Winding	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Collect winding data • Collect the former of appropriate size • Make / adjust former according to coil span • Verify adjustment of former according to coil span • Fix and adjust former according to coil span	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe importance of : ➢ Winding data ➢ Coil span ➢ Former size ➢ Types of formers ➢ Methods of preparation of former ➢ Methods of adjustment of formers	**Tools** • Different types adjustable formers • Wooden saw • Rasp cut file • Wooden chisel **Consumable Material** • Wooden piece • Pencil • Sand paper
LU8. Prepare Coil Winding Machine for Rewinding	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Collect the already adjusted former • Collect relevant size winding wire • Prepare required number of coil sets	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe procedure of preparation of coil: ➢ With manual winding machine ➢ With motor operated winding machine • State importance of	**Tools** • Relevant former • Relevant winding data • Relevant winding machine **Consumable Material** • • Pencil • Sand paper

	• Calculate the total weight of winding coils • Update record	calculating total weight of winding coils State importance of updating record	
LU9. Set the Coils in the Core slots	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Collect core and the sets of coils to be inserted in core • Insert coils one by one in the core slots according to winding diagram • Set the coils in core slots • Verify the sequence of coil insertion • Insert latheroid paper or bamboo wedge to prevent coils from slipping out from the core slots	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe procedure of insertion / setting of coil in core slots sequentially • State importance & method of insertion of wedges.	**Tools** • Mallet/ Rubber Hammer **Consumable Material** • Relevant winding coils • Latheroid paper • Bamboo wedges
LU10. Interlink Coils as per number of Poles	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Collect Core having coils inserted in it • Insert appropriate size sleeves on one side of	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe procedure of sleeving the coils inserted in the core slots & make demonstration of the sleeve insertion process	**Tools** • Mallet/ Rubber Hammer • Soldering Iron • Soldering gun • Series Test Board • AVO metre

	coils ends • Remove varnish insulation from ends of coils • Interlink coils end as per number of poles and winding diagram • Connect supply leads according winding diagram with coils • Check that the coils have sound: • Continuity • Insulation between over lapping coils • Insulation between coils and core • Verify the connections • Solder the joints • Slide sleeves over the joints to insulate the joint • Press the winding coils to ward outer edge of core	• State method of jointing: ➢ Technique of Enamel / Varnish removing from coil ends ➢ Interlinking coils ➢ Connecting supply leads with coils ➢ Soldering the joints ➢ Insulating joint with sleeve • State Importance of verification of continuity before and after soldering the joints • State method of strengthening insulation between over lapped coils • State importance of pressing the winding coils Describe method of testing insulation resistance between coils and core	• Megger (insulation tester) **Consumable Material** • Relevant winding coils • Latheroid paper • Bamboo wedges
LU11. Perform Winding Tests	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Collect newly wound core • Perform winding test to	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe techniques to Perform the following winding tests	**Tools** • Series Test Board • AVO metre • Megger (insulation

	verify • Continuity • Insulation between overlapping coils • Insulation between coil and core • Megger Test	• Continuity • Insulation between overlapping coils • Insulation between coil and core • Describe types and use of electrical measuring instruments	tester) **Consumable Material** • Testing leads for test board and Megger
LU12. Perform Binding of Coils	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Put latheroid paper between two coils to strengthen insulation on both sides of core ends • Perform binding of coil with binding thread or cotton tape on both sides of core ends • Press the coil ends toward outer side of core • Verify that the coils have sound: • Continuity • Insulation between each other • Insulation between coil and	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe the steps of coil binding • Importance of following tests after insertion and binding of coils : • Continuity • Insulation between each other(coils) • Insulation between coil and core	

	core		
LU13. Conduct Baking of Winding	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Varnish the winding • Verify that the coils have sound: • Continuity • Insulation between each other • Insulation between coil and core • Perform baking of winding	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe purpose of Varnishing and baking of winding coil of stator • Importance of following tests after varnishing and baking of winding of the stator : • Continuity • Insulation between each other(coils) • Insulation between coil and core • Perform baking of winding	**Tools** • Baking oven • Series Test Board • AVO metre • Megger (insulation tester) **Consumable Material** • Relevant winding coils • Latheroid paper • Bamboo wedges
LU14. Verify Winding Tests	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Perform winding tests to verify that the coils have: ➢ Continuity ➢ Insulation between each other ➢ Insulation between coil and core	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe techniques to Perform the following winding tests • Continuity • Insulation between overlapping coils • Insulation between coil and core	**Tools** • Series Test Board • AVO metre • Megger (insulation tester) **Consumable Material** • Testing leads for test board and Megger

LU1. Prepare for work to perform motor rewinding

- Recognition of required Tools, Equipment and PPEs for performing motor rewindin**g**
- **Importance of functional conditions of required Tools, Equipment and PPEs and safe storage after their use**
- **Importance of safe working condition regarding**
  - **Clear passage**
  - **Cleanliness**
  - **Adequate light**
  - **Ventilation**
- **Define insulator and types of insulating material used in motor for insulations**

An electrical insulator is a material whose internal electric charges do not flow freely; very little electric current will flow through it under the influence of an electric field. This contrasts with other materials, semiconductors and conductors, which conduct electric current more easily. The property that distinguishes an insulator is its resistivity; insulators have higher resistivity than semiconductors or conductors.
A perfect insulator does not exist, because even insulators contain small numbers of mobile charges (charge carriers) which can carry current. In addition, all insulators become electrically conductive when a sufficiently large voltage is applied that the electric field tears electrons away from the atoms. This is known as the breakdown voltage of an insulator. Some materials such as glass, paper and Teflon, which have high resistivity, are very good electrical insulators.

Latheroid paper, Nomex paper and Nomex based laminates, press board are used in motors as Slot liners, Wedges and mid sticks, Phase insulation, Conductor insulation, Coil separators, OCP tape, Tubing, Pole insulation, Turn insulation and Main wall insulation.

LU2. Shift Faulty part of Motor to work Bench

- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **State method of safe shifting of faulty parts of motor to work bench**

Observe the following method

✓ Collect the sheet of list of faulty parts of motor
✓ Locate & Identify the faulty parts of motor
✓ Shift the faulty parts of motor one by one by using man force according to weight of each faulty part

LU3. Remove the Winding Coils

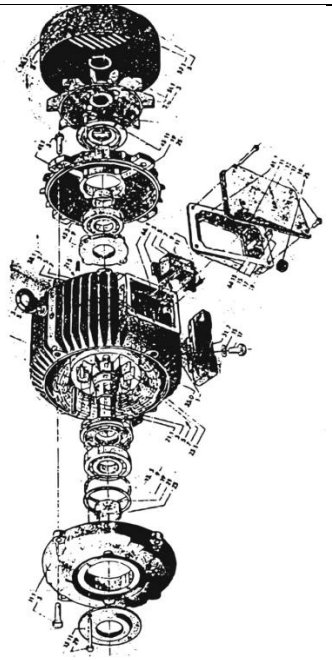
- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe methods and advantages of exact marking at motor body**
- **Explain dis assembling procedure of motor**
- **State importance of tagging**
- **Describe the procedure to remove the faulty coils/windings:**

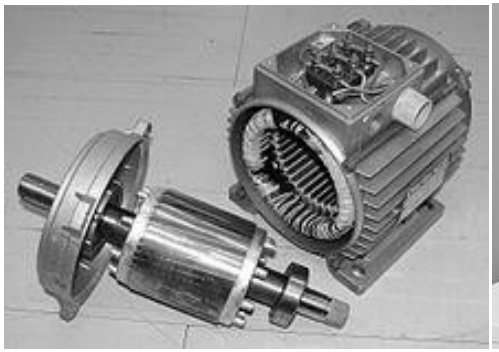
PROCEDURE: DISMANTLING:

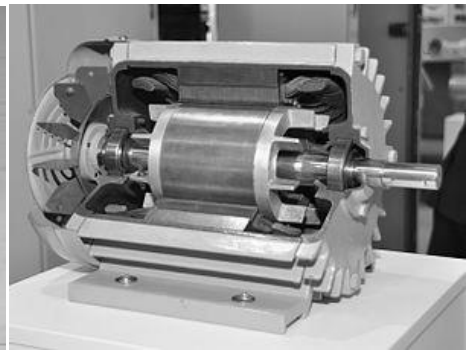
(I) Mark the position at end plates (Front & back cover) and body of motor
(II) Unscrew the back & front cover of motor.
(ii) Dismantle the rotor from the stator.
(iii) Disconnect the connection from the starting winding.
(iv) Test the winding.
(v) Test the capacitor

TESTING:

(i) Connect the series test lamp with the main and starting winding and conduct the open, short and earth fault.
(ii) Conduct the earth fault on the winding by connection one end of the test lamp to the winding terminal and the other end to the body.
(iii) Dismantle the centrifugal switch and check the spring.
(iv) Conduct the test on the capacitor.





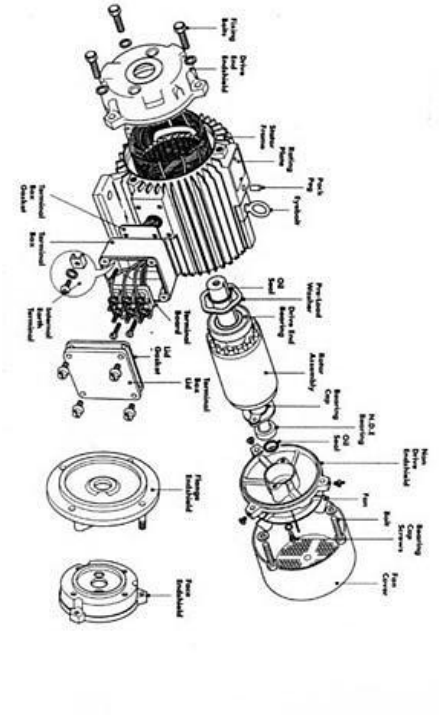


DISMANTLING OF THREE PHASE MOTORS:

To disassemble a three phase motor first;

- Remove the cooling fan shroud.
- Remove the fan from the rotor shaft.
- Remove the four long bolts that hold the end bells on to the stator.
- Center punch the fan end bell with one dot on both the bell and the stator.

- Do the same with the other end bell and stator using two center punch dots. This is for reassembly purposed.
- Separate the end bells from the stator on both ends.
- Slide the rotor out of the stator from either end.
- To reassemble work in reverse making sure to get the end bells on the right ends. This is where the punch marks come into play.
- Align the marks up and install the through bolts.
- Tighten up the bolts.
- Tap the end bells lightly with a hammer in the area of the bearings.
- This will properly seat the bearings in the end bells.
- Reinstall the fan and fan covering.



DISMANTLING OF MOTOR TRACES THE CONNECTION AND REPAIRS THE WINDING:

One of the common faults occurring with motor windings is a turn-to-turn fault. This occurs when the insulation between two turns in the same coil breaks down and reduces the coil's ability to produce a balanced magnetic field. Unbalanced magnetic fields result in vibration, which can then cause degradation of the insulation as well as bearing failures. Localized heating around the short can also spread to other coils, resulting in a coil-to-coil short. Excessive heating will eventually not only destroy the motor windings, but will also damage the insulation between the laminations of the stator core.

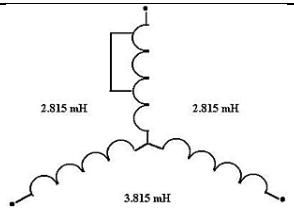
Another fault that can occur with motor windings is a phase-to-phase fault. This results from the insulation breaking down between two separate phases, usually lying adjacent to each other in the same slot. A higher difference in voltage potential tends to make this fault accelerate very quickly. Slot paper is installed between different phases in the same slot to reduce the opportunity for leakage between phases.

A turn-to-turn or a phase-to-phase short can occur many times without resulting in an immediate ground fault. Because of this, testing with just a Megger for preventive maintenance or following a motor trip may not identify the fault. This could cause a small winding fault to develop into a major catastrophic failure. Permanent core damage may necessitate replacing an entire motor.

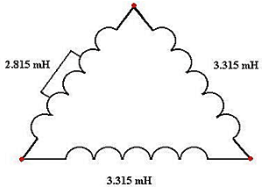
Testing of the stator can be done by connecting directly at the motor as well as connecting at the MCC. During the test, high-frequency AC signals are sent into the motor. These signals produce magnetic fields around the windings which should be matched between phases. The inductance measurement for each phase is then compared to the other phases and calculated into an inductive imbalance. This imbalance minus the influence of the rotor is used to compare the ability of each of the phases to produce a balanced magnetic field.

Also during a test, DC signals are sent into the motor. From these signals the actual resistance of the winding or windings is measured. The three resistance readings of a three-phase induction motor are compared and calculated to produce a resistive imbalance. If this imbalance exceeds a predetermined level, then high-resistance connections may exist in the solder joints between coils.

There are two basic types of stator winding configurations. The first is wye (or "Y") connected and the second is delta connected. To more fully understand what the inductance readings are telling you, a simple understanding of the winding configuration can help.



A “Y” configuration winding with a turn-to-turn short will result in two low-inductance readings and one high-inductance reading, when looking at phase-to-phase inductance.



A delta configuration winding with a turn-to-turn short will result in one low-inductance reading and two high-inductance readings, when looking at phase-to-phase inductance.

- Cutting of coil fastening threads
- Recording of connection details of stator coils
- Locating of faulty winding coils
- Cutting of faulty winding coils from both ends of stator core
- Removing faulty coils from stator core

Coil Cutoff; The critical objective of the Coil Cutoff 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.

Burnout Procedures; Following the cutting off of the coils, the next step is Burnout. Important objectives of 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.

Winding Stripping Procedures; Primary objectives are understand 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, 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.

- **Counting / measuring and recording**
  - Number of turns of each coil
  - Number of poles
  - Pole pitch
  - Coil span
  - Weight of each coil
  - Measurement of size of winding wire of each coil

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.

LU4. Collect the required Materials for Rewinding

- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe importance of estimation of winding wire and other required related winding materials**

It's impossible to underestimate the importance of estimation of winding wire & materials when it comes to successfully completing a rewinding of machine. It's important to get a handle on cost estimation to help keep you on task and in touch with rewinding constraints and limitations. As one of the defining features of successful progress, accurate rewinding project cost estimation must take a front seat when it comes to setting up a rewinding project's parameters. If you want to understand more about the effect cost estimation has on meeting client expectations and guiding a rewinding project toward success.

- **State importance of verification of winding wire size**

It's important to verify of winding wire size, before starting rewinding of machine. Use of smaller size of wire will increase the resistance of winding; hence the machine will not work effectively and shows poor efficiency. Using a larger size winding wire will decrease the resistance of winding; hence machine will draw more than its normal current, heats up and possibly burnt again.

- **State method of arranging required winding materials**

✓ Prepare list of required winding material.

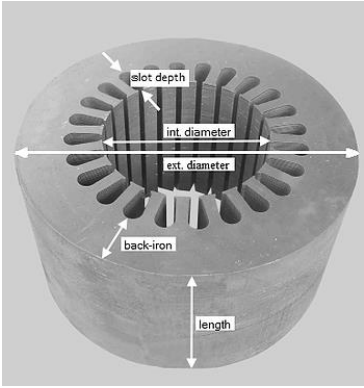
✓ Check availability of material in store and tick mark the available material from the list.

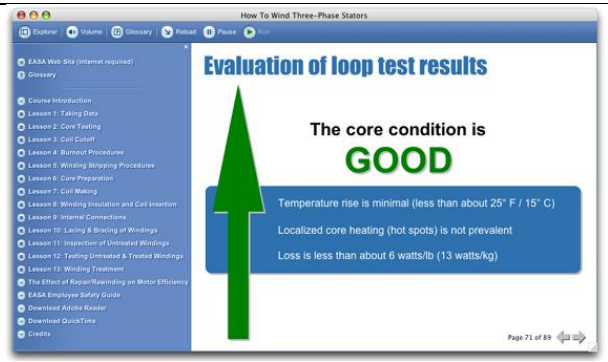
- ✓ Prepare requisition of purchase from market of remaining materials.
- ✓ Visit market and purchase

LU5. Prepare Core for Rewinding

- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe importance and method of cleaning laminations of stator core**
- **State method of setting laminations of stator core**

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.





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.

- **Describe method of Laying latheroid paper in stator slots:**
  - Measuring size of stator slot
  - Marking on Latheroid paper sheet as per slot size
  - Cutting of latheroid paper
  - Inserting procedure of latheroid paper in stator slots
  - Winding symbols
  - Types of winding
  - Types of connections

CORE INSULATING:

Stator core of motor is made with silicon steel, for better insulation coils are insulated from core by inserting with Latheroid paper in the core slots before laying coils in stator core. After inserting the coils, they are laced with the help of thread or cotton brace and the further insulation is provided with varnish. Following sizes of Latheroid papers are often used.

1- Number 7 (Thin)
2- Number 10 (Medium thick)
3- Number 15 (Thick)

SLOT INSULATION: Materials used for slot insulation are Latheroid, mica, glass cloth, and flexible type of Micanite. The type of slot insulation will vary according to the capacity of the machine.

- **Slot Liner:** The slot liner is an insulation sheet cut to the inner dimensions of the slots and projected on either side of the slots. In some applications, the edges of the slot liner are folded on either end to prevent them from sliding in the slots.
- **Coil Separator:** When multilayer windings are used, to insulate the winding layers from each other, coil separators are used. They should be extended on either side of the slot.

- **Packing Strip:** The thick insulation paper used in between the slot liner and wedge is called a packing strip. This should extend beyond each end of the armature core.
- **Wedge:** It is a solid insulation piece like bamboo or fiber used to prevent the conductors from coming out of the slots. It should be tightly held in the slots.

CUTTING OF PAPER ACCORDING TO SLOT:

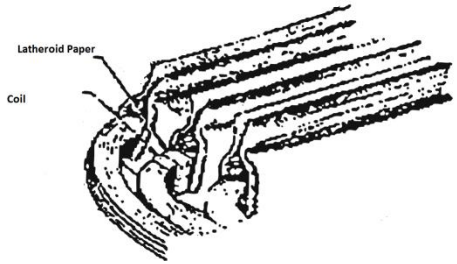
Latheroid paper is used for insulating the stator slots from coil, before cutting it, proper marking with pencil or marker is made according to size of slots (Length and height) keeping margin for bending in both length and height measurement. After marking, cutting of Latheroid paper is made with scissor. Following steps are observed.

1. Cut a strip of insulation to fit inside the periphery of the core slot, plus an allowance of $^{1}/2$ inch (12 mm) longer than the length of the slot.
2. Fold back the $^{1}/4$-inch (6 mm) protruding ends of insulation along the length of the slots to reveal the opening and to facilitate threading the winding into the slot.
3. Center and crease the insulation strip length on the insulation former according to the inside dimensions of the bottom of the core slot.

4. Insert the insulation sections into the slots with 1/8 inch (3 mm) protruding at each end.

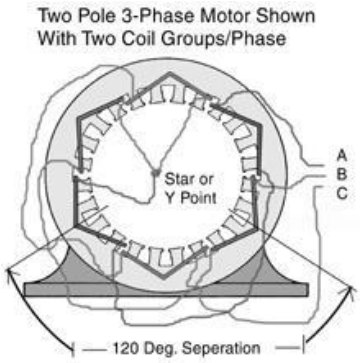
BENDING OF PAPER / LAYING OF PAPER IN SLOTS:

After cutting Latheroid paper is bended according to shape of slots, on both sides (Length wise) a collar of ¼ inch is bended to enhance the strength of the paper and then played in slots.



CONNECTION OF MOTORS ACCORDING TO POLE:

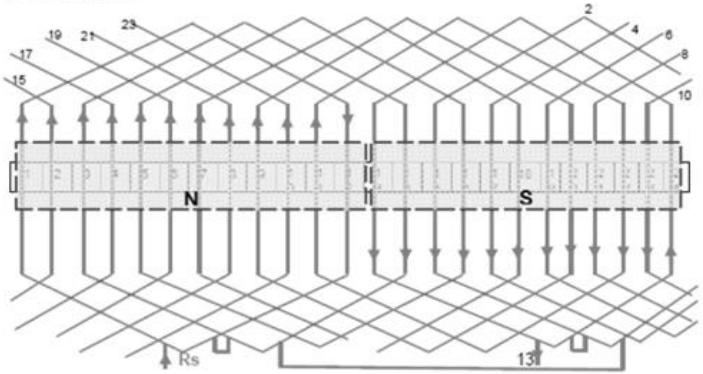
CONNECTION OF TWO POLES:



Winding Table:

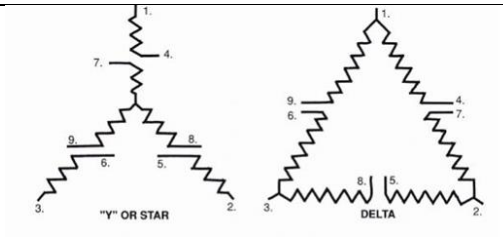
Phase	1st pole	2nd pole
R	1 + 11= 12	13 + 11 = 24
	3 + 11 = 14	15 + 11 = 26 (2)
B	5 + 11 = 16	17 + 11 = 4
	7 + 11 = 18	19 + 11 = 6
Y	9 + 11 = 20	21 + 11 = 8
	11 + 11 = 22	23 + 11 = 10

Winding Diagram:

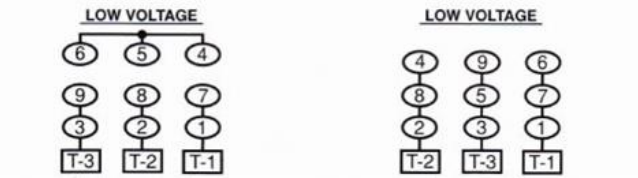


MOTOR SINGLE PARALLEL CONNECTION:

If the starting end of one coil is connected with starting end of other coil and finishing end of the same one coil is connected with the finishing end of the same other coil then these coils are connected in parallel. It means that in this type of connection similar ends of coils are joined together. The resistance of coils decreased and it draws more current. This method is used for low voltage connection. Figure below shows double star and double delta parallel configuration.



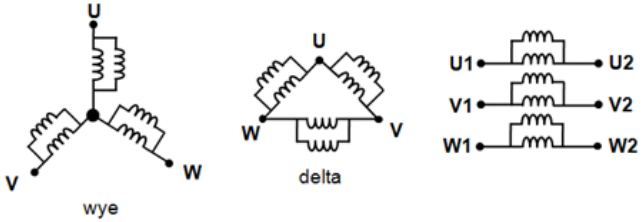
On connecting the above 12 connection in following way will give double star and double delta configuration hence winding will be connected in two parallel circuits.



MOTOR TWO PARALLEL CONNECTIONS:

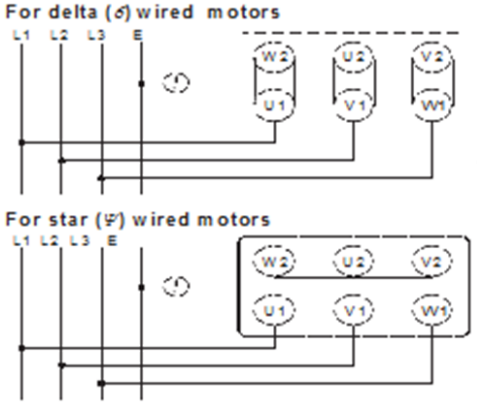
If the starting end of one coil is connected with starting end of other coil and finishing end of the same one coil is connected with the finishing end of the same other coil then these coils are connected in parallel. It means that in this type of connection similar ends of coils are joined together. The resistance of coils decreased and it draws more current.

All the coils of one phase are divided into two circuits and both are connected in parallel. This method is used for low voltage connection. Figure below shows star and delta two parallel configuration.

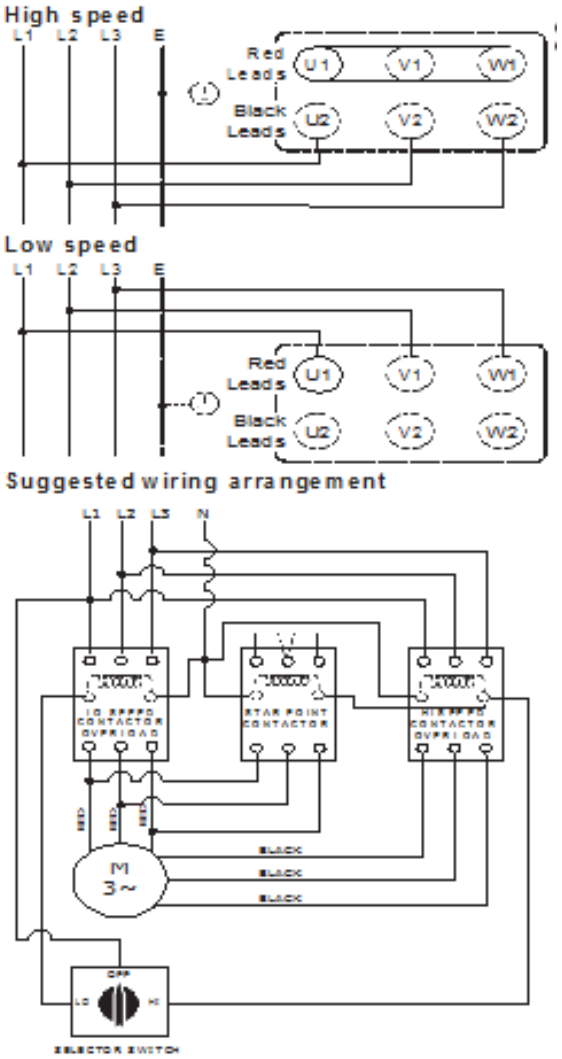


CONNECTION OF MOTOR ACCORDING TO SPEED:

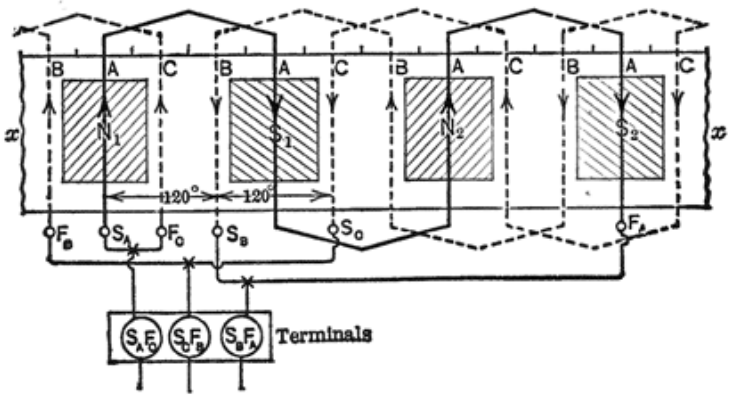
- Single speed motor connection are shown below both in case of delta or star connection, mostly single speeds motors are used.



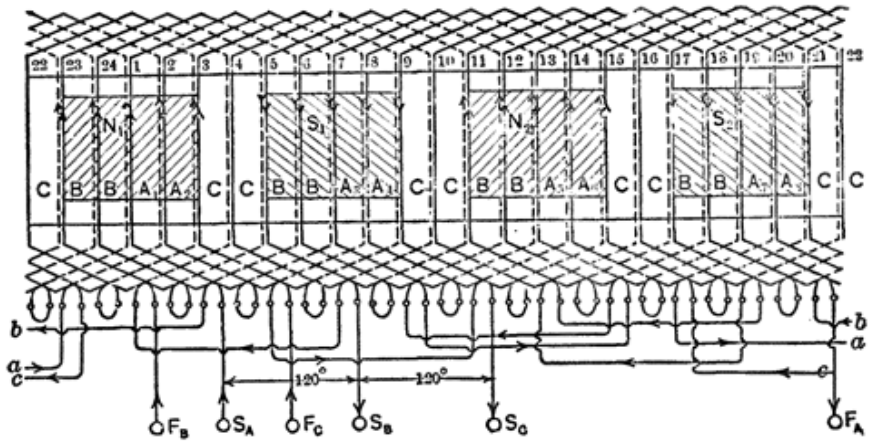
- Two speed motor connections are shown below.



CONNECTION OF 4 POLE MOTOR WITH SIX SETS:

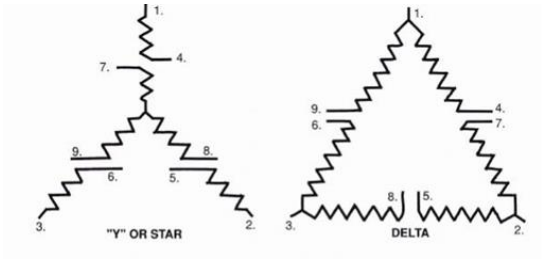


CONNECTION OF 4 POLE MOTOR WITH 12 SETS:

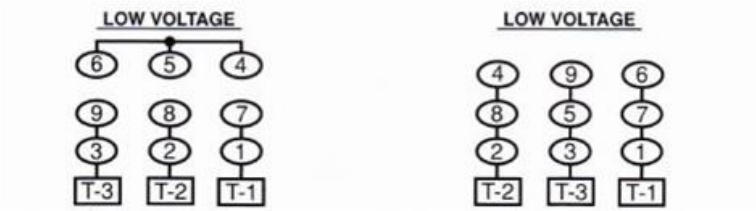


SINGLE PARALLEL CONNECTION:

If the starting end of one coil is connected with starting end of other coil and finishing end of the same one coil is connected with the finishing end of the same other coil then these coils are connected in parallel. It means that in this type of connection similar ends of coils are joined together. The resistance of coils decreased and it draws more current. This method is used for low voltage connection. Figure below shows double star and double delta parallel configuration.



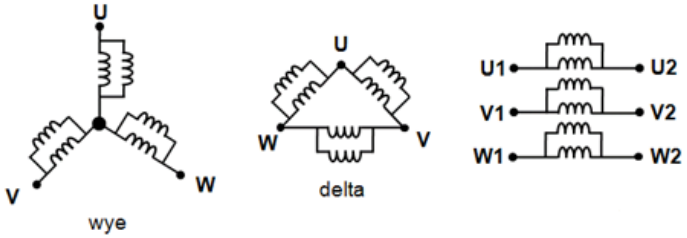
On connecting the above 12 connection in following way will give double star and double delta configuration hence winding will be connected in two parallel circuits.



TWO PARALLEL CONNECTIONS:

If the starting end of one coil is connected with starting end of other coil and finishing end of the same one coil is connected with the finishing end of the same other coil then these coils are connected in parallel. It means that in this type of connection similar ends of coils are joined together. The resistance of coils decreased and it draws more current.

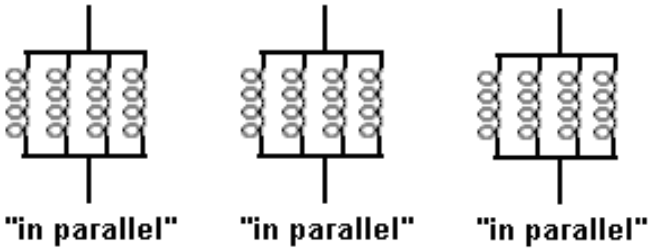
All the coils of one phase are divided into two circuits and both are connected in parallel. This method is used for low voltage connection. Figure below shows star and delta two parallel configuration.



FOUR PARALLEL CONNECTIONS:

If the starting end of one coil is connected with starting end of other coil and finishing end of the same one coil is connected with the finishing end of the same other coil then these coils are connected in parallel. It means that in this type of connection similar ends of coils are joined together. The resistance of coils decreased and it draws more current.

All the coils of one phase are divided into four circuits and all are connected in parallel. This method is used for low voltage connection. Figure below shows four parallel configurations for each phase.



CONNECTION OF 8 POLE MOTOR WITH 12 SETS

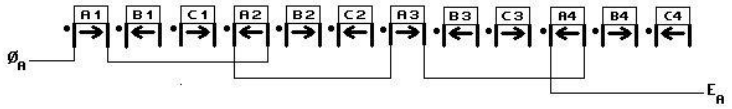


FIGURE 4A: Wiring diagram for the A phase coil group of an 8-pole, 3-phase motor/generator.

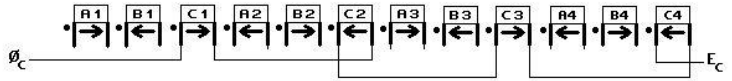


FIGURE 4B: Wiring diagram for the C phase coil group of and 8-pole, 3-phase motor/generator.

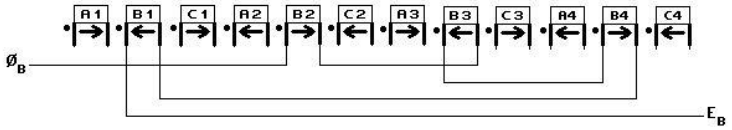
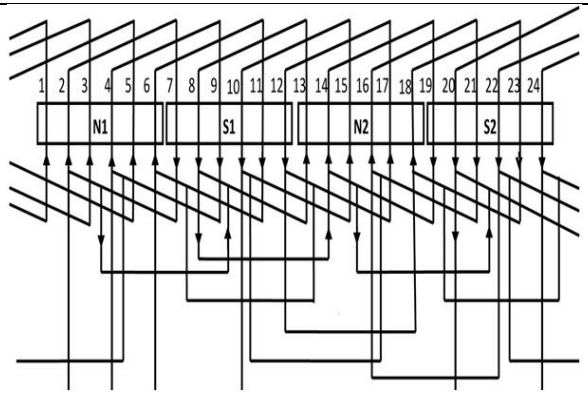


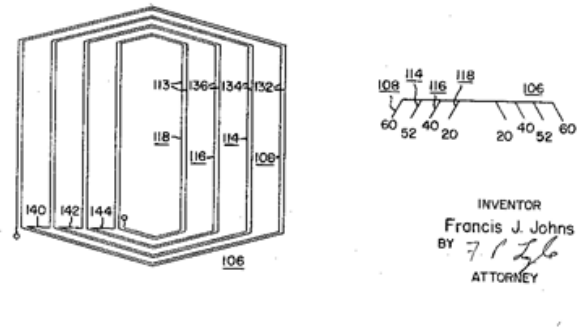
FIGURE 4C: Wiring diagram for the B phase coil group of an 8-pole, 3-phase motor/generator Note the start is on coil B2 to match the current direction with phases A and C.

CHAIN WINDING:

Chain winding is composed of a single layer coil element has the same shape and width, so named because of chain like set up each end of the coil winding. Single chain winding should pay particular attention to is that the coil pitch must be odd; otherwise the coil will not be arranged.


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
N1
S1
N2
S2

SET WINDING: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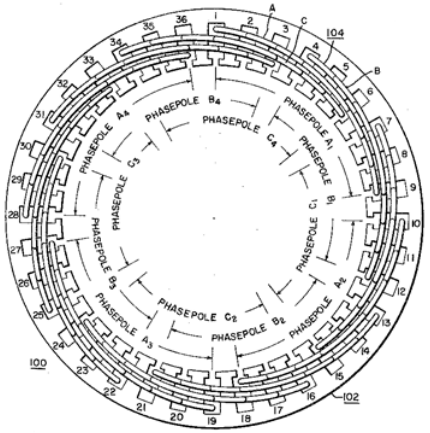
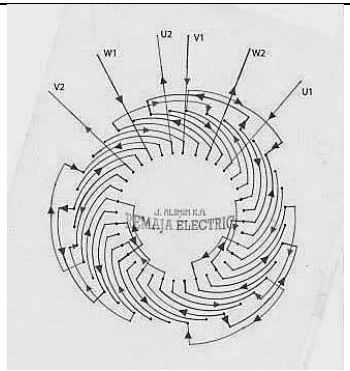
INVENTOR
Francis J. Johns
BY
ATTORNEY

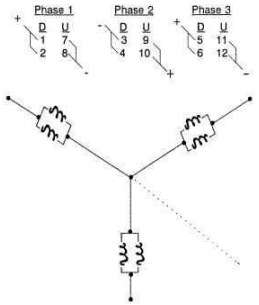


CONNECTION OF 6 POLE MOTOR

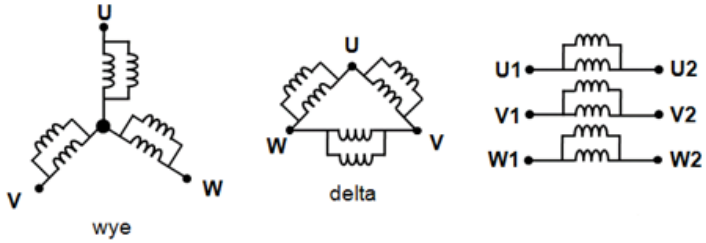
CONNECTION OF 6 POLE MOTOR WITH 18 SETS



SINGLE PARALLEL CONNECTION

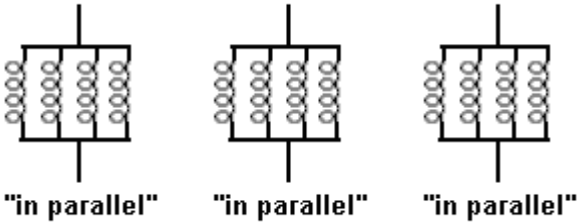


TWO PARALLEL CONNECTIONS



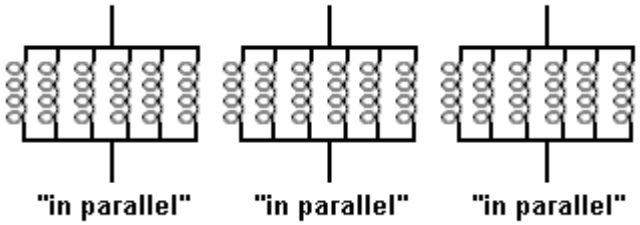
FOUR PARALLEL CONNECTIONS

If the starting end of one coil is connected with starting end of other coil and finishing end of the same one coil is connected with the finishing end of the same other coil then these coils are connected in parallel. It means that in this type of connection similar ends of coils are joined together. The resistance of coils decreased and it draws more current. All the coils of one phase are divided into four circuits and all are connected in parallel. This method is used for low voltage connection. Figure below shows four parallel configurations for each phase.

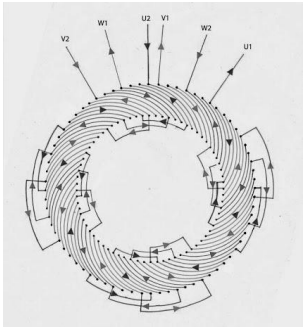


SIX PARALLEL CONNECTIONS

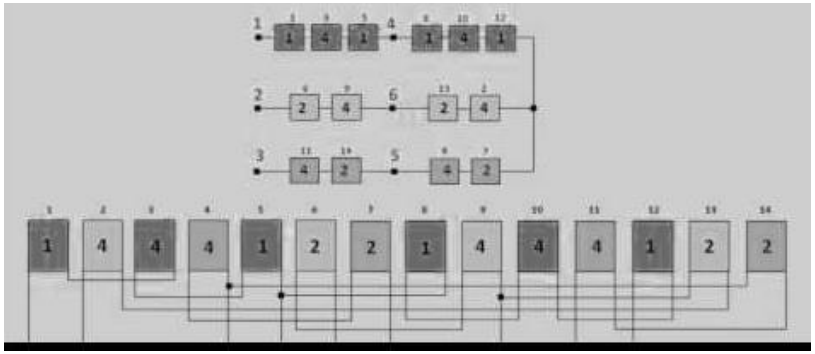
If the starting end of one coil is connected with starting end of other coil and finishing end of the same one coil is connected with the finishing end of the same other coil then these coils are connected in parallel. It means that in this type of connection similar ends of coils are joined together. The resistance of coils decreased and it draws more current. All the coils of one phase are divided into six circuits and all are connected in parallel. This method is used for low voltage connection. Figure below shows six parallel configurations for each phase.



CONNECTION OF 12 POLE MOTOR WITH 18 SETS



CONNECTION OF 6 POLE MOTOR WITH 9 SETS



CONNECTION OF 8 POLE MOTOR

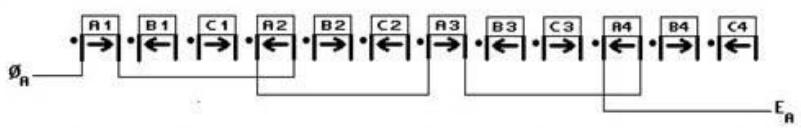


FIGURE 4A: Wiring diagram for the A phase coil group of an 8-pole, 3-phase motor/generator.

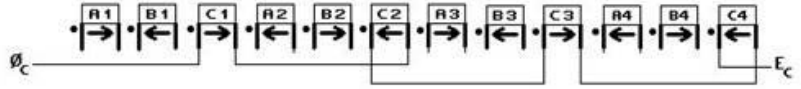


FIGURE 4B: Wiring diagram for the C phase coil group of and 8-pole, 3-phase motor/generator.

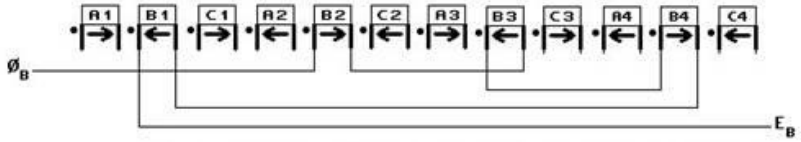
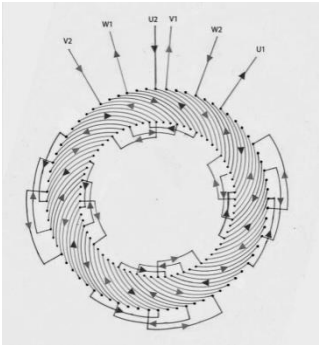
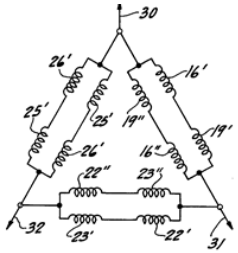


FIGURE 4C: Wiring diagram for the B phase coil group of an 8-pole, 3-phase motor/generator Note the start is on coil B2 to match the current direction with phases A and C.

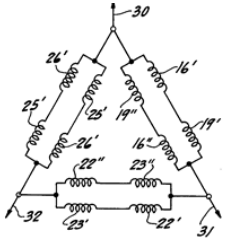
CONNECTION OF 8 POLE MOTOR WITH 24 SETS



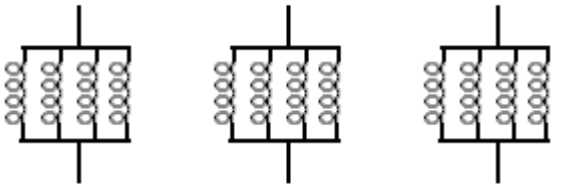
SINGLE PARALLEL CONNECTION



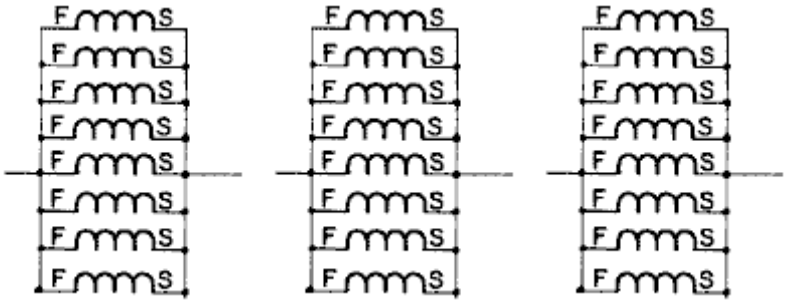
TWO PARALLEL CONNECTIONS



FOUR PARALLEL CONNECTIONS

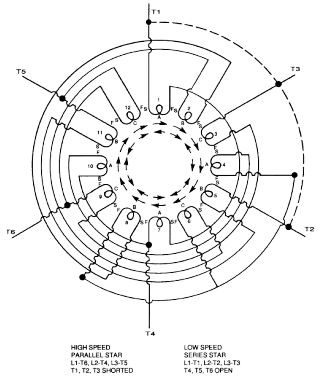


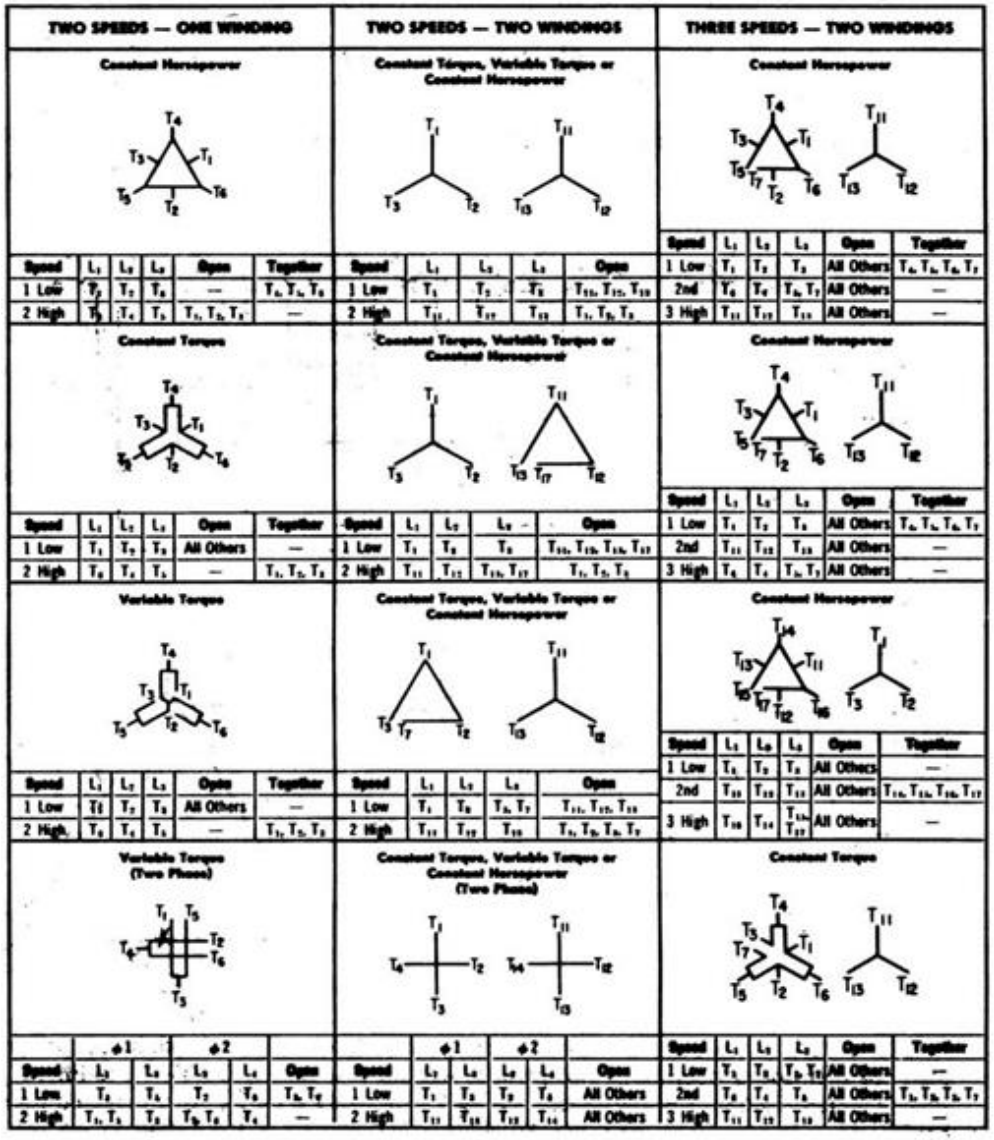
EIGHT PARALLEL CONNECTIONS



Phase 1 **Phase 2** **Phase 3**

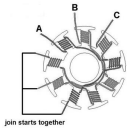
MULTI SPEED MOTOR 2 / 4 POLE
CONNECTION OF TWO SPEED MOTOR INTERNAL CONNECTION:





Connections for Multispeed Squirrel Cage Motors

STAR CONNECTION



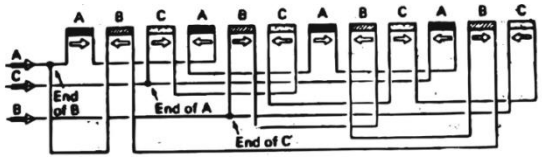
LU6. Interpret Winding Diagram

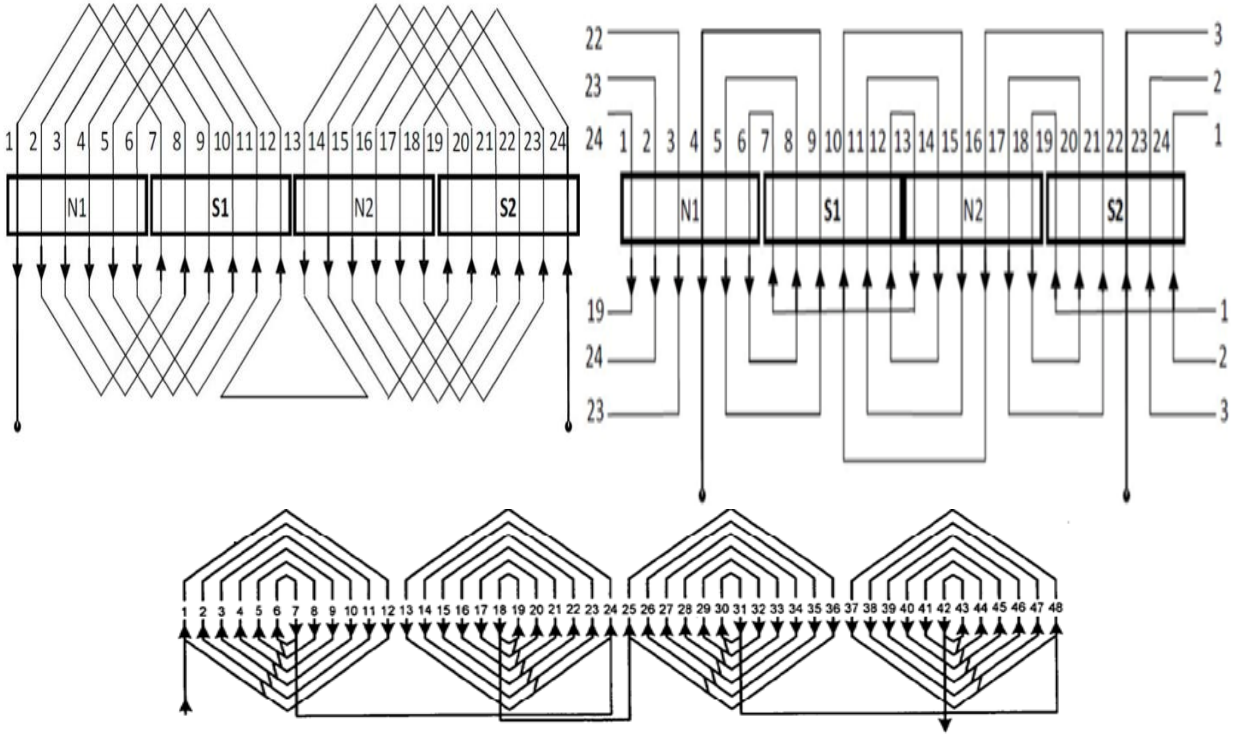
- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe importance of winding diagram:**

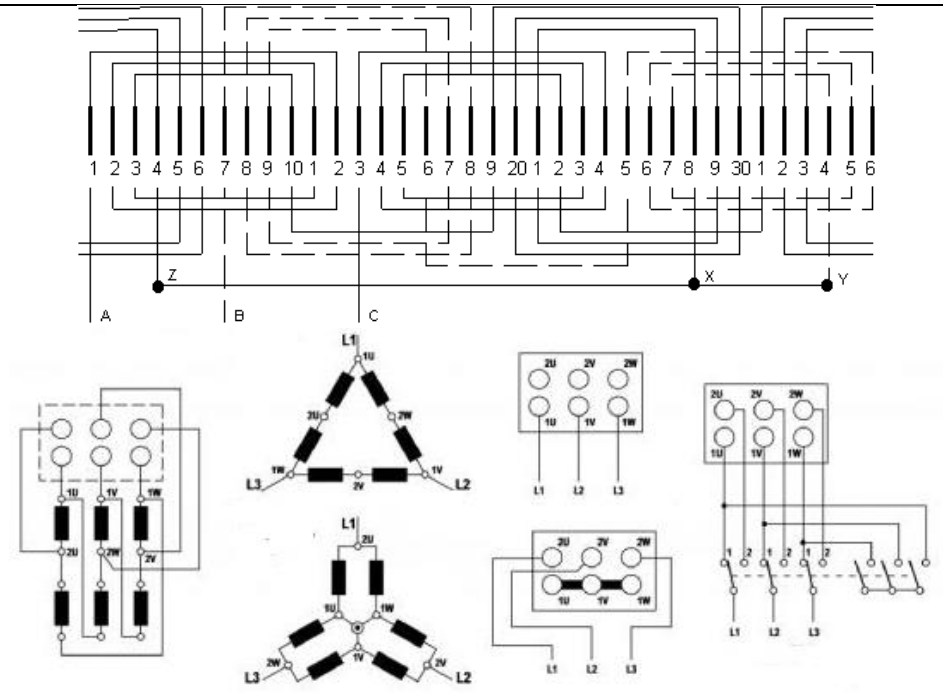
PROCEDURE FOR DRAWING WINDING DIAGRAM:

1. Calculate the number of coil sides for the main winding diagram.
2. Calculate the back pitch, Y_b, the winding pitch, Y, and the front pitch, Y_f.
3. Form a winding table using the back pitch, Y_b, and the front pitch, Y_f.
4. For drawing the main winding diagram, draw solid vertical lines of equal length at equal distance equal to number of coils. These solid lines indicate the top layer coil sides.
5. Draw dotted vertical lines of same length and distance close to the solid vertical lines (equal to number of coils). These dotted lines indicate bottom layer coil sides.
6. Assign odd numbers to the top left side of the solid lines and even number to the bottom right side of the dotted lines.
7. Complete the connection to the coil sides using the winding table, with solid lines for top layer coil sides and dotted lines for bottom layer coil sides.
8. Using the main winding diagram, draw solid vertical lines (equal to number of coils) from the top mid-point of each front end connections.
9. Represent commutator segments (equal to no. of coils) by rectangular boxes below the front end connections.
10. Divide the coils by the number of poles. This gives the allocation of coil sides to pole regions.
11. Find the current direction by applying Fleming's right hand rule, when the mode of operation is a generator and Fleming's left hand rule, when the mode of operation is a motor. Or the current direction to all coil sides can be arbitrarily assumed. Mark downward current direction for the coil sides under the North Pole regions and upward current direction under South Pole regions.
12. To fix the brush arm positions and to find the number of parallel paths offered by the armature winding, draw the commutator ring diagram or equivalent end ring diagram.
13. To draw the commutator ring diagram or equivalent end ring diagram, draw vertical solid lines equal to number of coil sides and join them with reference to winding table.
14. Also mark the current direction through the coil sides with reference to main winding diagram.

Winding drawings are drawn in following styles.







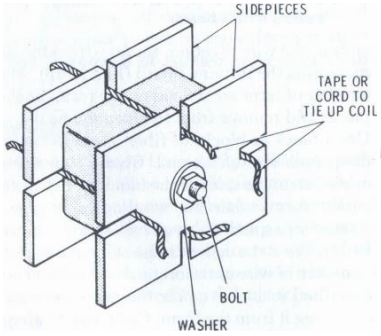
LU7. Make a Former for Coil Winding

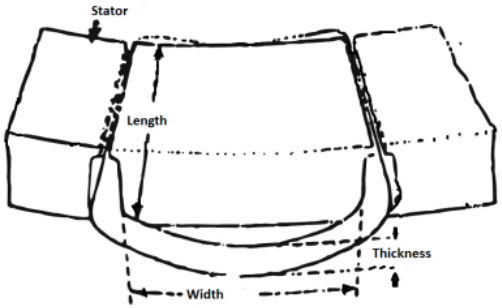
- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe importance of :**
  - **Winding data**
  - **Coil span**
  - **Former size**
  - **Types of formers**
  - **Methods of preparation of former**
  - **Methods of adjustment of formers**

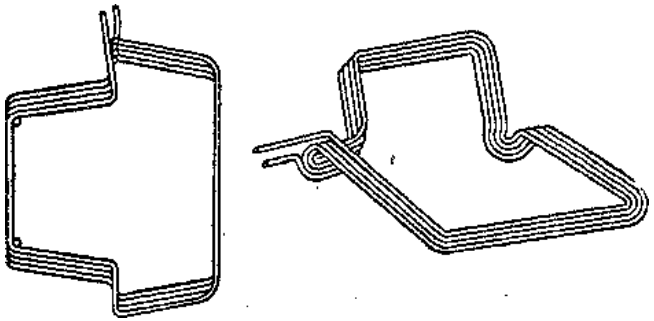
FORMA MAKING ACCORDING TO PITCH SPAN:

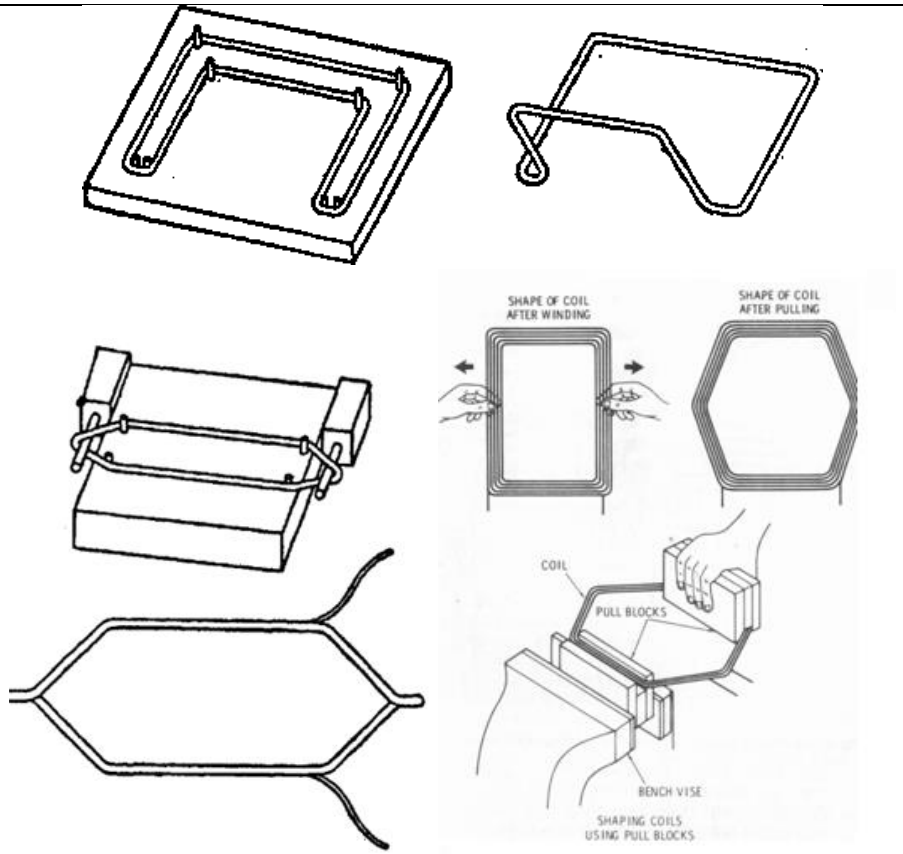
Hand-wound coils are expensive in labor and unsymmetrical. Therefore a scheme is necessary to develop to

arrange the winding incoils or formers, and then laying these formed coils in their respective places upon the core body. The individual sections of the winding are first wound and shaped upon a frame, or former. First of all forma is made according to pitch span by measuring the size of slots of stator core in case of winding or according to size of burnt coil in case of rewinding. Figures shown below indicate the process of making coils.









LU8. Prepare Coil Winding Machine for Rewinding

- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe procedure of preparation of coil:**
  - **With manual winding machine**
  - **With motor operated winding machine**

WINDING MACHINE:

Coils are wound with the help of winding machines for winding or rewinding of electric motors, transformers etc. A coil-winding machine generally consists of a stand, an electrical motor drive, a gear reduction unit, a hand wheel on the

output shaft for controlling the last few turns of a coil on the winder head, a turns-counting device, an adjustable coil-forming winder head, and a foot control. The general procedure for winding a coil or coils on this type of machine is:

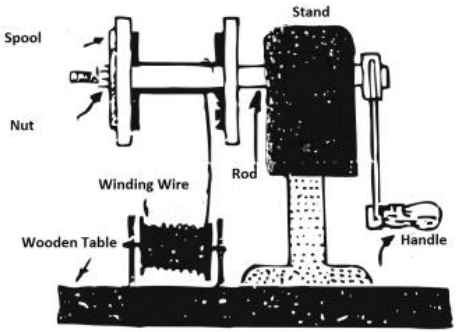
- ✓ Adjust the winder head to the size and shape of the coil required; this is obtained from a coil removed from the armature in its entirety or from a wire loop adjusted to the coil pitch and size of the core.
- ✓ Set up a reel of the proper wire size for the coil or coils on a reel rack with a suitable reel tension device on the floor.
- ✓ Set the reel-rack tension so that very little mechanical resistance is offered to a pull on the wire and so that when pulling is stopped, the reel will stop and thus prevent the wire from becoming uncoiled.
- ✓ Attach the end of the winding wire to one of the winder head rod spools by looping the end once and giving the wire a couple of twists.
- ✓ Start the motor by closing the motor-circuit switch.
- ✓ Start the machine by depressing the foot pedal and control the starting speed with the left hand on the hand wheel.
- ✓ Guide the wire onto the winder head with the right hand.
- ✓ Gradually let the coil winder attain the desired speed by relieving the pressure of the left hand on the hand wheel.
- ✓ Observe the counting device occasionally to determine the number of turns of wire being put on the coil form.
- ✓ When the required number of turns has been wound onto the coil, release the foot pedal (by taking the foot pressure off) to stop the machine.

TYPES OF WINDING MACHINES:

There are main two types of winding machines.

1- Hand operated (Non automatic), used by motor winder, low cost.

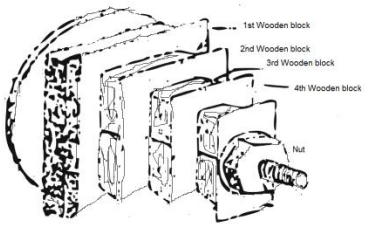
2- Motor operated (Automatic), used by manufacturers, high cost, less time consuming. May be Vertical or Horizontal type.

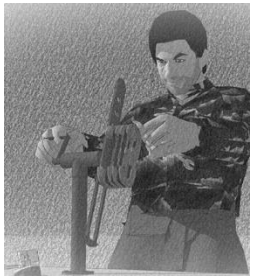


Coil Making; All of the steps have dealt with existing windings and stator components. The first step in actual rewinding is Coil Making; that is, creating new coils from new magnet wire and other materials. The primary objectives of Coil Making are recognizing the materials, tools and equipment needed; 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.

MAKING OF COIL ACCORDING TO OLD DATA:

In case of rewinding, size of burnt coils, size of wire and number of turns in each coil are measured. According to this available data forma is made and then coils of required size and shape are wound with the help of forma by hand or by hand operated machine. The figure shown below indicates the method of making coil of required data.





- **State importance of calculating total weight of winding coils**

- **State importance of updating record**

LU9. Set the Coils in the Core slots

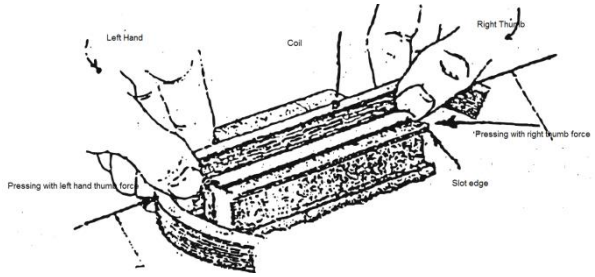
- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe procedure of insertion / setting of coil in core slots sequentially**
- **State importance & method of insertion of wedges.**

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 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.

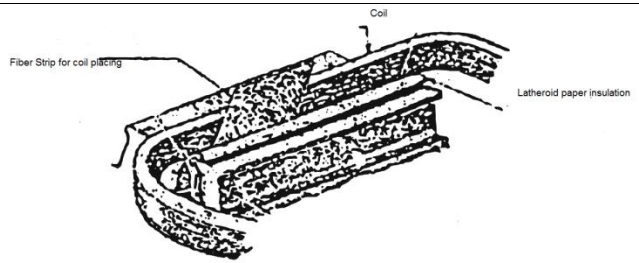
PLACING OF COILS IN SLOTS:
PLACE OF COIL:

Coils are inserted in slots by using;

1- Pressure of right and left thumb as shown in figure.



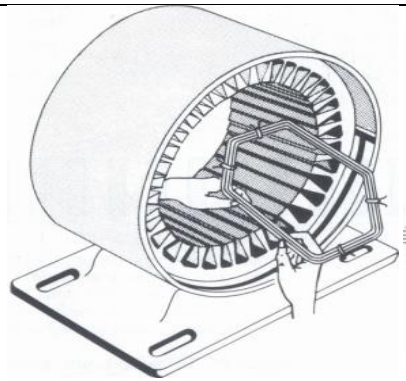
2- Using fiber strip as shown in figure.

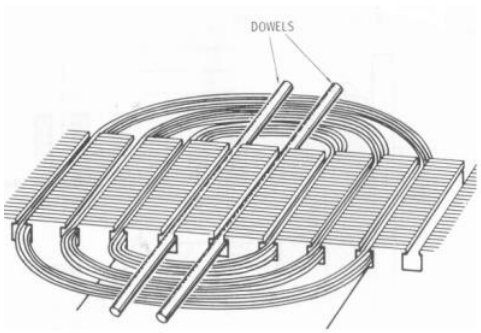


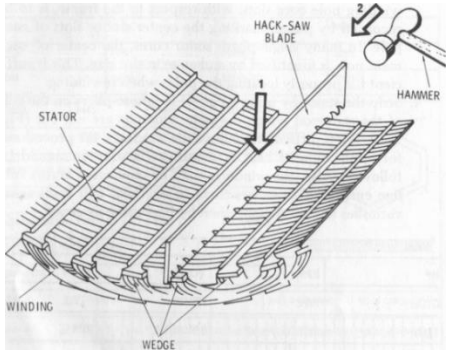
SET OF COIL ACCORDING TO PITCH IN SLOTS AND INSULATE:

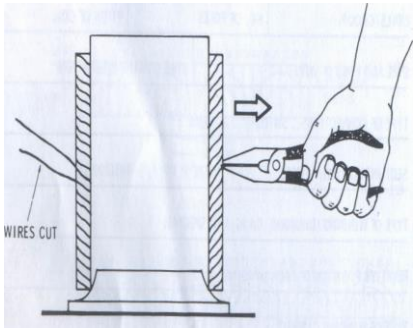
The placement of preformed coils into the slots is dependent on the type of slot. Care must be exercised so that conductors are not scraped, wrappings are not disturbed, and insulations are kept intact. Follow the outlined procedures for inserting the coils after the slots have been prepared with insulation.

1. Spread the turns on one side of an untapped or partially taped coil.
2. Hold the coil at an angle and introduce the turns into the first slot, one or a few at a time (depending on the space limitations of the slot opening) until all the turns are in the slot.
3. Place one coil side in all the slots as outlined in step 2 above. Do not insert the second coil side until every slot has one coil side placed.
4. Place a strip of insulation in every slot on top of each inserted coil side. The strip should be 0.020 inch thick, and $^{1}/4$ inch (6 mm) wider and 1 inch (25 mm) longer than the slot. Center it so that the width is evenly tucked around the coil side and extends '/2 inch (12 mm) on both ends. Another way is to bend the insulation feeder of every slot into the slot, one side overlapping the other.
5. In the case where the slot insulation was bent and folded inward, place another slot feeder. Insert the second side of a coil. Fit it on top of the first coil's side. This is done through the opening of the second feeder. Insert insulation. This may be done several slots away, depending on the coil pitch.
6. Make certain that each coil side extends beyond the slot at both ends and that it does not press against the iron core at the corners.
7. Fold in the slot feeder. Wedge the winding in the Slots.









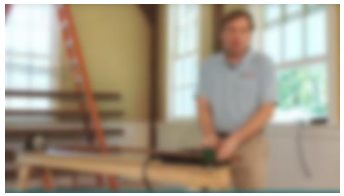
LU10. Interlink Coils as per number of Poles

Demonstration regarding selection & use of required Tools, equipment & PPEs

Describe procedure of Sleeving the coils inserted in the core slots & make demonstration of the sleeve insertion process

Tight braiding makes this Sleeving resistant to fraying when cut with scissors. It's expandable, so it stretches to fit over items for easy installation, and then tightens around its contents for a secure fit. The braided construction permits heat and moisture to dissipate. Made of polyester, it resists some wear and chemicals, so it's best used in indoor environments.

O see the method of Sleeving use the website address shown below

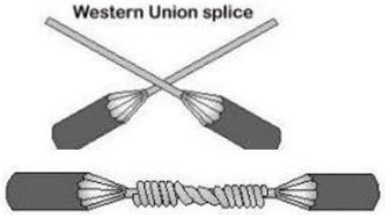


https://www.bing.com/videos/search?q=sleeving&view=detail&mid=62E2C277E42332A3CD7E62E2C277E42332A3CD7E&FORM=VIRE

State method of jointing:

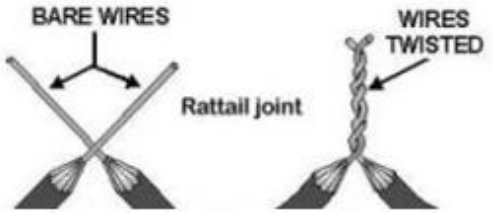
This is a straight joint used for small solid cables

- ✓ Remove the insulation
- ✓ Bring the two conductors to a crossed position and then make a long bend or twist in each wire.
- ✓ Wrap the end of one of the wires around the straight portion of the other wire, and then do the same for the other wire.
- ✓ Perform soldering on joint
- ✓ Press ends of the wires down close to the straight portions of the wire to prevent the ends from piecing through the sleeve.
- ✓ Insulate the joint using the sleeve



To create the rattail joint;

- ✓ Strip the insulation off the ends of the cable to be joined
- ✓ Twist the wires to create the rattail effect
- ✓ Perform soldering on joint
- ✓ Press ends of the wires down close to the straight portions of the wire to prevent the ends from piecing through the sleeve.
- ✓ Insulate the joint using the sleeve



Technique of Enamel / Varnish removing from coil ends

Interlinking coils

Connecting supply leads with coils

Soldering the joints: With a little practice it becomes very easy to make good solder joints. Coupled with careful inspection afterwards, virtually every solder should be good and free from problems. Follow these points to making good solder joints:

- Ensure that all surfaces to be soldered are clean and free from grease.
- Ensure that the items to be soldered are secured so that they will not move in the soldering process as this can result in a dry joint.
- Tin the tip of the soldering iron, wipe it clean on a damp sponge and then add a small amount of solder again - this helps the heat to flow onto the joint quickly.
- Apply the soldering iron to the joint and quickly add some solder
- Allow the solder to flow onto the joint, and just sufficient to allow a concave meniscus to form.
- Remove the soldering iron as soon as possible. If the iron is left on the joint for too long, the flux will become exhausted, the solder will oxidize and a dry solder joint will result. Typically a couple of seconds is sufficient to solder joints.
- Allow the solder on the joint to cool and solidify before allowing any movement.

Insulating joint with sleeve

To insulate joint with sleeve it is essential to put proper size sleeve on both ends of wires / cables before joining and soldering them together. After the soldering process slide sleeve over the joint to cover the joint and to insulate the live portion (un-insulated portion) of wire / cable.

State Importance of verification of continuity before and after soldering the joints

It is essential to check continuity of winding by series test board before soldering the joint. Repeat the test after performing the soldering to confirm the joining.

State method of strengthening insulation between over lapped coils:

Insulation between over lapped coils is strengthen by putting piece of insulation paper between their over lapping point / junction.The insulation paper is fastened with thread or cotton tape to avoid slipping from the relevant position.

State importance of pressing the winding coils:

The winding coils are pressed in slots and are fastened with insulation paper and bamboo strips. The two ends of coils which are also pressed to avoid them to touch with rotor, or end plates.

Describe method of testing insulation resistance between coils and core

Insulation resistance is tested with series board, connecting one wire with coil end and other end with motor body, if insulation is good, the lamp will not glow, if lamps glow this will indicate ground fault. Megger can also be used to test insulation resistance. Zero resistance will indicate ground fault, low resistance value will indicate poor insulation, while high value of resistance will indicate good insulation.

STRIPPING OF WIRE AND CONNECTION:

Stripping of wire means;

1. Stripping of burnt coils from stator core for rewinding.
2. Stripping of ends of coils of newly wind motor for connection.

- ✓ Burning out motors in ovens in connection with stripping them for rewind is a method long used. Modern ovens made for burn-offs operate on the controlled air principle. By restricting the air flow it is possible to restrict the combustion and temperature. The principle calls for smothering by limiting the oxygen available for burning. Pyrometers are usually attached so that the oven temperature can be monitored. This works with a circuit that will control the oxygen supply automatically when a preset temperature has been reached. When the temperature drops, the circuit calls for more oxygen and a valve is opened again.
- ✓ All modern burn off ovens includes an integral after burner. The after burner is sized to add air to the outlet gas to bring the temperature to 1,400°F (760°C). It takes a temperature this high to completely burn off the insulation and causes it to oxidize. These high temperatures call for an oven and its stack both lined with refractory brick.
- ✓ Ends of coils are stripped to make connection. Stripping is process of removing varnish insulation from the wires. Emery / sand paper, electrician knife, wire stripper is used for stripping wire insulation. After stripping connections of different coils according to winding diagram are made. After connection joints are insulated with sleeve of proper size and then varnished.

Primary objectives are understandings; and using winding removal methods and equipment to remove the old winding safely, and avoiding damage to the stator core. Winding Stripping also requires recording the important data

e.g., connection turns, span(s), wire sizes, poles, and grouping.

LU11. Perform Winding Tests

- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe techniques to Perform the following winding tests**
  - **Continuity**
  - **Insulation between overlapping coils**
  - **Insulation between coil and core**
- **Describe types and use of electrical measuring instruments**

Already described types and use of Voltmeter, Ammeter, Ohm meter, watt meter, Frequency meter, Multi-meter (analog & digital), Megger, Growler, Tong tester, Earth tester.

LU12. Perform Binding of Coils

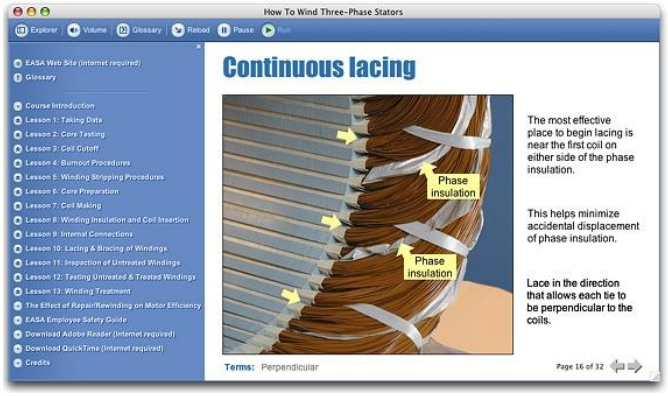
- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe the steps of coil binding**
- **Importance of following tests after insertion and binding of coils :**
- **Continuity**
- **Insulation between each other(coils)**
- **Insulation between coil and core**

BINDING / LACING OF WIRES:

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.

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.
Then coils are bind with thread or cotton tape, then coils are varnished, this also enhance the insulation of coils. The most effective place to begin lacing is near the first coil on either side of the phase insulation. This helps minimize accidental displacement of phase insulation. Lace in the direction that allows each tie to be perpendicular to the coil.



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. Detect visual indications of unsatisfactory winding condition versus acceptable appearance.

LU13. Conduct Baking of Winding

- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe purpose of Varnishing and baking of winding coil of stator**

VARNISH OF WINDING:

Varnish functions to insulate the motor windings from contaminants, to make the windings rigid and tight, and to dissipate heat. The varnishing method selection is based on application.

Standard Ultra-Coat "Trickle" varnishing, ensuring heavier varnish build-up and cooler running.

Vacuum Pressure Impregnation (VPI) for high moisture environments;
Industry Standard Dip-and-Bake.
Double Dip & Bake Epoxy varnishing for corrosive chemical resistance.

Fibrous material, such as paper, was traditionally used as the primary insulation on inductor coils. To improve the insulation properties of the coils without having to use wire with thicker insulation, a secondary insulation (i.e. impregnation resin) was used to "impregnate" the assembled coils of wire.

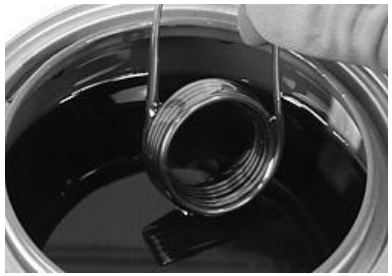
Primary insulation is considered impregnated when all the spaces and gaps between fibers are completely filled by the impregnation resin, which is why secondary insulation and impregnation resin are interchangeable terms. By this definition, a winding can be impregnated even if there are still spaces between coils as long as the spaces between the fibers of the primary insulation are filled in.

Insulating varnish refers to the electrical insulation used for impregnating coils of wire, such as the inductor coils found in transformers. It is also known as impregnating or transformer resin. Keep in mind that insulating varnish may refer to the primary insulation (wire enamel) used to initially coat a bare conductor, or it may refer to the secondary insulation that is applied to assembled windings of enameled wire.

How is insulating varnish applied?

Insulating varnish comes in liquid form and can be sprayed, brushed, or trickled onto coil windings. The method of application depends on the size of the coil and the desired production rate, and different methods for insulation varnish, such as;

- Dip and bake method,



- Vacuum pressure impregnation (VPI),

- Trickle impregnation can result in different degrees of impregnation of the winding. The use of solvents also plays an important role in diluting insulating varnish so that it will flow more easily.

Benefits of Electrical Resin

- Provides protection from mechanical damage
- Dampens vibrations by immobilizing windings
- Prevents moisture and other foreign matter, like dust and debris particles, from getting in between coils and damaging the primary insulation
- Increases the dielectric strength (i.e. improves insulating properties) of fibrous insulation (e.g. paper was commonly used as primary insulation for the coils in very old transformers)
- Helps carry heat away from the windings either to the surrounding air or to the core

Electrical resin (i.e. secondary insulation or impregnating resin) is used to provide extra protection for wire windings and coils. This is especially important for inductor coils where the coils are packed so tightly that internal damage from coils rubbing against each other could easily cause their primary insulating layer to wear out.

DRYING OF WINDING

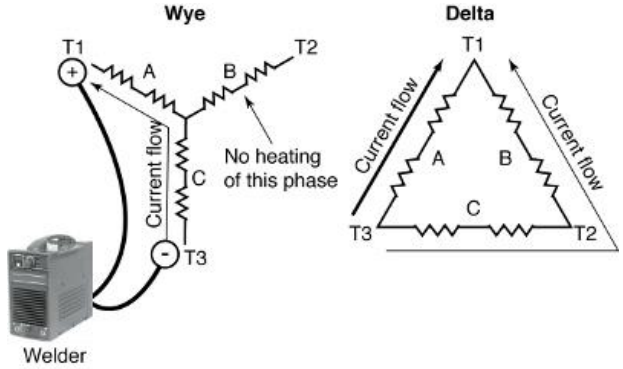
Drying of winding after varnish must be done by keeping the motor in direct sun heat, but it will take long time for complete drying, or produce heat inside the stator core by passing current in coils as per detail shown below.

Welding machine method:

Before using a welder or other dc power source to dry out an electric motor, make sure you know what you're getting into.

For starters most electric motors large enough to warrant consideration have three leads–one per phase. Internally, they are connected either wye (Y) or delta (∆). With the welder applying current from T1 to T3, only two phases of a wye-connected motor are heated. If the internal connection is delta, one phase is heated with four times the wattage of the other two phases. In both cases, the welder leads must be periodically moved to heat the entire winding evenly.

If you apply dc to any two leads of a delta winding, two phases will be in series, and the third will be in parallel with them. That means one phase will carry twice as much current as the series pair, so it will get much hotter. For the wye connection, only two phases carry current, leaving the third phase cold. Whether the winding is connected wye or delta, someone must monitor the current and winding temperature, and periodically move the welder leads. Otherwise, parts of the winding may not dry completely, if at all. Welding machines are useful when both ends of each phase are brought out as six leads. An ohmmeter will confirm three separate circuits. In that case, the three phases can be connected in parallel or series, depending on the capacity of the welding machine, and dried simultaneously.



BAKING OF WINDING:

At room temperature long time is required to dry the varnish, hence for quick drying it is essential to bake the stator in temperature controlled oven.

Windings should be dried at oven temperatures of 180 F (82 C) for 3 hours, for baking the varnish insulation. The windings could somehow be heated instantly to above boiling temperature 100 C can burst the insulation, so care must be taken while baking varnish of motor. The windings, placed in an oven, heat up very slowly. Moisture will get out the same way it got in. As the temperature of the winding slowly increases, the moisture (just as slowly) will evaporate.

- **Importance of following tests after varnishing and baking of winding of the stator :**
  - ✓ **Continuity:** Continuity between two ends of winding, this will identify that all coils are connected properly and there is no open circuit.

- ✓ **Insulation between each other(coils):** Insulation between two coils sets, this will indicate that all coils are insulated properly and there is no short circuit fault between two coils.
- ✓ **Insulation between coil and core:** Insulation between coil and core, this will indicate that all coils have proper insulation and no coil has ground fault.

- **Perform baking of winding**

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.

LU14. Verify Winding Tests

- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe techniques to Perform the following winding tests**
- **Continuity:**

  Continuity between two ends of winding can be checked with:

  Series board; connect two points of series board with two ends of coil, if lamps glow this will indicate continuity; if lamp doesn't glow this will indicate that coilis not connected properly and there is open circuit.

  Megger; Megger can also be used; connect the two points of Megger with two ends of coil, rotate the handle of Megger at prescribed speed in case of Analog Megger or switch "ON" button in case of Digital Megger, if readings goes to Zero this will indicate continuity; if reading shows infinity reading this will indicate that coilisnot connected properly and there is open circuit.

  Multi-meter; Multi-meter can also be used; connect the two points of Multimeter with two ends of coil, set the selector knob at resistance (X 1) point, switch "ON" button, if readings goes to Zero this will indicate continuity; if reading shows infinity reading this will indicate that coilis not connected properly and there is open circuit.
- **Insulation between overlapping coils;**

  Insulation between overlapping coils of winding can be checked with:

  Series board; connect one point of series board with one end of coil, and the other point of series board with other coils one by one, if lamps glow this will indicate continuity, insulation failure, short circuit between two coils; if lamp doesn't glow this will indicate that coils are properly insulated and they are not short circuited.

Megger; Megger can also be used; connect one point of Megger with one end of 1st coil, and the 2nd point of Megger with other coils one by one, rotate the handle of Megger at prescribed speed in case of Analog Megger or switch "ON" button in case of Digital Megger, If reading shows infinity this will indicate that coils are properly insulated and they are not short circuited, if reading goes to zero this will indicate insulation failure, short circuit between two coils.

- **Insulation between coil and core:**

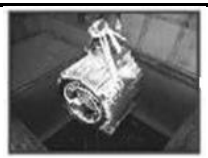
  Insulation between coils & core can be checked with:

  Series board; connect one point of series board with core, and the other point of series board with coils one by one, if lamps glow this will indicate continuity, insulation failure, short circuit, ground fault between core and coils; if lamp doesn't glow this will indicate that coils are properly insulated and they are not short circuited / grounded.

  Megger; Megger can also be used; connect one point of Megger with core, and the 2ndpoint of Megger with coils one by one, rotate the handle of Megger at prescribed speed in case of Analog Megger or switch "ON" button in case of Digital Megger, If reading shows infinity this will indicate that coils are properly insulated and they are not short circuited / grounded, if reading goes to zero this will indicate insulation failure, short circuit / ground fault between core & coils.

REWINDING OF MOTOR: Rewinding of motor is completed by observing following steps left → right.

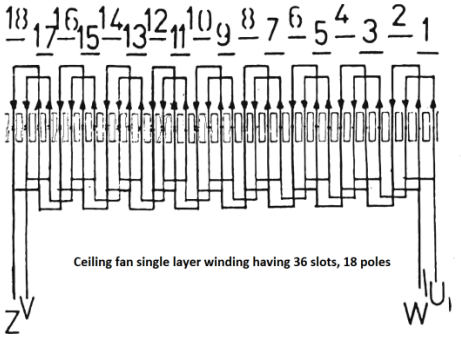
Receiving Motor for rewinding	Recording data
	
Dismantling	Removing burnt winding
	
Rewinding	Varnishing

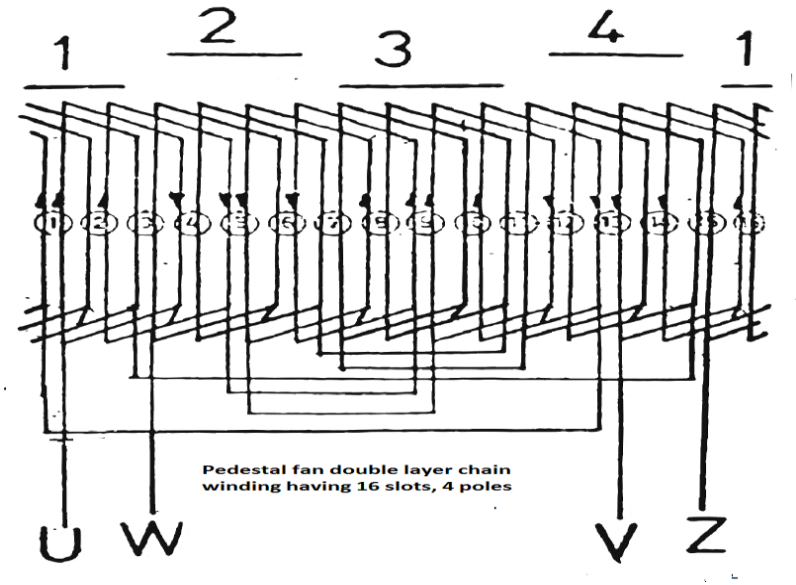
	
Baking varnish	Checking & setting rotor
	
Making Connection	Assembling Motor
	
Delivery After Rewinding	
	

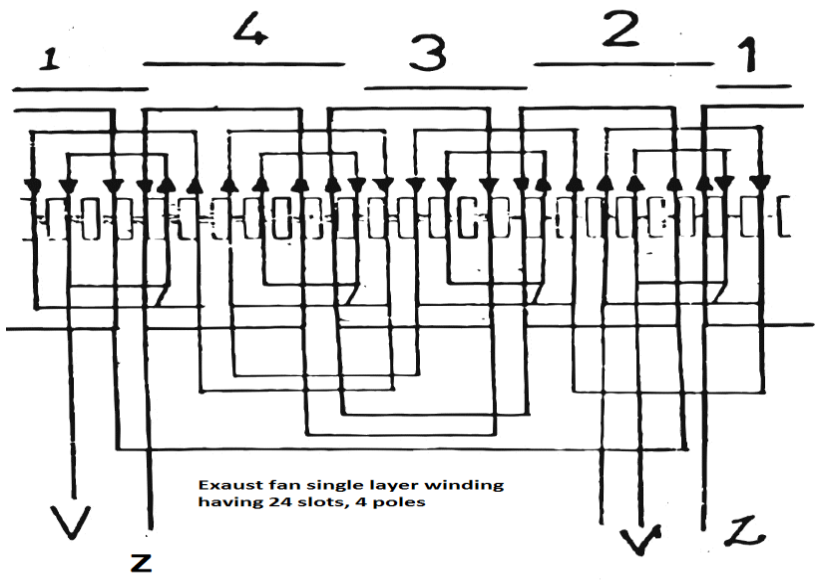
To see Motor rewinding video use the given website address

https://www.youtube.com/watch?v=5Mu42TzHy8M&https://www.youtube.com/watch?v=bsS_7EEYx1Y

STUDENTS WILL PRACTICALLY REWIND THE FOLLOWING WINDINGS






1
4
3
2
1
V
Z
Exaust fan single layer winding
having 24 slots, 4 poles
V
Z

ELECTRICAL MACHINE WINDING TECHNICIAN

Module-E
LEARNER GUIDE
National Vocational Certificate Level 3

Version 1 - September, 2018

Module E: 0713001133 Perform Transformer Rewinding

Objective: This Module covers the knowledge & skills required to Perform Transformer Rewinding through Prepare for work , Collect Faulty Coil of Transformer , Compile data of Faulty Transformer , Collect the Materials required for Winding , Prepare a Former for Coil Winding , Prepare Coil on Winding Machine , Re- Assemble the Coil on Core , Make Connections as per rating plate of Transformer , Calculate Total Turn Ratio of Transformer , Conduct Baking of live part of Transformer ,

Duration: 110 Hours **Theory: 22 Hours** **Practice: 88 Hours**

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1.Prepare for work to perform transformer rewinding	**The trainee will be able to:** • Identify the required PPE's • Collect the required PPE's • Identify the required tools and equipment • Collect the required tools and equipment • Ensure functional condition of PPE's/Tools and equipment • Ensure safe working conditions ➢ Clear Passage ➢ Cleanliness ➢ Adequate light ➢ Ventilation	• Recognition of required Tools, Equipment and PPEs for performing transformer rewinding • Importance of functional conditions of required Tools, Equipment and PPEs and their use • Importance of safe working condition regarding • Clear passage • Cleanliness • Adequate light • Ventilation • Define insulator and types of insulating material used in Transformer for insulations	**Tools** • Spanner set • Screw driver set • Combination plier • Wire cutter • Tri pod and chain block • U bold shackle **Consumable Material** • Hand gloves • Cotton waste • Ball pen and paper

LU2. Collect Faulty Coil of Transformer	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Remove cover of transformer • Identify faulty coil • Disconnect connections of faulty coil • Disassemble the channel of core • Remove the required part of core • Remove the faulty coil / coils from the limb of core • Ensure proper placing of removed coils • Update record	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Concept of working principle of transformer, Parts, core, HT /LT windings • Describe procedure for identification and safe removal of faulty coils from transformer limb of the core / coil assembly • State Importance of proper placing of faulty coils • State importance of updating record	**Tools** • Spanner set • Screw driver set • Combination plier • Wire cutter • Tri pod and chain block • U bold shackle **Consumable Material** • Hand gloves • Cotton waste • Ball pen and paper
LU3. Compile data of Faulty Transformer Coil / Coils	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Collect the faulty coil • Measure / calculate: ➢ Dimensions (Height, inner & outer diameter) of coil / coils ➢ Size of winding wire ➢ No of turns of coil • Collect data from name plate of	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe method of taking dimensions (Height, inner & outer diameter) of coil / coils ➢ Size of winding wire ➢ No of turns of coil	**Tools** • Steel rule • Vernier calliper • Standard wire gauge • Weigh Scale • Micro meter **Consumable Material** • Hand gloves • Cotton waste • Ball pen and

	transformer • Compile data of faulty coil / coils of transformer • Update record	• Describe method of collecting the data from name plate of transformer • Procedure of compiling data of faulty coil / coils of transformer • State importance of updating record	paper • Magnifying glass • Sand paper zero size • Kerosene oil
LU4. Collect the required Materials for Re-winding	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Prepare estimate of the required material for rewinding • Collect material required for rewinding • Update record	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Procedure for preparation of estimate of required material for rewinding and its collection • State importance of updating record	**Tools** • Calculator • Computer • Printer **Consumable Material** • Hand gloves • Cotton waste • Ball pen and paper • Estimating Performa
LU5. Prepare Former for Coil Winding	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Collect winding data • Collect/Prepare former as per required dimensions(Volume) • Verify the size of former according to the coil	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe method of preparing coil former and its size verification as per coil size	**Tools** • Steel rule • Vernier Calliper • Wooden Saw • Rasp Cut file • Wooden Chisel • Hammer • Wooden lathe machine **Consumable Material**

			• Hand gloves • Cotton waste • Ball pen and paper • Wooden Sand Paper • Nails • Latheroid paper • Wood Piece • Wooden Screw
LU6. Prepare Coil on Winding Machine	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Collect former • Fix former on winding machine • Collect required winding material • Wrap two, three layers of insulation paper as per requirement (latheroid / impregnated/diamond dotted/ cable paper) on the former • Fasten one end of winding wire with former • Put small pieces of cotton tape on former for coil binding • Wind quarter length of coil • Pull the cotton tape to bind the wound turns	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe method of preparing coil on winding machine: ➢ Arrangement of relative winding material (Winding wire, insulation paper, cotton tape, varnish) ➢ Fixing of former on winding machine ➢ Wrapping process of winding wire layers to form coil up to required size	**Tools** • Steel rule • Vernier Calliper • Outside calliper • Inside calliper • Mallet / rubber hammer • Soldering iron • Copper brazing torch **Consumable Material** • Hand gloves • Cotton waste • Ball pen and paper • Insulation paper (Latheroid / impregnated /diamond dotted

	• Complete winding of first layer of coil • Wrap latheroid paper over first layer of coil • Complete winding of all coil layers according to number of turns • Bind the coil with cotton tape • Apply varnish on last / end layer of coil • Remove the former from winding machine • Remove the former from the coil • Update record	➢ Tapping leads ➢ Soldering / brazing of tapping end joints ➢ Checking continuity of coil ➢ Binding of coil ➢ Removing former from winding machine ➢ Removing coil from former	/ cable paper) • Cotton tape • Varnish& Paint brush • Winding wire / winding strip • Copper brazing rod • Soldering flux
LU7. Re-Assemble the Coil on Core	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Insert the wound coil over the limb of core • Assemble the opened layer of the core • Fit the channel on core • Fix the channel on core • Update record	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe method of inserting coil on core limb: ➢ Coil insertion on core limb ➢ Re-assemble of upper limb of core ➢ Fitting of channel of core ➢ Fixing of channel of core	**Tools** • Mallet / rubber hammer • Spanner set • Screw driver set • Combination plier • Knife cutter **Consumable Material** • Hand gloves • Cotton waste • Ball pen and paper

LU8. Make Connections as per rating plate of Transformer	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Make connection as per data / rating plate of transformer • Perform joints soldering / brazing of coils connections • Update record	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe method of making connections as per data / rating plate of transformer • State jointing / brazing method of coil connection with tap changer and transformer bushing	**Tools** • Mallet / rubber hammer • Spanner set • Screw driver set • Knife cutter Soldering iron • Copper brazing torch **Consumable Material** • Hand gloves • Cotton waste • Ball pen and paper • Copper brazing rod • Soldering flux
LU9. Calculate Turn Ratio of Transformer	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Collect specifications from data / rating plate of transformer • Calculate turn ratio of transformer • Update record	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Define transformer turn ratio (TTR) and its importance in transformer working, its method of calculation	**Tools** • Calculator **Consumable Material** • Ball pen and paper
LU10. Conduct Baking of live	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and	• Demonstration regarding selection & use of required Tools,	**Tools** • Transformer baking oven

part/Coil Assembly of Transformer	equipment • Place the transformer's coil assembly / live part in baking oven • Set specific temperature of the baking oven • Perform baking of coil assembly / live part • Update record	equipment & PPEs • Define importance of baking of transformer winding and process of baking in oven	**Consumable Material** • Ball pen and paper

LU1.Prepare for work to perform transformer rewinding

- Recognition of required Tools, Equipment and PPEs for performing motor rewindin**g**
- **Importance of functional conditions of required Tools, Equipment and PPEs and their storage after use**
- **Importance of safe working condition regarding**
  - **Clear passage**
  - **Cleanliness**
  - **Adequate light**
  - **Ventilation**
- **Define insulator and types of insulating material used in Transformer for insulations**

Transformer insulation is based on basic impulse insulation level together with voltage rating. Insulating media in up to 11KV transformer is mostly comprised of paper wrapped around the conductor in transformer coils, mineral oil and pressboard to insulate the coil from the ground. One basic requirement of all insulating materials is that they should be compatible with insulating oil and should not react with oil. The types of materials used for insulations are and their applications:

Insulating Oil: Insulation oil plays a very important in transformer insulation system. In low voltage transformer, for example, transformers used in the range of 12-1000V or low power rating transformers there is no need of insulating oil in such transformers. Heat dissipation is very low in low voltage transformers. In 11KV transformers, insulating oil has the important rule of acting as an electrical insulation as well as a coolant to dissipate heat losses. Transformer oil is basically obtained by fractional distillation and subsequent treatment of crude petroleum. So Transformer oil act as liquid dielectric and coolant and it is placed in a tank in which core of the transformer is placed.

Insulating paper: Paper is a fabric made from vegetables fibers which are felted to form a web or sheet. The fibrous raw materials are obtained from plants including cotton, hemp, manila, straw, and coniferous trees. It attains a very high value of electric strength when emerged in oil under vacuum. ”Craft insulating paper of medium air permeability” is used in layer winding insulation, condenser core of oil impregnated bushing. Craft insulating paper of high air permeability” is used in covering over rectangular copper conductor and continuously transposed copper conductor. “Crepe Kraft paper” is used in covering over flexible copper cable insulation of winding lead. “Press paper” is used as backing paper for axial cooling duct.

Pressboard: Pressboard is a widely used insulating material for making a variety of components used in electrical, mechanical and thermal design of transformers. Pressboard id also made from vegetable fibers, whose cells contains much cellulose. The most difficult practical insulation in power transformers occur at the end of the windings and the lead outs from the windings. Pressboard molded components can be made to any required shape. Angle rings and caps are

the widely used mouldings. There are many kind of pressboards use in high voltage transformers but “soft pressboard – laminated” is used in 11KV transformers as a block washer, terminal gear cleat and support and spacer etc. “Pressboard moulding from wet sheet or wet wood pulp” is used in angle ring, cap, sector, snouts, square tube, lead out, for insulating ends of winding, insulation between windings and numerous other applications.

Wood: Wood based laminates are manufactured from selected veneers obtained from various timbers. The veneers are dried and partially or fully impregnated with natural phenomenon. The areas which required higher mechanical and lower electric strength, densities laminated wood is used for making a variety of insulation components like coil clamping ring, cleat, support, core and yoke etc.

Insulated copper conductor for winding: Different type of insulated copper conductor windings are used in power transformers for example paper covered rectangular copper conductor, twin paper covered rectangular copper conductor bunched together, paper covered continuously transposed copper conductor, twin transposed copper conductor bunched together, twin rectangular copper bunched together and provided with a common paper strip between the two conductors and epoxy coated continuously transposed conductor. These are used to the winding space factor and mechanical strength of windings.” paper covered rectangular copper conductor” is used for making different kind of windings. “Paper covered standard copper cable” is used for making lead and terminal. “Crepe paper covered flexible copper cable” is used for making lead and terminal required to be bent to a small radius. “PVC insulated copper cable-single and multicore” is used to control wiring in marshaling box, nitrogen, sealing system.

Insulating tape: Insulating tape is used for various taping purposes .For example cotton tape, cotton newer tape, glass woven tape, woven tape and phenol laminated paper base sheet. These tapes are used in taping, banding, core bolt insulation, places where required high strength and in banding of transformer cores.

LU2. Collect Faulty Coil of Transformer

- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Concept of working principle of transformer, Parts, core, HT /LT windings**

TRANSFORMER:

A transformer is a static machine used for transforming power from one circuit to another without changing frequency. Electrical power transformer is a static device which transforms electrical energy from one circuit to another without any direct electrical connection and with the help of mutual induction between two windings. It transfer power from one circuit to another without changing its frequency but may be in different voltage level. Commonly, transformers are used to increase or decrease the voltages of alternating current in electric power applications.

WORKING PRINCIPLE:

The working principle of transformer is very simple. It depends upon Faraday's law of electromagnetic induction. Actually,

mutual induction between two or more winding is responsible for transformation action in an electrical transformer.

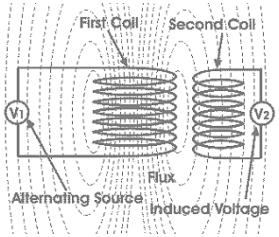
Faraday's Laws of Electromagnetic Induction

According to these Faraday's laws, "Rate of change of flux linkage with respect to time is directly proportional to the induced EMF in a conductor or coil".

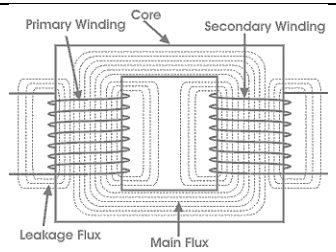
Basic Theory of Transformer

If one winding is supplied by an alternating electrical source. The alternating current through the winding produces a continuously changing flux or alternating flux that surrounds the winding. If any other winding is brought nearer to the previous one, obviously some portion of this flux will link with the second. As this flux is continually changing in its amplitude and direction, there must be a change in flux linkage in the second winding or coil. According to Faraday's law of electromagnetic induction, there must be an EMF induced in the second. If the circuit of the later winding is closed, there must be a current flowing through it. This is the simplest form of electrical power transformer and this is the most basic of working principle of transformer**.**

Whenever we apply alternating current to an electric coil, there will be an alternating flux surrounding that coil. Now if we bring another coil near the first one, there will be an alternating flux linkage with that second coil. As the flux is alternating, there will be obviously a rate of change in flux linkage with respect to time in the second coil. Naturally emf will be induced in it as per Faraday's law of electromagnetic induction. The winding which takes electrical power from the source, is generally known as primary winding of transformer. Here in our above example it is first winding.



The winding which gives the desired output voltage due to mutual induction in the transformer, is commonly known as secondary winding of transformer. Here in our example it is second winding.



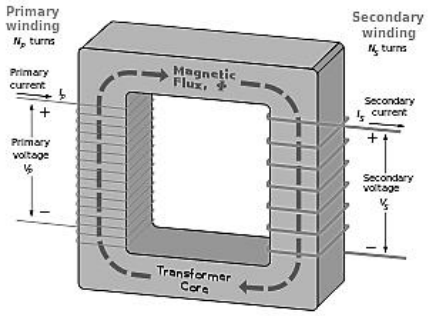
The above mentioned form of transformer is theoretically possible but not practically, because in open air very tiny portion of the flux of the first winding will link with second; so the current that flows through the closed circuit of later, will be so small in amount that it will be difficult to measure.

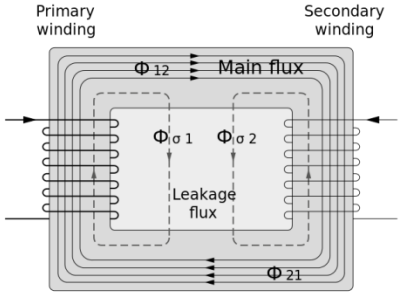
The rate of change of flux linkage depends upon the amount of linked flux with the second winding. So, it is desired to be linked to almost all flux of primary winding to the secondary winding. This is effectively and efficiently done by placing one low reluctance path common to both of the winding. This low reluctance path is core of transformer, through which maximum number of flux produced by the primary is passed through and linked with the secondary winding.

CONSTRUCTION:

The three main parts of a transformer are,

1. **Primary winding of transformer** - which produces magnetic flux when it is connected to electrical source.
2. **Secondary winding of transformer** - the flux, produced by primary winding, passes through the core, will link with the secondary winding. This winding also wounds on the same core and gives the desired output of the transformer.
3. **Magnetic core of transformer** - the magnetic flux produced by the primary winding, that will pass through this low reluctance path linked with secondary winding and create a closed magnetic circuit.





Laminating the core greatly reduces eddy-current losses. One common design of laminated core is made from interleaved stacks of E-shaped silicon steel sheets capped with I-shaped pieces, leading to its name of 'E-I transformer'.

TRANSFORMATION RATIO:

$$\frac{E_1}{E_2} = \frac{4.44\phi_m f T_1}{4.44\phi_m f T_2}$$

$$\Rightarrow \frac{E_1}{E_2} = \frac{T_1}{T_2}$$

This constant is called transformation ratio of transformer and denoted with **"K"**, if $T_2 > T_1$, K > 1, then the transformer is step up transformer. If $T_2 < T_1$, K < 1, then the transformer is step down transformer.

Voltage Ratio of Transformer

This above stated ratio is also known as **voltage ratio of transformer** if it is expressed as ratio of the primary and secondary voltages of transformer.

Turns Ratio of Transformer

As the voltage in primary and secondary of transformer is directly proportional to the number of turns in the respective winding, the transformation ratio of transformer is sometime expressed in ratio of turns and referred as turn's ratio of transformer**.**

SIMPLE CALCULATION:

EXAMPLE:

A single phase transformer has 525 primary and 70 secondary turns. It is connected with 3300 volts supply. Find secondary voltage?

SOLUTION:

$N_1 = 525$

$N_2 = 70$

V_1 = 3300 Volts

V_2= ?

$K = N_2 / N_1 = 70 / 525 = 0.1333$

$K = V_2 / V_1$

$V_2 = K V_1 = 0.1333 \times 3300 =$ **440 Volts**

EXAMPLE:

A 25 KVA transformer has 500 primary and 50 secondary turns. The primary is connected with 3000 Volts, 50Hz supply. Find full load primary and secondary currents and secondary voltage.

SOLUTION:

Output = 25 KVA

N_1 = 500

N_2 = 50

V_1 = 3000 Volts

V_2 =?

I_1 =?

I_2 =?

$K = N_2 / N_1 = 50 / 500 = 0.1$

$K = V_2 / V_1$

$V_2 = K V_1 = 0.1 \times 3000 =$ **300 Volts**

I_2 = Output / V_2 = 25000 / 300 = **83.33 A**

$K = I_1 / I_2$

$I_1 = K I_2 = 0.1 \times 83.33 =$ **8.33 A**

LOSSES IN TRANSFORMER:

Losses of transformer are;

1- Winding losses

These losses are also called copper losses. These transformer losses vary with load, it is often useful to express these losses in terms of no-load loss, full-load loss, half-load loss, and so on. Current flowing through a winding's conductor causes copper losses. As frequency increases, skin effect and proximity effect causes the winding's resistance and, hence, losses to increase. Mathematically these are calculated;

Copper losses in primary winding = $I_1^2 R_1$

Copper losses in secondary winding = $I_2^2 R_2$

Total copper losses in transformer = $I_1^2 R_1 + I_2^2 R_2$ or

$= I_2^2 R_{02}$ or

$= I_1^2 R_{01}$

2- Core losses

These losses are constant losses and independent from load variations. These losses related to core and include Hysteresis and eddy current losses, constant at all load levels.

- **Hysteresis losses**

Each time the magnetic field is reversed, a small amount of energy is lost due to hysteresis within the core. According to Steinmetz's formula, the heat energy due to hysteresis is given by

$$W_{\mathrm{h}} \approx \eta \beta_{\mathrm{max}}^{1.6}, \text{ and,}$$

Hysteresis loss is thus given by

$$P_{\mathrm{h}} \approx W_{\mathrm{h}} f \approx \eta f \beta_{\mathrm{max}}^{1.6}$$

where, f is the frequency, η is the hysteresis coefficient and β_{max} is the maximum flux density, the empirical exponent of which varies from about 1.4 to 1.8 but is often given as 1.6 for iron.

- **Eddy current losses**

Ferromagnetic materials are also good conductors and a core made from such a material also constitutes a single short-circuited turn throughout its entire length. Eddy currents therefore circulate within the core in a plane normal to the flux, and are responsible for resistive heating of the core material. The eddy current loss is a complex function of the square of supply frequency and Inverse Square of the material thickness. Eddy current losses can be reduced by making the core of a stack of plates electrically insulated from each other, rather than a solid block; all transformers operating at low frequencies use laminated or similar cores.

- **Stray losses**

Leakage inductance is by itself largely lossless, since energy supplied to its magnetic fields is returned to the supply with the next half-cycle. However, any leakage flux that intercepts nearby conductive materials such as the transformer's support structure will give rise to eddy currents and be converted to heat. There are also radioactive losses due to the oscillating magnetic field but these are usually small.

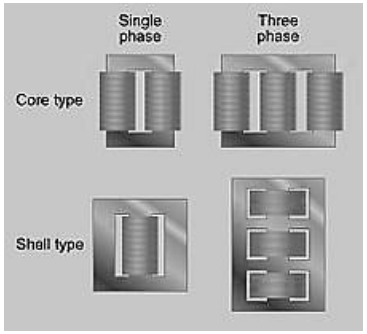
TYPES OF TRANSFORMER:

Various specific electrical application designs require a variety of transformer types. Although they all share the basic characteristic transformer principles, they are customizing in construction or electrical properties for certain installation requirements or circuit conditions. Transformers are classified according to;

1- Core
2- Use
3- Voltage

- **Core form and shell form transformers**

Closed-core transformers are constructed in 'core form' or 'shell form'. When windings surround the core, the transformer is core form; when windings are surrounded by the core, the transformer is shell form.



- **Step Up Transformer & Step Down Transformer** –

Generally used for stepping up and down the voltage level of power in transmission and distribution power network.

- **Three Phase Transformer & Single Phase Transformer** –

Former is generally used in three phase power system as it is cost effective than later but when size matters, it is preferable to use bank of three single phase transformer as it is easier to transport three single phase unit separately than one single three phase unit.

- **Electrical Power Transformer, Distribution Transformer &Instrument Transformer**–

Transformer is generally used in transmission network which is normally known as power transformer, distribution transformer is used in distribution network and this is lower rating transformer and current transformer&potential

transformer, we use for relay and protection purpose in electrical power system and in different instruments in industries are called instrument transformer.

- **Two Winding Transformer &Auto Transformer** –

Former is generally used where ratio between high voltage and low voltage is greater than 2. It is cost effective to use later where the ratio between high voltage and low voltage is less than 2.

- **Outdoor Transformer & Indoor Transformer** –

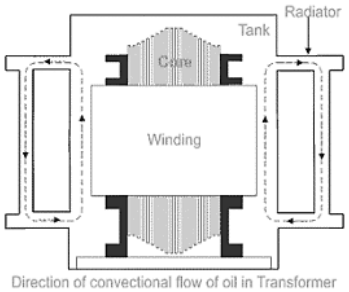
Transformers that are designed for installing at outdoor are outdoor transformers and transformers designed for installing at indoor are indoor transformers.

COOLING METHODS:

The main source of heat generation in transformer is its copper loss or I^2R loss. Although there is other factors contribute heat in transformer such as hysteresis &eddy current losses but contribution of I^2R loss dominates them. If this heat is not dissipated properly, the temperature of the transformer will rise continually which may cause damages in paper insulation and liquid insulation medium of transformer. So it is essential to control the temperature with in permissible limit to ensure the long life of transformer by reducing thermal degradation of its insulation system. In electrical power transformer we use external transformer cooling system to accelerate the dissipation rate of heat of transformer. There is different transformer cooling methods.

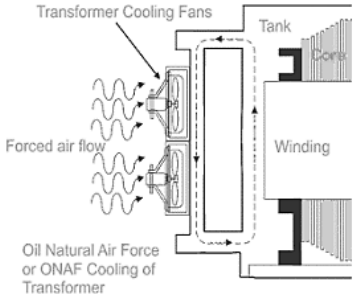
- **ONAN Cooling of Transformer**

This is the simplest transformer cooling system**.** The full form of ONAN is "Oil Natural Air Natural". Here natural convectional flow of hot oil is utilized for cooling. In convectional circulation of oil, the hot oil flows to the upper portion of the transformer tank and the vacant place is occupied by cold oil. This hot oil which comes to upper side will dissipate heat in the atmosphere by natural conduction, convection & radiation in air and will become cold. In this way the oil in the transformer tank continually circulate when the transformer put into load. As the rate of dissipation of heat in air depends upon dissipating surface of the oil tank, it is essential to increase the effective surface area of the tank, so additional dissipating surface in the form of tubes or radiators connected to the transformer tank. This is known as radiator of transformer or radiator bank of transformer. We have shown below a simplest form on natural cooling or ONAN cooling arrangement of an earthing transformer below.



- **ONAF Cooling of Transformer**

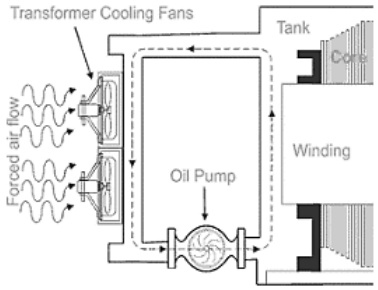
Heat dissipation can obviously be increased, if dissipating surface is increased but it can be make further faster by applying forced air flow on that dissipating surface. Fans blowing air on cooling surface is employed. Forced air takes away the heat from the surface of radiator and provides better cooling than natural air. The full form of ONAF is "Oil Natural Air Forced". As the heat dissipation rate is faster and more in ONAF transformer cooling method than ONAN cooling system, electrical power transformer can be put into more load without crossing the permissible temperature limits.



- **OFAF Cooling of Transformer**

In oil forced air natural cooling system of transformer, the heat dissipation is accelerated by using forced air on the

dissipating surface but circulation of the hot oil in transformer tank is natural convectional flow.



Oil Forced Air Forced or OFAF Cooling of Transformer

The heat dissipation rate can be still increased further if this oil circulation is accelerated by applying some force. In OFAF cooling system the oil is forced to circulate within the closed loop of transformer tank by means of oil pumps. OFAF means "Oil Forced Air Forced" cooling methods of transformer. The main advantage of this system is that it is compact system and for same cooling capacity OFAF occupies much less space than farmer two systems of transformer cooling. Actually in oil natural cooling system, the heat comes out from conducting part of the transformer is displaced from its position, in slower rate due to convectional flow of oil but in forced oil cooling system the heat is displaced from its origin as soon as it comes out in the oil, hence rate of cooling becomes faster.

- **OFWF Cooling of Transformer**

We know that ambient temperature of water is much less than the atmospheric air in same weather condition. So water may be used as better heat exchanger media than air. In OFWF cooling system of transformer, the hot oil is sent to oil to water heat exchanger by means of oil pump and there the oil is cooled by applying sowers of cold water on the heat exchanger's oil pipes. OFWF means "Oil Forced Water Forced" cooling in transformer.

- **ODAF Cooling of Transformer**

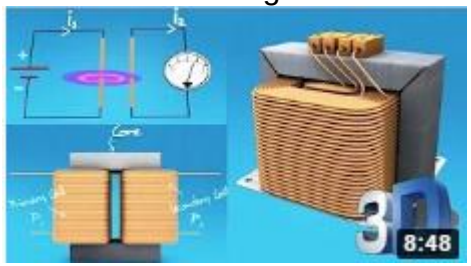
ODAF or oil directed air forced cooling of transformer can be considered as the improved version of OFAF. Here forced circulation of oil directed to flow through predetermined paths in transformer winding. The cool oil entering the transformer tank from cooler or radiator is passed through the winding where gaps for oil flow or pre-decided oil flowing paths between insulated conductors are provided for ensuring faster rate of heat transfer. ODAF or oil directed air forced cooling of transformer is generally used in very high rating transformer.

- **ODWF Cooling of Transformer**

ODAF or oil directed water forced cooling of transformer is just like ODAF only difference is that here the hot oil is

cooled in cooler by means of forced water instead of air. Both of these transformer cooling methods are called forced directed oil cooling of transformer.

To see working of transformer please use the website address given below



https://www.youtube.com/watch?v=U3CubKnkO4c

- **Describe procedure for identification and safe removal of faulty coils from transformer limb of the core / coil assembly**

  To remove faulty coil, following procedure should be adopted.

  - ✓ Remove cover of transformer tank.
  - ✓ Remove the whole core structure out of tank
  - ✓ Remove Tap changer.
  - ✓ Locate the faulty coil by visual inspection.
  - ✓ Confirm the faulty coil after performing test.
  - ✓ Remove the upper limb of transformer core
  - ✓ Pull out the faulty coil from transformer limb.
  - ✓ Perform appropriate numbering on faulty coil.

To see video of Dismantling of faulty coils use the website address shown below

https://www.youtube.com/watch?v=GMQjUa9GByc&t=189s

- **State Importance of proper placing of faulty coils**

After removing the faulty coils from the transformer core limbs, it is required to place them properly in workshop store. Proper placing address (such as in rack # 12) should be recorded in repair job sheet. This will facilitate to locate quickly the faulty parts when it is necessary to perform rewinding.

- **State importance of updating record**

Updating record will facilitate you to prepare same exact size coil, which is essential for proper working of repaired transformer.

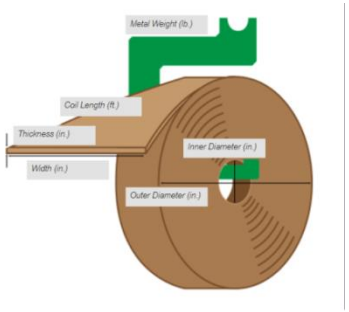
LU3. Compile data of Faulty Transformer Coil / Coils

- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe method of taking dimensions (Height, inner & outer diameter) of coil / coils**
  - **Size of winding wire**

- **No of turns of coil**

  Dimensions of faulty coils of transformer are measured with;

  - ✓ Inside caliper (Inner diameter of coil)
  - ✓ Outside caliper (Outer diameter of coil)
  - ✓ Measuring tape (Height of coil)
  - ✓ SWG or Micro meter or Vernier Caliper (Size of winding wire)
  - ✓ Counting turns in one layer and multiplying with number of layers

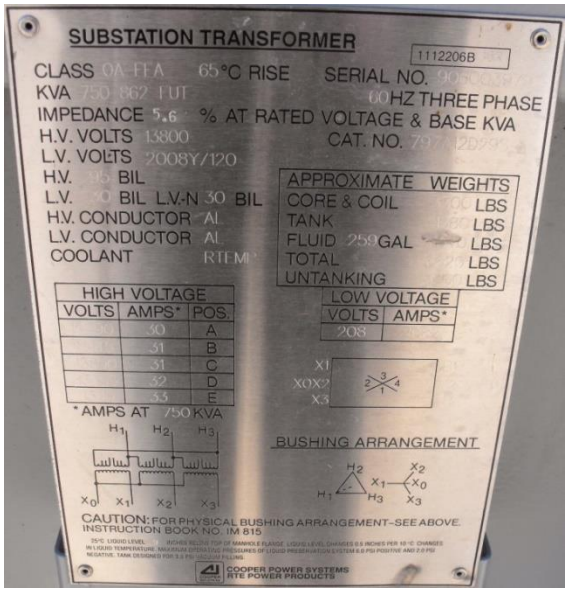


- **Describe method of collecting the data from name plate of transformer**

In present Day, you can find the following minimum information and Data on a transformer nameplate. The following information and data for above 500 kVA transformers:

• Name of manufacturer
• Serial number
• Year of manufacture
• Number of phases
• KVA or MVA rating
• Frequency
• Voltage ratings.
• Tap voltages.
• Connection diagram.
• Cooling class
• Rated temperature in °C
• Polarity (for Single Phase Transformers)
• Phasor or vector diagram (For Polyphase or Three Phase Transformers)
• % impedance.

• Approximate mass or weight of the transformer
• Type of insulating liquid.
• Conductor material of each winding.
• Oil volume (of each transformer Container/Compartment)
• Instruction for Installation and Operation



- **Procedure of compiling data of faulty coil / coils of transformer**
  Data of faulty coil / coils of transformer such as coil size (Inner & outer diameters, length of coil), number of layers, number of conductors per layer, weight of coil, size of winding wire, insulation class are collected / measured and recorded in repair history sheet.
- **State importance of updating record**

Updating record will facilitate you to prepare same exact size coil, which is essential for proper working of repaired transformer.

LU4.Collect the required Materials for Re-winding

- **Demonstration regarding selection & use of required Tools, equipment & PPEs**

- **Procedure for preparation of estimate of required material for rewinding and its collection**

For estimating a quantity and cost of rewinding of faulty coils of a transformer, the method comprising:
(a) Receiving data of faulty coil (Size of wire, weight of wire, dimensions of coil etc.);
(b) Calculating quantity of winding wire required for rewinding
(c) Calculating quantity of insulating paper, press board etc.
(d) Receiving a unit price for each of the corresponding material
(e) Calculating estimated cost for repair
(f) Preparing an estimated budget report of the quantity and cost of the corresponding materials based on the estimated cost.

Sr. #	Specifications of required material	Required Quantity	Measuring Unit	Rate / Unit	Cost
1	Enameled copper winding wire 16 SWG	10	Kg	1500/-	15000/-
2	Latheroid paper # 10	10	$Ft.^2$	250/-	2500/-
3	Cotton Tape	2	Roll	50/-	100/-
4	Thread	1	Roll	100/-	100/-
5	Varnish	5	Quarter	300/-	1500/-
6	Press Board	10	$Ft.^2$	850/-	8500/-
Grand Total					**27700/-**

- **State importance of updating record**

Updating record will facilitate you to prepare list of material required, its cost and estimate of repair cost, which is essential for doing the repair of transformer.

LU5.Prepare Former for Coil Winding

- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe method of preparing coil former and its size verification as per coil size**

✓ To prepare coil farmer follow the given process;
✓ Measure the inner and outer diameter of coil.
✓ Check the sizes of coil former available in workshop.
✓ If relevant size is not available, then prepare it or get it prepared from wood shop.
✓ Verify its size by measurement from outside caliper or by putting the faulty coil of former.

LU6. Prepare Coil on Winding Machine

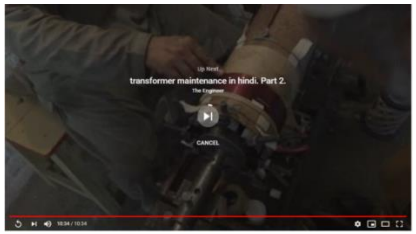
- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe method of preparing coil on winding machine:** To prepare HT & LT coils on winding machine, follow the process elaborated below.

- ✓ Arrange relative winding material (Winding wire, insulation paper, cotton tape, varnish)
- ✓ Fix former on winding machine
- ✓ Perform Wrapping process of winding wire layers to form coil up to required size
- ✓ Perform Tapping of leads
- ✓ Perform Soldering / brazing of tapping end joints
- ✓ Perform Checking continuity of coil
- ✓ Perform Binding of coil
- ✓ Remove former from winding machine
- ✓ Remove coil from former

To see the preparation of HT coils please use the website address shown with picture.

Automatic transformer coil winding machine with paper strip winding

https://www.youtube.com/watch?v=MCaWwUcODZc



https://www.youtube.com/watch?v=j5zw658-Bdw&t=33s

To see the preparation of LT coils please use the website address shown with picture.

LV Coil Winding Machine For Distribution Transformers

https://www.youtube.com/watch?v=ZGM0CB0axZM

https://www.youtube.com/watch?v=K914C9DoI50

LU7. Re- Assemble the Coil on Core

- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe method of inserting coil on core limb:**
  - **Coil insertion on core limb**
  - **Re-assemble of upper limb of core**
  - **Fitting of channel of core**
  - **Fixing of channel of core**

  After rewinding the faulty coils, following sequence is used to complete the core assembly.
  - ✓ Insert LT coil in relevant limb of transformer core, and then insert HT coil over LT coil.
  - ✓ Put wedges between LT & HT coils to fasten them and to leave a channel for free flow of transformer oil.
  - ✓ Re-assemble upper limb of core.
  - ✓ Reassemble and fix core channel.
  - ✓ To see video please use website address given below

https://www.youtube.com/watch?v=3-HfRB8DsGE&t=17s

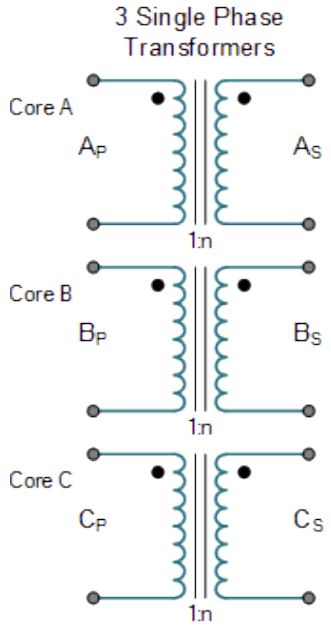
LU8. Make Connections as per rating plate of Transformer

- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Describe method of making connections as per data / rating plate of transformer**

Three Phase Transformer Connections

The primary and secondary windings of a transformer can be connected in different configuration as shown to meet practically any requirement. In the case of *three phase transformer* windings, three forms of connection are possible: “star” (wye), “delta” (mesh) and “interconnected-star” (zigzag).

The combinations of the three windings may be with the primary delta-connected and the secondary star-connected, or star-delta, star-star or delta-delta, depending on the transformers use.



Primary Configuration	Secondary Configuration
Delta (Mesh)	Delta (Mesh)
Delta (Mesh)	Star (Wye)
Star (Wye)	Delta (Mesh)
Star (Wye)	Star (Wye)
Interconnected Star	Delta (Mesh)
Interconnected Star	Star (Wye)

Three Phase Transformer Star and Delta Configurations

But what do we mean by “star” (also known as Wye) and “delta” (also known as Mesh) when dealing with three-phase transformer connections. A three phase transformer has three sets of primary and secondary windings. Depending upon how these sets of windings are interconnected, determines whether the connection is a star or delta configuration.

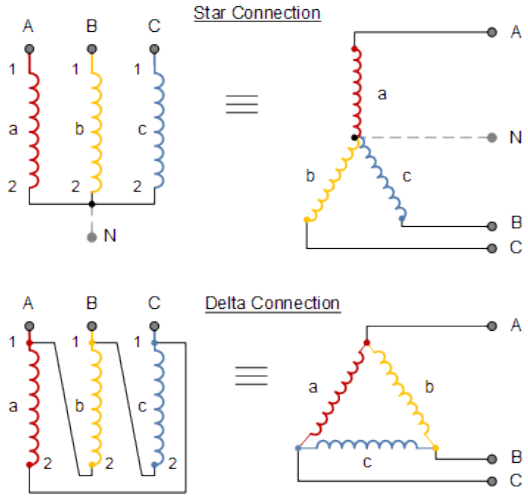
The three available voltages, which themselves are each displaced from the other by 120 electrical degrees, not only

decided on the type of the electrical connections used on both the primary and secondary sides, but determine the flow of the transformers currents.

With three single-phase transformers connected together, the magnetic fluxes in the three transformers differ in phase by 120 time-degrees. With a single the three-phase transformer there are three magnetic fluxes in the core differing in time-phase by 120 degrees.

The standard method for marking three phase transformer windings is to label the three primary windings with capital (upper case) letters A, B and C, used to represent the three individual phases of RED, YELLOW and BLUE. The secondary windings are labeled with small (lower case) letters a, b and c. Each winding has two ends normally labeled 1 and 2 so that, for example, the second winding of the primary has ends which will be labeled B1 and B2, while the third winding of the secondary will be labeled c1 and c2 as shown.

Transformer Star and Delta Configurations



Symbols are generally used on a three phase transformer to indicate the type or types of connections used with upper case Y for star connected, D for delta connected and Z for interconnected star primary windings, with lower case y, d and z for their respective secondary's. Then, Star-Star would be labeled "Yy", Delta-Delta would be labeled "Dd" and interconnected star to interconnected star would be "Zz" for the same types of connected transformers.

State jointing / brazing method of coil connection with tap changer and transformer bushing:

For jointing coil connection between coils and between coils & tap changer is performed by copper phosphorus brazing alloys. Self-fluxing copper based brazing alloys containing phosphorus thereby facilitating brazing on copper to

copper in air without the use of a flux. Use of flux recommended for copper alloys like brass and bronze. For improved ductility and electrical conductivity silver containing lower phosphorus alloys also used. These alloys are available in a wide range of compositions to suit specific applications in Wires and Rods, Strips, Wire Flattening, Wire Preforms, Strip Preforms, Granules and Spheres, Copper Winding Wires (Bare & Enameled).

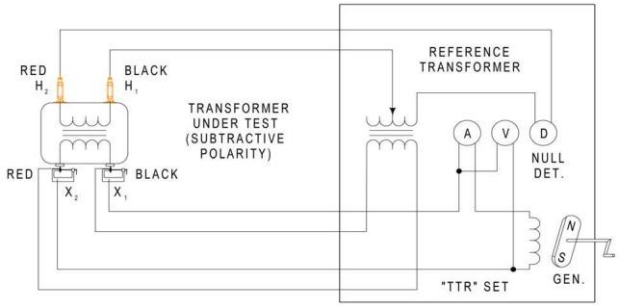
To see the video about transformer connections, use website address given below.

https://www.youtube.com/watch?v=K5VWoSLQD8c

LU9. Calculate Turn Ratio of Transformer

- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Define transformer turn ratio (TTR) and its importance in transformer working, its method of calculation**

  The Transformer Turns Ratio (TTR) method compares the test transformer ratio with an adjustable-ratio standard transformer by using a null balance detector to determine when the standard transformer ratio is the same as the test transformer. During test procedures transformer polarity is determined by comparison with the standard transformer.



A TTR test should be made for any new high-voltage power transformer at the time it is being installed. This test is also desirable for any transformer that has been overhauled or relocated.

Note: TTR is the preferred ratio method as its accuracy is 0.1%. All maintenance districts use the TTR data as a diagnostic base when performing transformer maintenance. The Voltmeter method is also used because it is an excellent test for verifying the proper tap changer make and break, and is easily converted to the impedance test setup that follows.

TTR Operation

Excitation current and voltage are supplied by two separate test lead pairs attached to the secondary of the transformer, and a third pair of test leads monitors the primary voltage. These quantities are fed into the test set null detector. As the hand-crank generator is operated at moderate speed, the bridge-like TTR controls are manipulated to obtain a "null." The final balance point appears as dial readout when the null is attained while cranking out a steady eight-volt excitation level.

A relatively simple and straightforward description of how to connect and operate the TTR set can be found in a small instruction book usually stored inside the test lead storage compartment. Brief operational instructions are also glued to the inside of the test set lid. The instructions illustrate the test connections, etc. Winding connections may have to be swapped side for side on some transformers if excitation requirements are too high.

The test set built-in hand-crank generator provides a repeatable, stable, sinusoidal test voltage. Power system interference is minimized by the frequency of the generator and power systems. However, if the adjacent bay is energized or if there is an energized line overhead, ground one bushing terminal of each test winding being measured and ground the TTR tester with its ground terminal. Follow the manufacturer’s instructions for the use of the TTR set and observe the following precautions:

Tap ratios should be pre-calculated so that test readings can be quickly evaluated. Data sheets should be filled out as completely as possible ahead of time. The best place to record the TTR test data is on the Power Transformer Test Record sheet, next to the voltage ratio test readings. The advantage of recording TTR data on this sheet is that it can be conveniently compared to the expected ratio values, which can be calculated from the recorded transformer nameplate data. Recording information in this manner serves to keep similar types of data together and eliminates the need for another data sheet.

The TTR basically operates as a very accurate bridge (analogous to the Wheatstone Bridge). Measurements are dependent on the winding ratio between the excited winding and the measured winding. The test results are repeatable, a fact which makes data obtained from this test significant. This data is most useful for analyzing transformer problems where a shorted turn is suspected.

ELECTRICAL MACHINE WINDING TECHNICIAN

Module-F

LEARNER GUIDE

National Vocational Certificate Level 3

Version 1 - September, 2018

LU10. Conduct Baking of live part/Coil Assembly of Transformer

- **Demonstration regarding selection & use of required Tools, equipment & PPEs**
- **Define importance of baking of transformer winding and process of baking in oven**

Module F: 0713001134 Carry out Re- Assembly of Machine

Objective: This Modulecovers the knowledge & skills required to Carry out Re- Assembly of Machine through Prepare for work , Arrange parts of the Machine , Re- Assemble the Machine , Ensure Quality of Repair Work , Ensure safe storing/placing of Machine , Tag the Machine ready for delivery ,

Duration: 70 Hours **Theory: 14 Hours** **Practice: 56 Hours**

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1: **Prepare for work to carryout re- assembly of machine**	**The trainee will be able to:** • Identify the required PPE's • Collect the required PPE's • Identify the required tools and equipment • Collect the required tools and equipment	Recognition of required Tools, Equipment and PPEs for carrying out re-assembly of machine • • Importance of functional conditions of required	**Tools** • Spanner Set • Screw Driver Set • Allen key Set • Clamp Meter • Safety Belt

	• Ensure functional condition of PPE's/Tools and equipment • Ensure safe working conditions ➢ Clear Passage ➢ Cleanliness ➢ Adequate light ➢ Ventilation	Tools, Equipment and PPEs and their use • Importance of safe working condition regarding • Clear passage • Cleanliness • Adequate light • Ventilation	**Consumables Items** • Hand Gloves • Safety Shoes • Safety Goggles
LU2:Arrange parts of the Machine	**The trainee will be able to:** • Identify the required parts of machine • Collect the required parts • Count total number of parts for deficiency • Arrange parts of the machine in sequential order	• Demonstration regarding selection & use of required Tools, equipment & PPEs • State importance of arranging parts in sequential order to reassemble machine	**Tools** • **Consumable Material** • Ball pen and paper
Lu3:Re-assemble the Machine	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Collect parts of machine in sequential order • Perform Re-assembling of machine as per numbering of parts: • Adjust/Align parts of machine as per marking	• Demonstration regarding selection & use of required Tools, equipment & PPEs • Describe process of re-assembling of machine: ➢ Matching numbering of parts ➢ Putting parts in sequential order ➢ Adjusting / aligning parts of machine	**Tools** • Spanner set • Screw driver set • Allen Key set • Hammer • Mallet / rubber hammer • Grease gun • Bearing puller **Consumable Material** • Ball pen and

	• Verify tightening of nut bolts with torque Wrench	➢ Final checking of tightening of bolts	paper • Grease • Cotton Waste • Cotton gloves
LU4: Ensure Quality of Repair Work	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Perform physical inspection of the Re-Assembled Machine • Perform Megger test of machine • Energize/Power Up the machine • Perform test run of machine ➢ Observe vibration ➢ Observe sound ➢ Measure Input current ➢ Observe Heat ➢ Check output	• Demonstration regarding selection & use of required Tools, equipment & PPEs • State importance of physical inspection of re-assembled machine • Describe Megger testing of machine • State advantages of test run of machine • Describe observations observed during test run of machine: ➢ Vibration ➢ Sound ➢ Heating ➢ Measurement of input current ➢ Checking of output	**Tools** • AVO meter • Megger • Clamp on meter • Thermometer • Tachometer • Series test board **Consumable Material** • Ball pen and paper
LU5. Ensure safe storing/placing of Machine	**The trainee will be able to:** • Wear the required PPE's • Pick the required tools and equipment • Prepare site for safe storage of machine	• Demonstration regarding selection & use of required Tools, equipment & PPEs • State importance of safe shifting of machine from workbench to store	**Tools** • Use proper mean of transportation for safe shifting **Consumable Material**

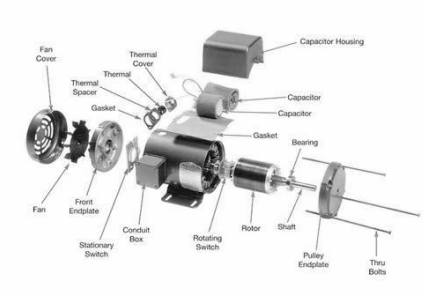
	• Collect machine from workbench • Shift machine to the safe storing site • Ensure safe storing/placing of machine	• State importance of safe storing / placing of machine in store	• Plastic sheet to cover the machine • Wooden wedges • Old used tyres
LU6. Tag the Machine ready for delivery	**The trainee will be able to:** • Prepare delivery tags • Identify the machine to be tagged • Tag the machine • Update record • Prepare final bill of repair • Communicate client/customer regarding readiness of machine	• State importance of delivery tag • Describe process of making final bill after communication with the client	**Tools** **Consumable Material** • Tag • Ball point • Permanent ink marker

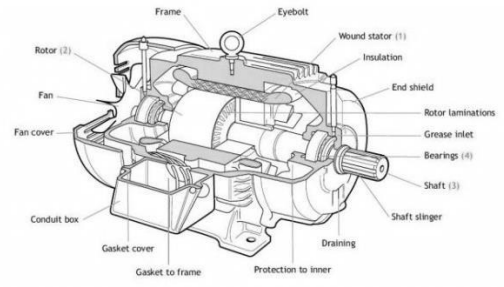
LU1: Prepare for work to carryout re- assembly of machine • Importance of functional conditions of required Tools, Equipment and PPEs and their safe storage after use • Importance of safe working condition regarding ➢ Clear passage ➢ Cleanliness ➢ Adequate light ➢ Ventilation
LU2: Arrange parts of the Machine • Demonstration regarding selection & use of required Tools, equipment & PPEs • State importance of arranging parts in sequential order to reassemble machine

MAIN PARTS OF MOTOR:

In figures below all parts of single phase and three phase electric motors are shown. Major parts are:

1. Stator (Core and winding)
2. Rotor (Core and winding)
3. Shaft
4. Bearings
5. Frame / Body / Yoke
6. End shields / covers
7. Terminal box (Conduit box)
8. Eyebolt
9. Fan
10. Capacitor & Centrifugal switch





Lu3: Re-assemble the Machine

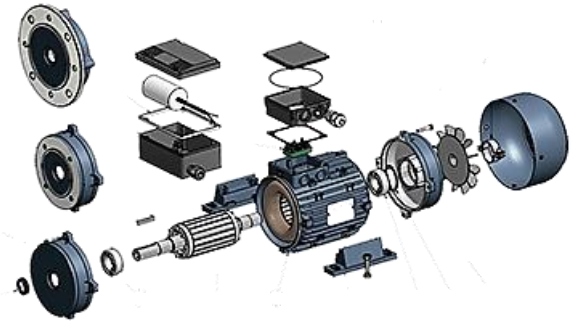
- Demonstration regarding selection & use of required Tools, equipment & PPEs
- Describe process of re-assembling of machine:
  - Matching numbering of parts
  - Putting parts in sequential order
  - Adjusting / aligning parts of machine
  - Final checking of tightening of bolts

REASSEMBLY OF MOTORS:

Reassemble in reverse order of disassembling.

1. Clean all parts, brush or blow out any built up dust and dirt and thoroughly clean the shaft, bushings. Re lubricate using electric motor oil for plain bearings and light grease for non-sealed ball / roller bearings. Badly worn ball bearings must be replaced.

2. Refit flat washers or spacers that were present on the shaft(s) or stuck to the bushings or bearings at their mark down exact location during disassembly.
3. Refit the end plate on the power (long shaft) end. Refit the end plate on the non-power shaft end. Use a soft mallet if necessary to gently close the two halves or end of the motor until they are in exactly the same orientation with the alignment marks present on their ends which were marked with indelible pen during dismantling.
4. Screw the nuts or bolts that hold the end plates together. Tighten the nuts or bolts evenly and securely but do not over tight.
5. Connect the load - fan blades, gears, pulleys, etc.
6. Connect the power wiring accordingly.



RE-ASSEMBLING OF TRANSFORMER: To see re-assembling process please use the website address given below.

https://www.youtube.com/watch?v=9Y958Vc5ohI

LU4: Ensure Quality of Repair Work

- Demonstration regarding selection & use of required Tools, equipment & PPEs
- State importance of physical inspection of re- assembled machine
- Describe Megger testing of machine
- State advantages of test run of machine
- Describe observations observed during test run of machine:
  - Vibration
  - Sound
  - Heating
  - Measurement of input current
  - Checking of output

After repair of machine, a test run is performed in which you observe / check / measure the values vibration, sound, heat, input current etc. This helps you to ensure good repair work. You can see the test run procedure by using the website address given below.

https://www.bing.com/videos/search?q=general+electric+motor+test+run&&view=detail&mid=D169921AEF1C9AA01048D169921AEF1C9AA01048&&FORM=VRDGAR

LU5. Ensure safe storing/placing of Machine

- Demonstration regarding selection & use of required Tools, equipment & PPEs
- State importance of safe shifting of machine from workbench to store

It is very important to shift the repaired machine from work bench to store safely. For safe shifting load moving skates are used to transport heavy machinery and other items in the work area. Machinery skates mainly use nylon, polyurethane or steel wheels / castors and work though are also less often fitted with roller tracks, like tank tracks (Economical and ideal for general workshop moving jobs, all types of machine tools, fabrication etc.). Mostly materials

skates are designed to be manually maneuvered (push / Pull), or assisted by a tug or fork truck. Materials load moving skates work best on a flat smooth surface free from dirt or other obstructions.

State importance of safe storing / placing of machine in store

When machines are received from the workshop work bench after repair or reallocated from another location it is necessary to;

- ✓ Verify that each machine is dry,
- ✓ No damage has occurred during shifting,
- ✓ Internal connections have not been loosened, and the machine is ready for service.
- ✓ Locate some proper place to store the machine in store
- ✓ Place safely the machine at this allocated place in store
- ✓ Cover the machine to prevent it from dust
- ✓ Tag regarding delivery

LU6. Tag the Machine ready for delivery

- State importance of delivery tag

  When a machine is ready to deliver to client after successfully completion of repair work, it is properly tagged. In its tag major repair work done are shown such as;

  In motor;

  - ✓ Rewinding
  - ✓ Change of bearing
  - ✓ Alignment of shaft

  In transformer;

  - ✓ Rewinding of HT Coil
  - ✓ Repair of tap changer
  - ✓ Filtration of transformer oil

ELECTRICAL MACHINE WINDING TECHNICIAN

Module-G
LEARNER GUIDE
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- **Describe process of making final bill after communication with the client:**

After the completion of repair work final bill is prepared showing detail of repair cost of machine:

- ✓ Material cost
- ✓ Transportation cost
- ✓ Labour cost
- ✓ Overhead charges
- ✓ Profit margin

Bill of accumulative cost for repair of machine includes;

Sr. #	Detail of cost	Amount
1	Material cost	12100/-
2	Transportation cost	6000/-
3	Labour cost (Services)	13600/-
4	Overhead charges	1250/-
5	Profit margin	4500/-
6	Income tax at services @ 17%	2312/-
7	Sales tax at material cost @ 17.5%	2118/-
Total claim		**41880/-**

ELECTRICAL MACHINE WINDING TECHNICIAN

Module-H
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Module G: Apply Work Health and Safety Practices (WHS)

Objective:

Duration: 30 Hours **Theory: 6Hours** **Practice: 24 Hours**

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1. Implement safe work practices at work place			
LU2. Participate in hazard assessment activities a work place			
LU3. Follow emergency procedures at workplace			
LU4. Participate in OHS consultative processes			

ELECTRICAL MACHINE WINDING TECHNICIAN

Module-I

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Module H: Identify and Implement Workplace Policy and Procedures

Objective:

Duration: 20 Hours **Theory: 4Hours** **Practice:16 Hours**

Learning Unit	Learning Outcomes	Learning Elements	Materials
			Required
LU1. Identify workplace policy & procedures			
LU2. Implement workplace policy & procedures			
LU3. Communicate workplace policy& procedures			
LU4. Review the implementation of workplace policy & procedures			

ELECTRICAL MACHINE WINDING TECHNICIAN

Module-J

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Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1. Communicate within the organization			
LU2. Communicate outside the organization			
LU3. Communicate effectively in workgroup			
LU4. Communicate in writing			

Module J: Perform Computer Application Skills

Objective:

Duration: 40 Hours **Theory:8 Hours** **Practice: 32 Hours**

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1. Prepare In-page documents as per required information			
LU2. Prepare Spreadsheets as per required information			
LU3. Use MS Office as per required information			
LU4. Perform computer graphics in basic applications			
LU5. Create Email account for communications			

ELECTRICAL MACHINE WINDING TECHNICIAN

Module-K
LEARNER GUIDE
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Version 1 - September, 2018

Module K: Manage Personal Finances

Objective:

Duration: 30 Hours **Theory: 6 Hours** **Practice: 24 Hours**

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1. Develop a personal budget			
LU2. Develop long term personal budget			
LU3. Identify ways to maximize future finances			

Summary of Modules

Module	Learning Unit	Duration
Module A: Disassemble Machine at Workshop **Aim:** The aim of this module is to develop basic knowledge, skills and understanding required to shift machine to the work bench, Perform marking for Positions of Parts, Perform numbering on Machine parts as per Inventory Record, Remove the faulty parts and Ensure safe and Sequential Placing of healthy parts of Machine	**LU1.** Prepare for work to disassemble machine at workplace **LU2.** Shift Machine to work Bench **LU3.** Perform marking for Positions of Parts **LU4.** Perform numbering on Machine parts as per Inventory Record **LU5.** Remove the Faulty Parts **LU6.** Ensure safe and Sequential Placing of healthy parts of Machine	90 hours

Module	Learning Unit	Duration
Module B: **Diagnose fault of machine (motor)** **Aim:** The aim of this module is to develop basic knowledge, skills and understanding required to Diagnose fault of machine (motor) through checking alignment of rotar shaft, bearing bush of machine and identify faulty parts of machine.	**LU1.** Prepare for work to diagnose fault of machine (Motor) **LU2.** Verify pre inspection test results of machine **LU3.** Check Alignment of Rotor Shaft **LU4.** Check Bearing/ Bush of Machine **LU5.** Update Test Results of Machine **LU6.** Identify the Faulty Parts of Machine	90

Module	Learning Unit	Duration
Module C:Estimate Repair/Replacement Cost **Aim:** The aim of this module is to develop basic knowledge, skills and understanding required to estimate the accumulative cost of repair on machine and liaise with the client/customer on the said repair cost of the machine.	**LU1.** Prepare for work to estimate repair/replacement cost **LU2.** Estimate Cost of the required Materials **LU3.** Estimate Transportation Charges **LU4.** Estimate Labour Cost of the materials **LU5.** Calculate accumulative cost of the materials **LU6.** Liaise with client/customer on repair cost **LU7.** Arrange the required Materials/Parts	50

Module	Learning Unit	Duration
Module D: **Perform Motor Rewinding** ○ **Aim:** The aim of this module is to develop basic knowledge, skills and understanding required to Perform Motor Rewinding through removing the coils,preparation of core for rewinding,interpretation of winding diagram,making of Former for coil winding,setting of coils in the core slots,interlinking of coils as per number of poles, binding of coils and baking of winding.	**LU1.** Prepare for work to perform motor rewinding **LU2.** Shift Faulty part of Motor to work Bench **LU3.** Remove the Winding Coils **LU4.** Collect the required Materials for Rewinding **LU5.** Prepare Core for Rewinding **LU6.** Interpret Wiring Diagram **LU7.** Make a Former for Coil Winding **LU8.** Prepare Coil Winding Machine for Rewinding **LU9.** Set the Coils in the Core slots **LU10.** Interlink Coils as per number of Poles **LU11.** Perform Winding Tests **LU12.** Perform Binding of Coils **LU13.** Conduct Baking of Winding **LU14.** Verify Winding Tests	110

Module	Learning Unit	Duration
Module E: Perform Transformer Rewinding ○ **Aim:** The aim of this module is to develop basic knowledge, skills and understanding required to Perform Transformer winding through collection of coils,preparation of Former for coil winding,Reassembly of coils on the core ,making connections as per rating plate of transformer,calculation of transformer turn ratio and baking of live part/coil assembly of transformer.	**LU1.** Prepare for work to perform transformer rewinding **LU2.** Collect Faulty Coil of Transformer **LU3.** Compile data of Faulty Transformer **LU4.** Collect the Materials required for Winding **LU5.** Prepare a Former for Coil Winding **LU6.** Prepare Coil on Winding Machine **LU7.** Re- Assemble the Coil on Core **LU8.** Make Connections as per rating plate of Transformer **LU9.** Calculate Turn Ratio of Transformer **LU10.** Conduct Baking of live part/coil of Transformer	110

Module	Learning Unit	Duration
Module F: Carry out Re-Assembly of Machine **Aim:** The aim of this module is to develop basic knowledge, skills and understanding to Carry out Re- Assembly of Machine.	**LU1.** Prepare for work to carryout re-assembly of machine **LU2.** Arrange parts of the Machine **LU3.** Re- Assemble the Machine **LU4.** Ensure Quality of Repair Work **LU5.** Ensure safe storing/placing of Machine **LU6.** Tag the Machine ready for delivery	70
Module G: Apply Work Health and Safety Practices (WHS) **Aim:** The aim of this module is to develop basic knowledge, skills and understanding required to apply Work Health and Safety Practices (WHS) imperative to maintain safe and healthy environment at the work place.	**LU1. Implement safe work practices at work place** **LU2. Participate in hazard assessment activities a work place** **LU3. Follow emergency procedures at workplace** **LU4. Participate in OHS consultative processes**	30
Module H: Identify and Implement Workplace Policy and Procedures **Aim:** The aim of this module is to develop basic knowledge, skills and understanding required to identify and implement work place policy and procedure in the work shop.	**LU1. Identify workplace policy & procedures** **LU2. Implement workplace policy & procedures** **LU3. Communicate workplace policy& procedures** **LU4. Review the implementation of workplace policy & procedures**	20

Module	Learning Unit	Duration
Module I: Communicate at Workplace **Aim:** The aim of this module is to develop basic knowledge, skills and understanding required to communicate within and outside the organization effectively.	**LU1. Communicate within the organization** **LU2. Communicate outside the organization** **LU3. Communicate effectively in workgroup** **LU4. Communicate in writing**	30
Module J: Perform Computer Application Skills **Aim:** The aim of this module is to develop basic knowledge, skills and understanding required to Perform Computer Application Skills for preparation of in page ,spreadsheet,MS Office documents,computer garphics and creation of email account.	**LU1. Prepare In-page documents as per required information** **LU2. Prepare Spreadsheets as per required information** **LU3. Use MS Office as per required information** **LU4. Perform computer graphics in basic applications** **LU5. Create Email account for communications**	40 hours

Module	Learning Unit	Duration
Module K: Manage Personal Finances **Aim:** The aim of this module is to develop basic knowledge, skills and understanding to Prepare personal budget and identify ways to maximize future Finances.	**LU1. Develop a personal budget** **LU2. Develop long term personal budget** **LU3. Identify ways to maximize future finances**	30 hours

Test Yourself (Multiple Choice Questions)

Level- 3

Please mark the correct one from the given options.

Q : Select the appropriate answer.

1- At what sequential order marking operation is performed in bench work?

a)- 4th b)- 3rd c)- 2nd d)- 1st

2- **In what direction stroke of hacksaw, cutting takes place?**

a)- Forward b)-Backward c)- Both a & b d)- In any one direction

3- **What are the number of teeth per square inch in smooth file?**

a)- 20 b)- 30 c)- 40 d)- 50

4- **What is the name of process which produces holes?**

a)- Cutting b)- Reaming c)- Drilling d)- Riveting

5- What will be the equivalent of One (1)meter in d**ecimeters :**

a)- 0.1 b)- 10 c)-100 d)- 1000

6- What will be the equivalent of 7 feet in meter ?

a)- 0.0214 b)- 0.214 c)- 2.14 d)- 21.4

7- **On standard wire gauge sizes ranges from 0 to:**

a)- 30 b)- 32 c)- 34 d)- 36

8- **When using try square, the blade is positioned ,compared to the edge, at a degree of:**

a)- 30 b)- 60 c)- 90 d)- 120

9- Electrical energy is converted in to mechanical energy by ?

a) Generator b) Alternator c) Transformer d) Motor

10- Which of the below motor can work both on AC & DC supply?

a) Synchronous b) Universal c) Induction d) Shunt

11- Field and armature are connected in parallel in:?

a) Series motor b) Compound motor c) Shunt motor d) Shaded pole motor

12- The phase displacement in three phase supply is?

a) 30º b) 60º c) 90º d) 120º

13- in which of the below motor starter timer is used?

a) Automatic star delta starter b) Manual star delta starter
c) Direct on line starter d) 3 point starter

14- When conductor cuts a magnetic flux; emf is induced in to it?

a) Lenz law b) Faraday's law c) Kirchhoff's law d) Ohm's law

15-Formula of induced emf is :

a) E= B v / l b) E= B l / v c) E= B / l v d) E= B l v

16- Phase and line voltages are same in:

a) Star Connection b) Series Connection c) Delta Connection d) Parallel Connection

17- Which one of the following is used to control fan speed?

a) Capacitor b) Regulator c) Choke d) Relay

18- Which one of the below measuring instruments is used to measure insulation resistance of winding?

a) Ohmmeter b) Ammeter c) Megger d) AVO meter

19- Which one of the below meters is used to measure current flowing without cutting the wire:

a) Ammeter b) Tachometer c) Growler d) Tong tester

20-Speed of motor is measured with:?

a) Ammeter b) Tachometer c) Growler d) Tong tester

21-Voltage is measured with :

a) Ohmmeter b) Ammeter c) Megger d) AVO meter

22-The device mostly used for measuring winding size of wire is :

a) SWG b) Steel rule c) Vernier caliper d) Growler

23-Winding wires are made up of ?

a) Copper b) Iron c) Silver d) Gold

24-which of the below tools is used to cut insulation paper?

a) Scriber b) Steel rule c) Scissors d) Files

25-Series board is used for:

a) Supply of motor b) Testing of motor c) Setting of motor d) Protection of motor

26-The distance between two sides of coils is called:

a) Pitch b) Pole c) Slot d) Segment

27-The device mostly used for motor over load protection is :

a) Fuse b) Circuit breaker c) Switch d) Thermal relay

28-Chemical energy is converted in to Electrical energy by:

a) Cell b) Generator c) Motor d) Alternator

29-To increase Voltage, cells are connected in?

a) Parallel b) Series c) Shunt d) Cross

30-To increase current, cells are connected in?

a) Parallel b) Series c) Shunt d) Cross

31-Combination of cells is called?

a) Large cell b) Mini cell c) Battery d) Solar cell

32-Batteries must be dealt with:

a) Careless b) Hydrometer c) Ammeter d) Care

33-The unit of electrical resistance is?

a) Ampere b) Volt c) Ohm d) Watt

34-In winding wire lacing is usually made with thread made by:

a) Copper b) Aluminum c) Cotton d) Waxed linen

35-Which of the below motor has carbon brush?

a)Universal b) Capacitor Start c) Capacitor run d) Shaded pole

36-What type of material is used in making transformer core?

a)Stainless steel b) Cupper c) Aluminium d) Silicon steel

37-Which one below tests is performed to check the voltage ratio of transformer?

a) Short Circuit b) Open Circuit c) Turn Ratio d) Insulation

38-What is used to regulate the voltage of transformer?

a)Tap Changer b) Capacitor c) Buchholz Relay d) Bushings

39-What is used to provide insulation & cooling in transformer?

a) Mobil Oil b) Mineral Oil c) Kerosene Oil d) Canola Oil

40-What is used in breather to avoid entrance of moisture in transformer?

a) Simon Gel b) Fish Gel c) Petroleum Gel d) Silica Gel

Answer Key			
Number	**Answer**	**Number**	**Answer**
1	d	21	d
2	a	22	a
3	d	23	a
4	c	24	c
5	b	25	b
6	c	26	a
7	d	27	d
8	c	28	a
9	d	29	b
10	b	30	a
11	c	31	c
12	d	32	d
13	a	33	c
14	b	34	d
15	d	35	a
16	c	36	d
17	b	37	c
18	c	38	a
19	d	39	b
20	B	40	d

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