

**1. Module details****Module name****Coil Winding, Testing and Soldering****Module duration**

It is expected that students with the appropriate entry knowledge and skills will successfully complete this module in 72 - 80 hours.

**Module code**

NUE655

**Discipline code**

0703110.

**2. Module purpose**

The purpose of the module is to provide the skills necessary to receive and log faulty electrical equipment into the workshop, record essential customer information, dismantle small electric motors, wind coils and conduct simple tests, on a variety of electrical coil types, which are likely to be encountered in the repair of both static and rotating electrical machines.

**3. Prerequisites**

NBB002 Occupational Health and Safety.

NE175 Workshop Practice.

NUE058 Electrical Concepts and Applications.

**4. Relationship to competency standards**

This module provides part of the underpinning knowledge and skills in the 'Evidence Guide' of specific units of competency in the National Electrotechnology Training Package and provides similar support, where mapped, to equivalent units in the National Metals and Engineering Competency Standards. For details refer to the module to unit maps, available from NUEITAB.

**5. Content****Initial receiving, recording and dismantling process of equipment from the customer**

Recording initial details

Customer

Type of equipment

Customers description of fault

Physical details of motor: position of pulley on shaft; broken/cracked components; mark motor end shields, grease caps, pulley end and which side the terminal block is located

Dismantle electric motor

Use bearing manufacturers' manuals

**Magnetism**

Common magnetic material

Magnetic terms

Permanent magnet alloy

Basic laws of magnetism

### **Electro magnetism**

Description of term “electro magnetism”

Flemings RH rule for a conductor

Flemings RH rule for a solenoid

Purpose of iron core

Practical applications

Core shapes: U & I; E & I; Concentrated pole; Distributed pole

Difference between an AC and DC supply.

Difference between iron cores used in DC and AC circuits: solid core; laminated core

### **Insulating materials**

Purpose

Temperature ratings

Common insulating materials: Polyester film backed elephantide; Nomex; Mylar; Nomex/mylar/nomex; Dacron/mylar/dacron; cloth, tape, and adhesive tape (glass); polyester glass laminate; sheet, tape, and adhesive tape (polyester film); Bakelite paper laminates

### **Coil tests and testing instruments**

Physical inspection

Type of electrical tests and purpose

Test instruments and equipment: multimeter; series light; insulation resistance tester; wheatstone bridge

Test coils for faults

### **Types of winding wire insulation and measurement of wire**

Types of winding wire varnish covering and their temperature ratings

Varnish removal

Use of metric micrometer

### **Types of winding machines**

Identify machine types: foot pedal, variable speed, winding head fitted with a chuck; Remote foot switch on a flexible lead, variable speed fitted with a face plate; layer winding machine; computer operated

Operational safety precautions

### **Joining methods - Soft soldering**

Types of soldering irons and tips

Types of solder

Fluxes: purpose; types; dangers

Soldering process

Inspection

**Hard soldering - Silver soldering**

Advantages

Types of silver soldering wire

Types of flux

Operation and safe working procedures with the oxy acetylene welding torch

Preparation of join

Silver soldering process and inspection

**Fusing**

Advantages

Preparation of join

Fusing process and safe working procedures

**Varnishes**

Purpose

Types: air drying; baking; epoxy

Dangers

Methods of application

**Rewind small and medium size solenoid coils**

Strip and record data

Prepare/insulate coil formers

Wind each type of coil

Finishing off process

Test procedures

**Coil shapes and formers**

Coil shapes

Factors which govern coil shape: end room; coil flexibility; bore size of stator iron core; depth of iron below the slots, in the iron core; pressure points between the coils

Types coil winding formers

**Wind single coils, and coil groups, insert into iron core and test**

Record data

Manufacture for universal field coils

Coil types: universal motor field coils (single phase);

distributed concentric coil group (single phase/three phase);

distributed "D" or mush shape coil group (three phase);

distributed round end (three phase); distributed diamond shape coil group wound as individual coils (three phase)

Coil finishing: insertion into slots; taping (where applicable); connection for correct polarity

Electrical testing

## 6. Assessment strategy

### Assessment methods

Assessment should be progressive reflecting a holistic approach to ensure the module purpose is met. To assist in ensuring validity, reliability and fairness assessment instruments should include practical exercises, assignments and written tests consisting of a number of item types, such as multiple choice, short answer and problem solving.

### Conditions of assessment

Learning and assessment will take place in an environment that is conducive to a learner's development.

## 7. Learning outcome details

### Learning outcome 1

**Record all customer and equipment details upon receipt of faulty equipment in the workshop. Strip a motor and use bearing manufacturers' manuals for bearing sizes.**

### Assessment criteria

- 1.1 List the type of information which would be required, when receiving faulty equipment from a customer.
- 1.2 List the information you would record prior to dismantling an electric motor.
- 1.3 Dismantle an electric motor.
- 1.4 Remove bearings, and consult bearing manufacturers' manuals for equivalent sizes.

### Learning outcome 2

**Principles of magnetism, and electromagnetism.**

### Assessment criteria

- 2.1 State a common material which is easily magnetised.
- 2.2 Describe the term "permanent magnet," and state what common metal alloy is suitable for producing a permanent magnet.
- 2.3 State the basic laws of magnetism.
- 2.4 Describe the meaning of the term "electro magnetism".
- 2.5 Determine the direction of the magnetic field around a conductor for a given direction of current flow.
- 2.6 Determine the magnetic polarities produced by a current carrying coil, connected to a DC supply.
- 2.7 List practical examples of where electro-magnetism is utilised in electrical equipment and machines.

- 2.8 State the purpose of the iron core used in electro magnetic equipment.
- 2.9 Identify iron core shapes.
- 2.10 Define the meaning of the following terms:
  - DC supply
  - AC supply.
- 2.11 Describe the difference in core construction when a coil is connected to either an AC or DC supply.

**Learning outcome 3**

**Insulating materials, their purpose, types and ratings.**

**Assessment criteria**

- 3.1 State the purpose of an electrical insulating material.
- 3.2 State how electrical insulating materials are classified.
- 3.3 Identify six common electrical insulating materials suitable for use on solenoid coils, electric motor stator slots and coils.

**Learning outcome 4**

**Describe methods of identifying faulty coils and test coils for serviceability using appropriate test instruments.**

**Assessment criteria**

- 4.1 Describe how some faulty coils may be initially identified, by appearance and odour, before resorting to test instruments to verify the result.
- 4.2 Describe the purpose of each of the following coil tests:
  - Continuity
  - Short circuited turns
  - Insulation resistance.
- 4.3 Choose the correct test instruments, to test the suitability of a coil for service.
- 4.4 Demonstrate how to test each instrument prior to performing a test on a coil.
- 4.5 Test a selection of coils for the following faults:
  - Open circuit
  - Short circuited turns
  - Insulation resistance.

**Learning outcome 5**

**Identify different types of wire varnish covering and use a metric micrometer to measure the size of copper winding wire.**

**Assessment criteria**

- 5.1 State two common types of varnish covering used on copper winding wire and the temperature ratings of each type.
- 5.2 Demonstrate how the wire varnish covering may be efficiently removed preparatory to measuring the wire.
- 5.3 Measure copper winding wires using a metric micrometer.

**Learning outcome 6**

**Identify types of coil winding machines and describe the procedures for their safe operation.**

**Assessment criteria**

- 6.1 Identify four types of coil winding machines.
- 6.2 Describe the operational and safety precautions which must be observed while operating a coil winding machine

**Learning outcome 7**

**Join copper winding wires using the soft soldering process.**

**Assessment criteria**

- 7.1 Identify different types of soldering irons and tips.
- 7.2 State the type of solder suitable for electrical purposes.
- 7.3 State the purpose of a soldering flux.
- 7.4 State which flux is most suitable for electrical soldering purposes.
- 7.5 Describe the dangers of using the wrong type of soldering flux.
- 7.6 Demonstrate an ability to soft solder winding wire to flexible leads using the correct safety procedures.
- 7.7 Inspect the joint for faults.

**Learning outcome 8**

**Join copper winding wire and flexible leads, using the hard soldering process (silver soldering).**

**Assessment criteria**

- 8.1 State the advantages of a silver soldered joint over a soft soldered joint.
- 8.2 State the type of silver soldering wire or rod suitable for joining copper winding wire.
- 8.3 State the type of flux suitable for silver soldering copper wire.
- 8.4 Demonstrate the correct method for preparing a joint for silver soldering, then silver solder the joint using the correct safety procedures.

**Learning outcome 9**

**Demonstrate how to fuse coil connections together by using the oxy acetylene torch.**

**Assessment criteria**

- 9.1 State the advantage of fusing coil connections when compared with the other methods of joining.
- 9.2 State a disadvantage of the fusing process.
- 9.3 Demonstrate how to prepare coil connections prior to the fusing process.
- 9.4 Demonstrate how to fuse coil connections together in a safe manner, using the oxy acetylene torch.

**Learning outcome 10**

**Identify the types, applications and dangers of insulating varnishes.**

**Assessment criteria**

- 10.1 State the purpose of an insulating varnish.
- 10.2 List three types of varnish.
- 10.3 Describe the types of dangers which exist when handling insulation varnishes, and the protective measures required.
- 10.4 State four methods of applying a varnish:
  - Brush
  - Spray
  - Dip
  - Trickle.

**Learning outcome 11**

**Strip and rewind both small random wound, and medium size layer wound solenoid coils.**

**Assessment criteria**

- 11.1 Demonstrate an ability to strip and record the winding information of both small random wound and medium size layer wound solenoid coils.
- 11.2 Demonstrate an ability to assemble all materials, prepare the formers for winding then set up in the winding machine.
- 11.3 Demonstrate the ability to random wind a small solenoid coil then layer wind a medium size solenoid coil using larger diameter round or rectangular section copper wire.
- 11.4 Demonstrate the ability to perform the soldering, taping and finishing off procedures for each type of coil.
- 11.5 Demonstrate the correct procedure to test each solenoid coil for:
  - Continuity
  - Total coil resistance
  - Insulation resistance
  - Operation.

**Learning outcome 12**

**Identify common coil shapes and formers and state reasons for the use of different coil shapes.**

**Assessment criteria**

- 12.1 Identify the following coil shapes used in both single phase and three phase AC motor windings:
  - Concentrated
  - Concentric
  - Mush/"D" shape
  - Round end
  - Diamond.
- 12.2 State six factors which govern the shape of coil to be used in a particular practical situation.
- 12.3 Identify the following types of coil winding formers:
  - Moulded plastic former (small solenoid)
  - Pin formers (aluminium and masonite)
  - Adjustable gang former
  - Adjustable concentric former
  - Split wooden formers
  - Round end former.

**Learning outcome 13**

**Wind single coils and coil groups which are suitable for use in both single phase and three phase motor windings.**

**Assessment criteria**

- 13.1 Demonstrate an ability to correctly record all winding data for each type of coil to be rewound.
- 13.2 Manufacture a wooden pin former for winding coils for the universal motor.
- 13.3 Demonstrate the correct procedure for setting up and adjusting the formers for each type of coil and/or coil group winding.
- 13.4 Demonstrate an ability to correctly wind all types of coils, and or coil groups.
- 13.5 Demonstrate the correct procedures to prepare the stator to receive the coils and/or coil groups.
- 13.6 Demonstrate the correct procedures for inserting the coils/coil groups into the stator slots.
- 13.7 Demonstrate an ability to evaluate the size of the coils and/or coil groups, once inserted into the stator slots.
- 13.8 Connect single diamond shaped coils to form a coil group.
- 13.9 Demonstrate the correct procedures to electrically test the coils, and or coil groups, once they have been placed into the stator slots.
- 13.10 Demonstrate the ability to test coils or coil groups for correct polarity.

## 8. Delivery of the module

### Delivery strategy

Delivery strategies must be suitable for learning both theoretical and practical aspects described in the module purpose. It is considered that the most effective method to achieve this is by integration of theory and practice where students learn by experimentation, research and reports. It is recommended that learning and assessment be facilitated in a holistic manner that may require learning outcome sequence other than that indicated in the module.

### Resource requirements

**Electrical laboratory** with equipment suitable to perform all aspects of the magnetic and electromagnetic experiments and demonstrations.

**Workshop** will require the following types of resources:

- Standard Electrical Fitting workshop and tools

#### **Winding Equipment**

- Variable speed coil winding machines
- Commercial adjustable gang formers
  - Concentric
  - Distributed
  - Distributed round end
- Small relay/solenoid plastic formers
- Formers to suit medium size solenoid coils
- A selection of single phase, three phase stators and universal motor field cores
- Wire strainer/s

#### **Materials**

- Wood and masonite to manufacture small winding formers.
- Insulating materials for former and coil insulation such as:
  - Sheet insulation materials
  - Tapes
  - Insulated tubing
- Flexible lead with silicon rubber covering
- Wooden slot sticks
- Tapex tying string

### Occupational health and safety requirements

A safe and healthy environment will be provided for students and teachers as well as the particular safety procedures followed as part of the learning / teaching activity and content.