Ethiopian TVET-System

ELECTROMECHANICAL EQUIPMENT OPERATION AND MAINTENANCE

NTQF Level –III

Based on Feb, 2017G.C. Occupational Standard

Module Title: Maintaining Electrical Generator/ Alternator

TTLM Code: EIS EME 3 TTLM 0620v1

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This module includes the following Learning Guides

LG 29: Plan and prepare for the work

LG Code: EIS EME3 M09 LO1-LG-29

LG 30: Carry out maintenance

LG Code: EIS EME3 M09LO2-LG-30

LG31: Complete the work

LG Code: EIS EME M09LO3-LG-31

Instruction Sheet 1	Learning Guide # 29: Plan and prepare for the work

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

- Identifying and clarifying Work requirements from request/work orders
- Identifying, applying and monitoring Occupational Health and Safety standards
- identifying, obtaining and inspecting Resources to satisfy the work plan
- selecting and interpreting plans, drawings and texts
- determining, obtaining and inspecting the size, type and quantity of materials
- Resolving the Coordination requirements that affected by the work
- Preparing work area

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, up on completion of this Learning Guide, **you will be able to –**

- Identify and clarify Work requirements from request/work orders
- Identify, apply and monitor Occupational Health and Safety standards
- identify, obtain and inspect Resources to satisfy the work plan
- select and interpret plans, drawings and texts in accordance with the work plan
- determine, obtain and inspect the size, type and quantity of materials
- Resolve the Coordination requirements that affected by the work
- Prepare work area in accordance with work requirements and site procedures

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 7”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2,3,4,5,6 and 7” in each information sheets on pages 7,13,15,21,34,38 and 41.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1, 2 and 3 on pages 42,43 and 44.and do the LAP Test on page 45”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.

7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG

Information Sheet-1	Identifying and clarifying Work requirements from request/work orders

1.1Introduction to a work order/ work request

A work order is a document that provides all the information about a maintenance task and outlines a process for completing that task. Work orders can include details on who authorized the job, the scope, who it's assigned to, and what is expected.

Work orders are crucial to an organization's maintenance operation. They help everyone from maintenance managers to technicians organize, assign, prioritize, track, and complete key tasks. When done well, work orders allow you to capture information, share it, and use it to get the work done as efficiently as possible.

While a work order and work request sound similar, they have a few key differences. A work request is used by non-maintenance staff to make the maintenance team aware of a task. For example, a machine operator might submit a work request when equipment breaks down. The work request is reviewed by a maintenance manager, who adds extra information, schedules the task, and assigns it to a technician. The work request is now a work order.

1.4. How to generate and complete a maintenance work order?

Work orders are like anything else your facility produces — they must be made well and free of defects. If one part of the process is off, it can affect the entire line. So, what information makes up a great work order

- **Asset:** What piece of equipment needs work?
- **Description of issue:** What's the problem? What did you hear, see, smell, or feel at the time of failure or leading up to it?
- **Scope of work:** What work is required to get the job done? What skills are needed?
- **Parts and tools required:** Are there any parts that need to be replaced or special tools that need to be used?
- **Health and safety notes:** What safety procedures and equipment are needed? Have there been any accidents or near-misses while working on a similar issue or asset?
- **Date requested:** When was the work order created and submitted?
- **Requester name/department/contact:** Who created and submitted the work order?
- **Expected completion date:** When should this work order be completed?
- **Actual completion date:** When was the work order completed and closed?
- **Expected hours of work:** How many hours should it take to complete the work order?
- **Actual hours of work:** How many hours did it take to complete the work order?
- **Task checklist:** Is there a step-by-step guide to completing the required work?
- **Priority:** How important is this work order? High, medium, or low?
- **Assigned to:** Who will be doing the work? Is more than one person required? Is an outside contractor required?

- **Associated documents:**Are there resources that can help the work order be completed more efficiently, like SOPs, manuals, diagrams, videos, asset history, purchase orders, or images?
- **Notes:**Are there any other observations that might be helpful in completing the work order or reviewing the work order after it closes, such as the frequency of an issue, troubleshooting techniques, or the solution reached?

1.4.1 Generate work orders for maintenance

Work orders (WOs) can be created manually or generated via the preventive maintenance (PM) Scheduler.

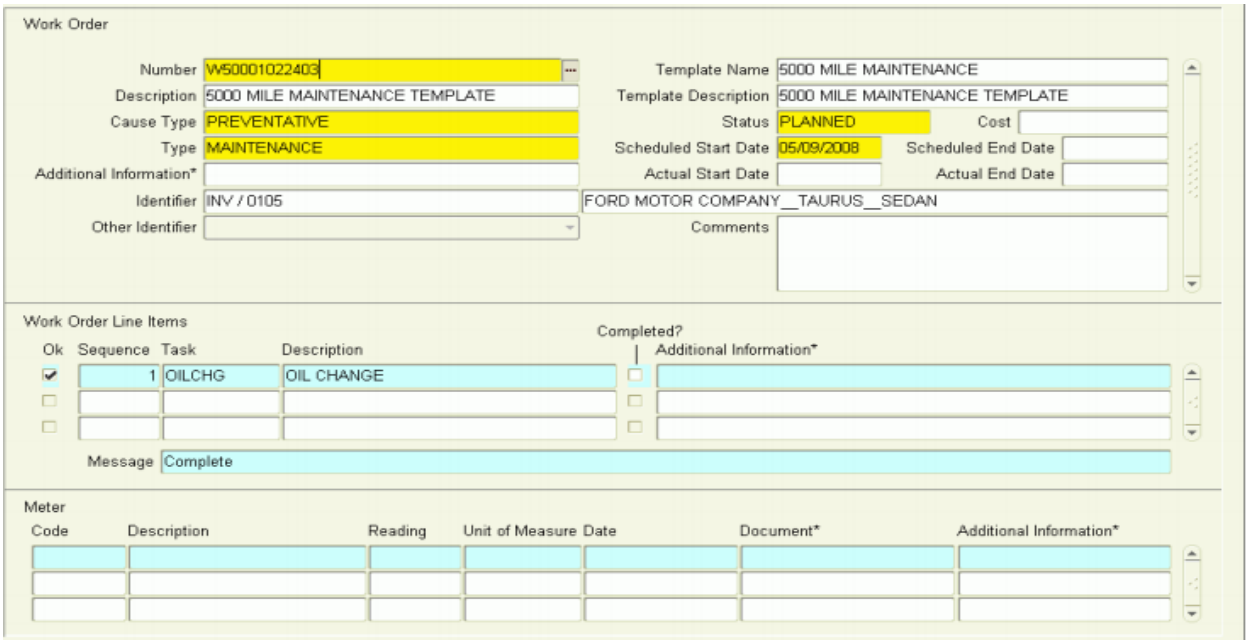

Fig.1.3 sample for generate work orders

1.4.2 Complete work order

After generating a work order the work order can be used to perform the tasks as they are defined on the work order. Once the tasks are completed, then the work order is ready to be completed and finalized in the system.

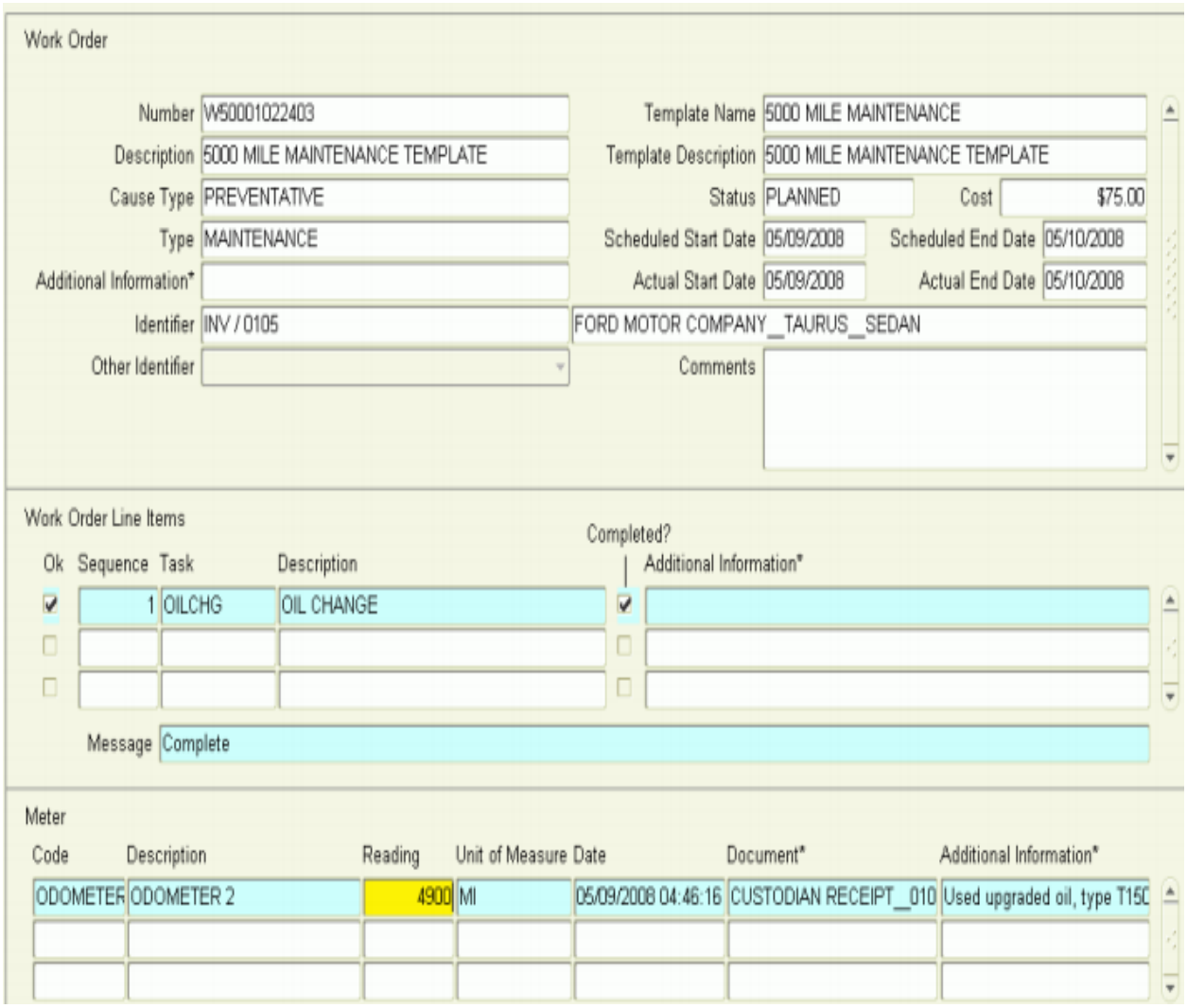

Fig.1.4 sample for complet work orders

Self-Check -1	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided:

1. A work order is a document that provides all the information about a maintenance task and outlines a process for completing that task.

A. True B. False

2. Every maintenance work order has a lifecycle with three main phases.
   A. True B. False
3. Which one of the following is maintenance work order phase?
   A.creation B. completion C. recording. D. All
4. Work orders are crucial to an organization's maintenance operation.
   A. True B. False
5. Work orders are like anything else your facility produces — they must be made well and free of defects.
   A. True B. False

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-1

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. 2. 3. 4. 5._____.

Information Sheet-2	**Identifying, applying and monitoring Occupational Health and Safety standards**

2.1 Occupational Health and Safety

Occupational health and safety are a discipline with a broad scope involving many specialized fields. It encompasses **the social, mental and physical** well-being of workers that is the "whole person".

2.2. OHS guidelines

Occupational safety and health are an extensive multidisciplinary field, invariably touching on issues related to scientific areas such as medicine – including physiology and toxicology – ergonomics, physics and chemistry, as well as technology, economics, law and other areas specific to various industries and activities. Despite this variety of concerns and interests, certain basic principles can be identified, including the following:

All workers have rights: - Workers, as well as employers and governments, must ensure that these rights are protected and must strive to establish and maintain decent working conditions and a decent working environment. More specifically: work should take place in a safe and healthy working environment conditions of work should be consistent with workers' well-being and human dignity; work should offer real possibilities for personal achievement, self-fulfillment and service to society.

OHS policies must be established: - Such policies must be implemented at both the national (governmental) and enterprise levels. They must be effectively communicated to all parties concerned.

Continuous improvement of occupational safety and health must be promoted: - This is necessary to ensure that national laws, regulations and technical standards to prevent occupational injuries, diseases and deaths are adapted periodically to social, technical and scientific progress and other changes in the world of work.

Education and training are vital components of safe, healthy working environments Workers and employers must be made aware of the importance of establishing safe working procedures and of how to do so. Trainers must be trained in areas of special relevance to particular industries, so that they can address the specific occupational safety and health concerns.

Workers, employers and competent authorities have certain responsibilities, duties and obligations: - For example, workers must follow established safety procedures; employers must provide safe workplaces and ensure access to first aid; and the competent authorities must devise, communicate and periodically review and update occupational safety and health policies.

2.3 Occupational safety, health and working environment

Article 92 clearly spells out the fundamental obligations of an employer with regard to putting in place of all the necessary measures in order to ensure, work places are safe, healthy and free of any danger to the well-being of workers.

Article 92 clearly spells out the fundamental obligations of an employer with regard to putting in place of all the necessary measures in order to ensure, work places are safe, healthy and free of any danger to the well-being of workers.

Article 93. In this article the law provides the obligations of workers pertaining to the required co-operation and putting in to practice of the regulation and instruction given by the employer in order to ensure safety health and working conditions at work places.

2.4 Occupational safety and health aspects of maintenance

Maintenance is one of the workplace activities that can affect the health and safety not only of the workers directly involved in it, but of other workers and even members of the public, if safe work procedures are not followed and the work is not done properly.

Maintenance activities can cause harm to workers and others in three main ways:

- **an accident/injury may occur during maintenance** — for example, workers repairing a machine may be injured if the machine is switched on by mistake, if they are exposed to dangerous substances, or if they have to adopt awkward postures;
- **poor-quality maintenance**, for example, using the wrong parts for replacement or repair, may result in serious accidents;
- **lack of maintenance** may not only shorten the lifespan of equipment or machine, but may also cause accidents— for example, unrepaired damage to the floor of a warehouse may cause a forklift accident, injuring worker/s, but also causing damage to the property

2.5. SAFETY in maintenance work

Safety precautions are essential to protect workers from preventable injuries. Equipment, tools and machinery all have the potential to be life threateningly hazardous to users. Each piece of equipment, from the point of operation, to the parts of the machine that move around all must be safeguarded.

- **wear PERSONAL PROTECTIVE EQUIPMENT (PPE)**

Fig Typical PPE to be worn by an Operator

- Appropriate PPE should always be worn whilst working in and around the generator set. Wear a hard hat, protective glasses, gloves and other protective equipment, as required by generator set location.
- When work is performed around an engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.
- Do not wear loose clothing or jewellery that can snag on controls or on other parts of the engine

Fig 2.1. personal protective equipment

Table 2.1 some waring in generator work (maintenance)

Warnings	What to do?

	If the danger occurs when the generator is running, primarily press the emergency stop button which located on the control panel or canopy. * If your generator does not run automatically despite electrical power shortage, the emergency stop button could have stayed down. Please check it
	• Before operating the generator, see the instruction manual and engine, alternator and control module manuals must be read.
	• Generator's control and load cable connections must be performed by an experienced electrician necessarily. Mistakes to be made in a cable connection of generator may occurs danger, as well as it will cause severe damage to your generator. • Wiring between the generator and the load must be used according to the power of generator. The use of unsuitable materials may cause a fire or electric shock.
	• When installing and removing the generator's load connections, make sure that the ground is not wet. • No one should touch the electrical parts of generator except the authorized electrician.
	Generator's electrical connections must be made in accordance with the electrical standards and generator must be grounded by making the connection to the grounding bolt on the chassis of the generator. All metal surfaces including doors of the generator is electrically connected to the grounding bolt.
	• Engine exhaust gas is extremely harmful to human health. When using a generator indoors, exhaust gas must be thrown out through pipes in compliance with related standards. Exhaust gases must be continuously checked whether the leak. • Flammable material should not be placed on the exhaust system.
	• Generator exhaust system must not be touched during operation. • Flammable materials and objects should not be approached to the exhaust system. • Engine should not be touched while the engine is hot and should not open the radiator cap. • Check the exhaust system output and rain cover are open while the generator is running

	• Generator room must be airy. Fuel, oil, antifreeze and electrolytes should not be poured on floor. • Do not keep flammable liquids near the engine. • Generator should not be near the fire burning, smoking should be avoided. • Do not fill the fuel while generator running
	• While open-type generator is running, must be avoided from rotating parts. • While generator is running, do not fill fuel, oil and radiator cooling water. • While generator is running, do not make maintenance and cleaning. • While generator is running, if an adjustment needs to be made should be very careful.
	Noise level of open type generator may be greater than 105 dBA and long-term exposure to more than 85 dBA, may harm your hearing. When you are next to the open type generator, absolutely ear protection must be used

Self-Check -2	**Written Test**

Directions: Choose the best answer for the following questions. Use the Answer sheet provided: and each contains 2pts

1. Occupational health and safety encompass the social, mental and physical well-being of workers that is the “whole person.

   A. True B. False

2. Occupational safety and health programs and policies must aim at_____ both A. prevention B. protection C. both prevention and protection D .none
3. Personal protective equipment, commonly referred to as_____

   A. PPE B.PSE C.PES D.B and C are answer

4. All personal protective equipment should be_____

   A. safely designed and constructed in good shape
   B. Should be kept clean
   C. fit comfortably, but not loose-fitting.
   D. All

5. Before performing the electrical generator maintenance, we have to_____:

   A. Wear appropriate PPE
   B. Ensure that the engine cannot be started
   C. Disconnect the battery ground leads.
   D. All

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-1

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. 2. 3. 4. 5.

Information Sheet-3	**identifying, obtaining and inspecting Resources to satisfy the work plan**

3.1 Introduction to Resources to satisfy the work plan

According to job specification there are different types of resource used in generators maintenance

- **Material resource:** a resource used for generator maintenance such as hand tools and equipment example screw driver, different types of wrench, chemical (fuel and oil) etc.
- **Human resource:** are the people who assigned to do the work force in the organization or in the maintenance sectors according to their skills or professionals (in electro-mechanical).
- **Financial resource:** -the budget allocated for the maintenance cost, fuel and oil cost and covering all financial funds of the organization.
- **Time resource: -**the most important resource in the world is time resource. Time resource is limited resource because once it passed it never back again

3.2 Inspecting resource:

Site Assessment and Preparation: Proper component location and site preparation have a very important impact on completing successful installation. The major components and sources of power needed for installation include the following items:

- Generator set
- Transfer switch
- Electrical utility
- Fuel source

Generator Set Installation Suggestions and Guide lines

- Locate the generator set on stable ground, not subject to flooding.
- Generator set should not be installed where significant water run-off from a roof or downspouts is present.
- Sump pump discharge should be routed away from the generator set.

Locate and orient the generator set such that prevailing winds will carry exhaust gases and fuel leaks away from the house or occupied areas. Accessories (may be required under certain condition.

Self-Check -3	**Written Test**

Directions: Choose the best answer for the following questions. Use the Answer sheet provided and each contains 2pts**.**

1. One the following resource is not return back again

A/ human resource B/ material resource C/ time resource D/ all

2. The major components and sources of power needed or generator installation are

   A/ generator set B/ transfer switch C/ electric utility D/ all

3. Why you Locate the generator set on stable ground?

   A/ to avoid vibration B/ to make the generator more long-life span C/ to prevent form causing vibration D/ all of the above

4. _____a resource used for generator maintenance such as hand tools and equipment.

   A. Material resource B. human resource C. financial resource D .time resource

5. Generator set should not be installed where significant water run-off from a roof or downspouts is present.

   A. True B. False

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-3

Name: _____Date: _____

Answer

1. 2. 3. ____4 _____ 5 _____

Score = _____

Rating: _____

Information Sheet-4	**Selecting and interpreting plans, drawings and texts**

4.1 Drawings (graphic language)

A technical person can use the graphic language as powerful means of communication with others for conveying ideas on technical matters. However, for effective exchange of ideas with others, operators must have proficiency in

- language, both written and oral,
- symbols associated with basic sciences and
- the graphic language.

Drawing is a suitable graphic language from which any trained person can visualize the required object. It displays the exact picture of an object; it obviously conveys the same ideas to every trained eye.

Irrespective of language barriers, the drawings can be effectively used in other countries, in addition to the country where they are prepared. So, it is the universal language.

4.1.1 Needs for correct drawing

The drawings prepared by any technical person must be clear, unmistakable in meaning and there should not be any scope for more than one interpretation. In a number of dealings with contracts, the drawing is an official document and the success or failure of a structure depends on the clarity of details provided on the drawing. Thus, the drawings should not give any scope for miss-interpretation even by accident.

4.1.2 Classification of drawings

- **Machine drawing**

It is pertaining to machine parts or components. It is presented through a number of orthographic views, so that the size and shape of the component is fully understood. **Part drawings** and **assembly drawings** belong to this classification. An example of a machine drawing

- **Part drawing**

Component or part drawing is a detailed drawing of a component to facilitate its manufacture. All the principles of orthographic projection and the technique of graphic representation must be followed to communicate the details in a part drawing. A part drawing with production details is rightly called as a **production drawing or working drawing.**

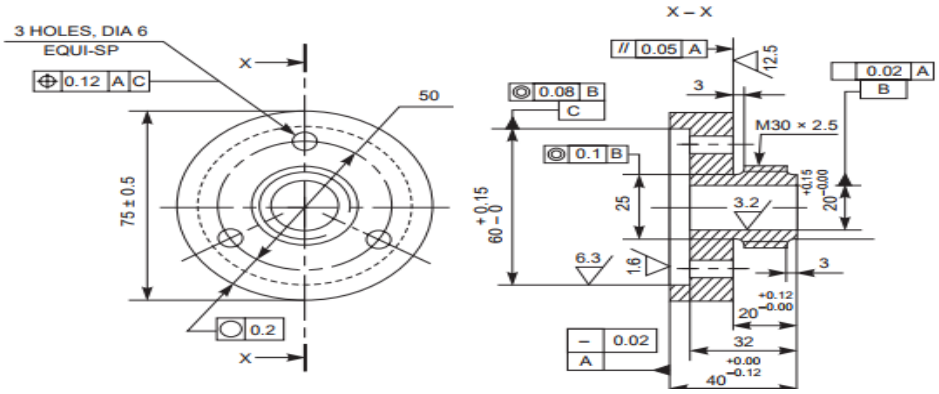

Fig 4.2.production drawing or working drawing.

- **Assembly drawing**

A drawing that shows the various parts of a machine in their correct working locations is an assembly drawing (Fig. 4.3). There are several types of such drawings.

- **Sub-assembly drawing:** A sub-assembly drawing is an assembly drawing of a group of related parts, that form a part in a more complicated machine. Examples of such drawings are: lathe tail-stock, diesel engine fuel pump, carburetor, etc.
- **assembly drawings for installation:**

  On this drawing, the location and dimensions of few important parts and overall dimensions of the assembled unit are indicated. This drawing provides useful information for assembling the machine, as this drawing reveals all parts of a machine in their correct working position.
- **assembly drawings for instruction manual**

  These drawings in the form of assembly drawings, are to be used when a machine, shipped away in assembled condition, is knocked down in order to check all the parts before reassembly and installation (maintenance) elsewhere.

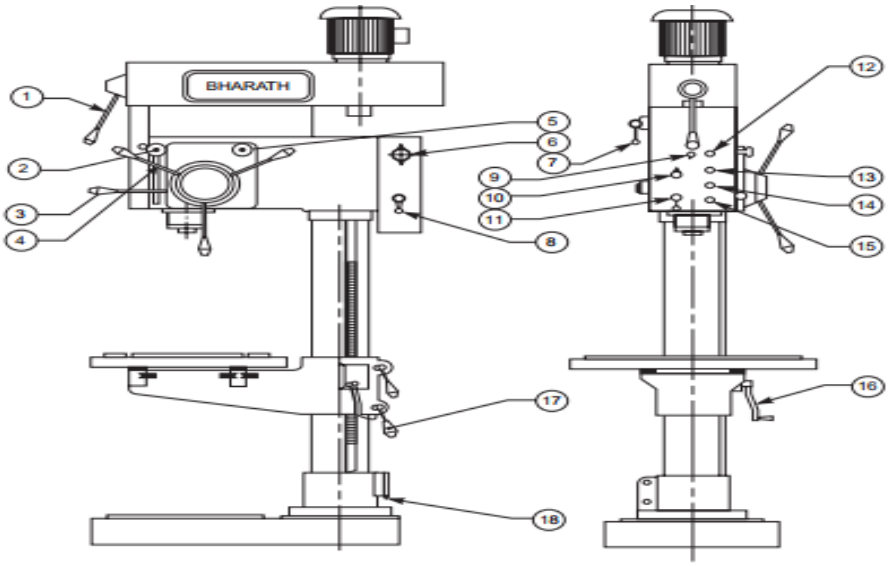

Fig 4.3 example for assembly drawings for instruction manual

- **Exploded assembly drawings:** In some cases, exploded pictorial views are supplied to meet instruction manual requirements.

  These drawings generally find a place in the parts list section of a company instruction manual. Figure 4.5 shows drawings of this type which may be easily understood even by those with less experience in the reading of drawings; because in these exploded views, the parts are positioned in the sequence of assembly, but separated from each other.

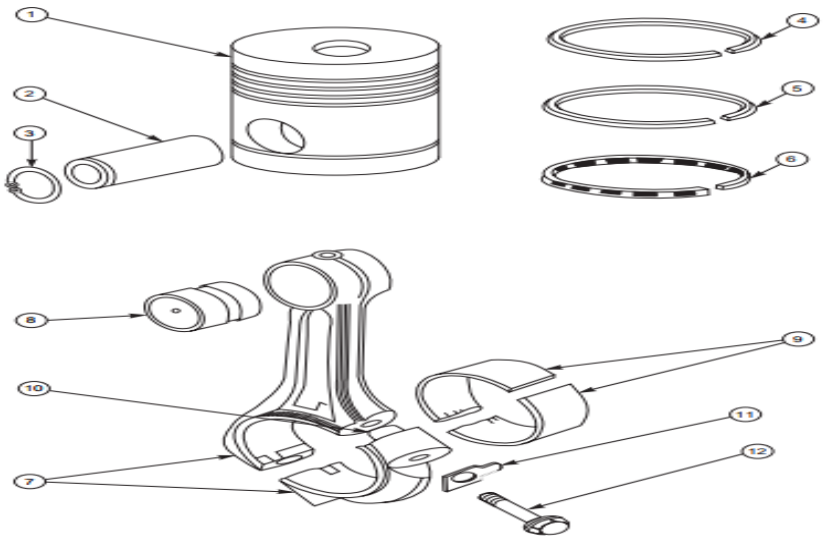

Fig.4.4 example for exploded assembly drawing

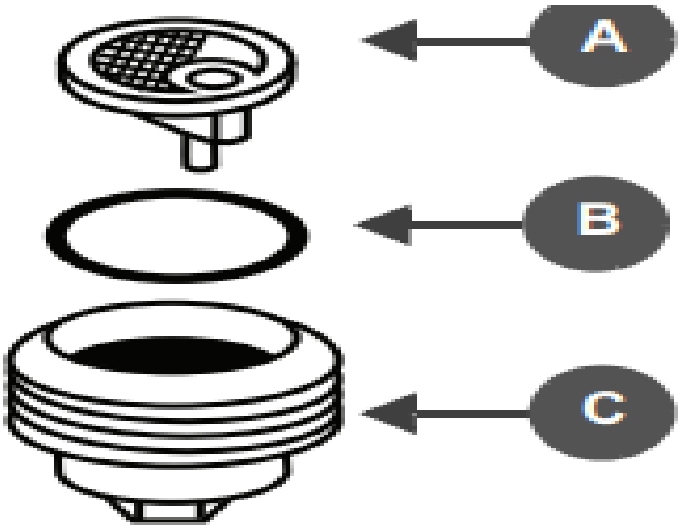

Fig 4.5 Fuel Sediment Cup Assembly by using exploded assembly

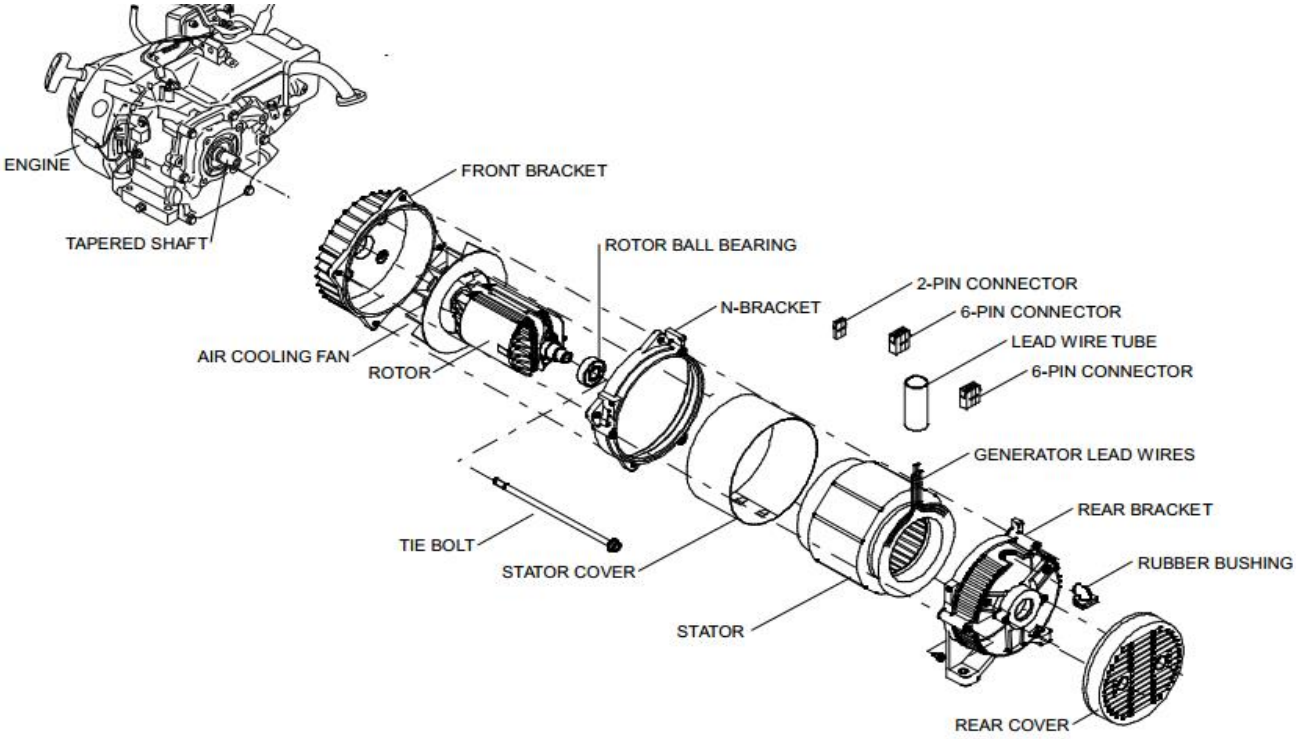

Fig. 4.6 Exploded View of TPG4 Generator Components

4. Installation Drawings (wiring diagram)

Installation drawings are provided by the installation contractor and maintained by the shop to give guidance to the operator and maintainer on equipment installation and other related activities.

Example: wiring diagram R1300 generator with emission certified as shown blow

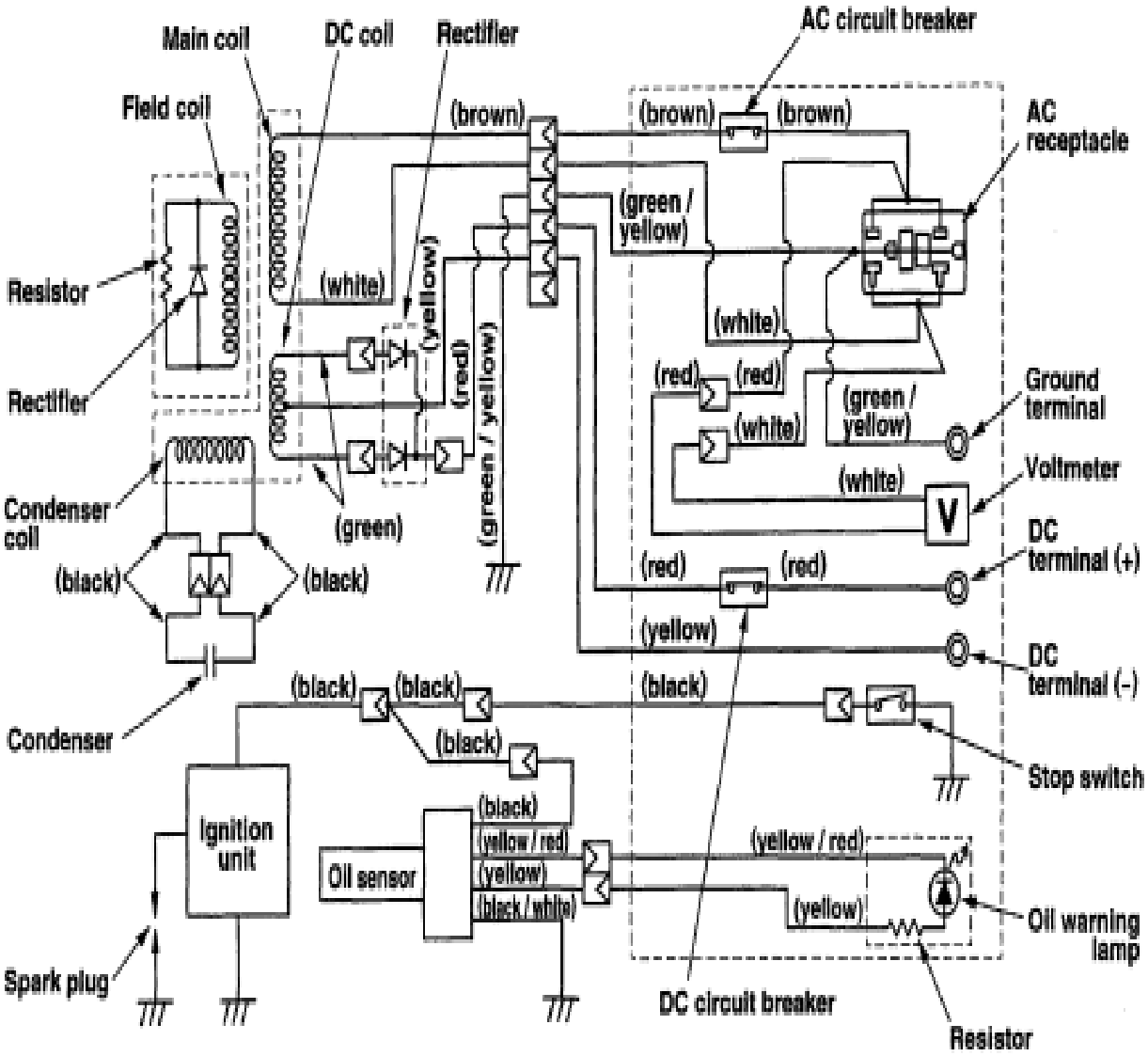

Fig 4.7Example of wiring diagram R1300 generator

Self-Check -4	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided:and each contains 2pts

2. Drawing is a suitable graphic language from which any trained person can visualize the required object.
   A. True B. False
3. Drawing is universal language
   A. True B. False
4. A drawing that shows the various parts of a machine in their correct working locations is
   A. Part drawing
   B. assembly drawing
   C. detail drawing
   D. Multiview drawing
5. Which type of drawing easily understood even by those with less experience in the reading of drawings;

Note: **Satisfactory rating - 4 points** **Unsatisfactory - below 4points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-4

Name: _____Date: _____

Score = _____

Rating: _____

Answer

1. 2. 3. ____4 _____

Information Sheet-5	determining, obtaining and inspecting the size, type and quantity of materials

5.1 Generator and it's parts(component)

Definition: An electric generator is a machine that converts mechanical energy into electrical energy. An electric generator is based on the principle that whenever flux is cut by a conductor, an e.m.f. is induced which will cause a current to flow if the conductor circuit is closed. The direction of induced e.m.f. (and hence current) is given by Fleming's right-hand rule.

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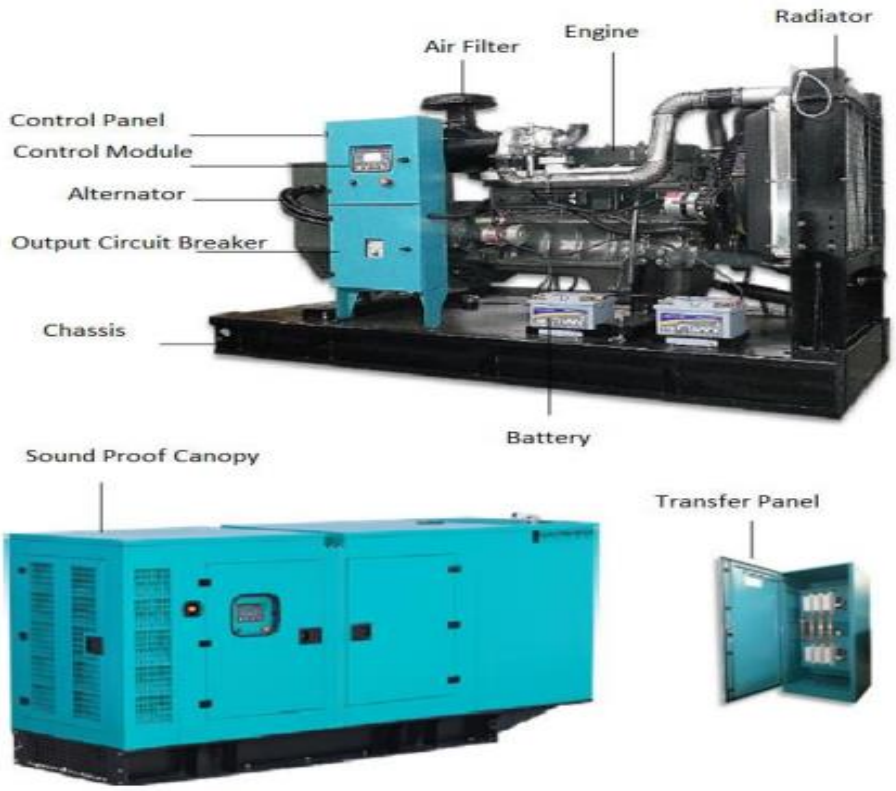


Fig 5.1 generator component

- **Chassis/frames:** All equipment of the generator is mounted on the steel chassis, inside of it the fuel tank is available. Diesel suction and return hoses, fuel filler cap, fuel level indicator float, lifting holes located on the generator chassis (frame). Engine and alternator are mounted on chassis with anti- vibration mounts.
- **Engine.** The engine supplies energy to rotates the alternator and the to generate electricity. The power of the engine determines how much electricity a generator can provide.

- **Alternator**. This is where the conversion from mechanical energy to electrical energy occurs. Also called a "**genhead",** the alternator contains **both moving and stationary parts** that work together to create the electromagnetic field and movement of electrons that generates electricity.
- **Fuel System**. The fuel system makes it possible for the generator to produce the energy needed.
- **Fuel System includes** a;
  - ✓ fuel tank,
  - ✓ a fuel pump,
  - ✓ a pipe connecting the tank to the engine, and a return pipe.
  - ✓ A fuel filter removes debris before it gets to the engine and an injector forces the fuel into the combustion chamber.
- **Voltage Regulator**. This component helps control the voltage of the electricity that is produced. It also helps convert the electricity from **AC to DC**, if needed.
- **Cooling and Exhaust Systems**. Generators create a lot of heat. The cooling system ensures the machine doesn't overheat. The exhaust system direct and remove **the fumes** the form during operation.
- **Lubrication System**. There are many small, moving parts inside a generator. It is essential to lubricate them adequately with **engine oil** to ensure smooth operation and protect them from **excess wear**. Lubricant levels should be checked regularly.
- **Battery: Batteries** are used **to start up** the generator by feeds the **starte**r that provide the first movement of the engine. Batteries emit explosive gas while: charging. This is why approaching to the battery with fire is dangerous**.**
- **Battery Charger: T**he battery charger is an electronic device which charges the battery with energy received from the network / mains in cases where long-term non operation of the generator. It keeps the appropriate value of the battery voltage.
- **Control Panel**. The control panel controls every aspect of generator operation from start up and running speed to outputs. Modern units are even capable of sensing when power dips or goes out and can start or shut off the generator automatically.
- **Circuit Breaker Panel:** circuit breaker prevents damage to the alternator by opening the circuit, in case of excessive current drawing from the generator.

- **Exhaust System:** Used for the purpose of ejecting the gases and the heat comes from engine to the outside and reducing the engine noise.
- **Sound Proof Canopy:** Used for to protecting the generator from external factors and reducing the sound of generator.

5.2 Sizing generator components

Sizing of components for generator is allocating the rating size of current, voltage, power and efficiency of the components for the generator**.**

Generators differ from other electrical power sources in their ability to withstand electrical overloads and fault currents. These differences should be respected when selecting and setting circuit breakers which protect generators.

- **Power Control Center**

Circuit breaker: A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by excess current from an overload or short circuit. Its basic function is to interrupt current flow after a fault is detected

Each circuit breaker has a specific rated amperage, or amount of current. When that amperage is exceeded, the circuit breaker shuts down the flow of current in that circuit to prevent damage to the wiring and appliances.

The circuit breakers should be specified in terms of

- The number of poles
- Rated voltage
- Rated current
- Rated frequency
- Operating voltage

Fig 5.2 a- three phase CB b- single phase CB

Fig 5.3. Different size and rating of circuit breaker

Circuit breaker is required to perform the following three duties

1. It must be capable of opening the faulty circuit and breaking the fault current.
2. It must be capable of being closed on to a fault
3. Must be capable of carrying fault current for a short time while another breaker is clearing the fault.

- **Fuse**A fuse is an electrical safety device built around a conductive strip that is designed to melt and separate in the event of excessive current. Fuses are always connected in series with the component(s) to be protected from overcurrent, so that when the fuse blows (opens) it will open the entire circuit and stop current through the component(s).

Fig.5.4 different type and rating of fuse

- **Battery**

Lead Acid Battery

- Lead acid Battery is an electrolytic solution converts chemical energy in to electrical energy and vice versa.
- The Lead Acid battery is made up of separator plates, lead plates, and lead oxide plates (various other elements are used to change density, hardness, porosity, etc.) with a 34% sulphuric acid and 66% water solution. This solution is called electrolyte which causes a chemical reaction that produce electrons.
- When a battery discharges the electrolyte dilutes and the Sulphur deposits on the lead plates.
- When the battery is recharged the process reverses and the Sulphur dissolves into the electrolyte.

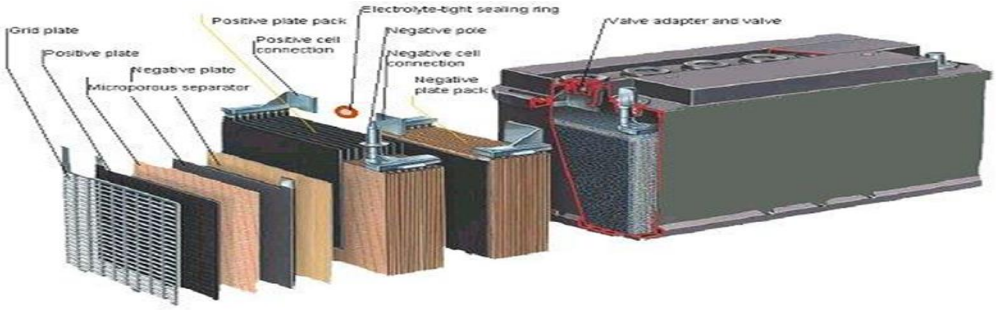


Fig5.5 battery cross section.

- **Alternator**: is exchangeable name of generator which converts mechanical energy in to electrical energy. according to their ratings size and number of poles there are different types of alternators

The alternator contains:

- A rotating field winding called **the rotor**.
- A stationary induction winding called the **stator.**
- A diode assembly called the **rectifier bridge**.
- A control device called the **voltage regulator**.
- Two internal fans to promote air circulation.

MAIN TECHNICAL DATA		
Type	AAN Compact	
Nominal voltage	14V	28V
Nominal current	100A-150A	60A – 100A
Stator diameter	142 mm	
Weight	~7.3 kg without pulley	
Max. speed	20,000 RPM	
Regulator	Built-in or separate Monofunction or multifunction Microelectronic technology	
Pulleys and drive end brackets	Different types according to customers' requirements.	
Terminals	Screw and/or blade terminal	
Drive end bearings	Type 6304E, 6230-E	
Rear end bearings	Type 6203	
Power diodes	Press fit Zener diodes	
Protection of the slip rings and brushes	Protected against ingress of solid foreign matter and powerful water jets (IP 56)	
Ambient temperature	From - 40°C to + 110°C	

Fig 5.7 AAN compact alternator and its rating size

This alternator is a three-phase, 12-pole synchronous self-excited generator with two internal fans and built-in regulator and rectifier.

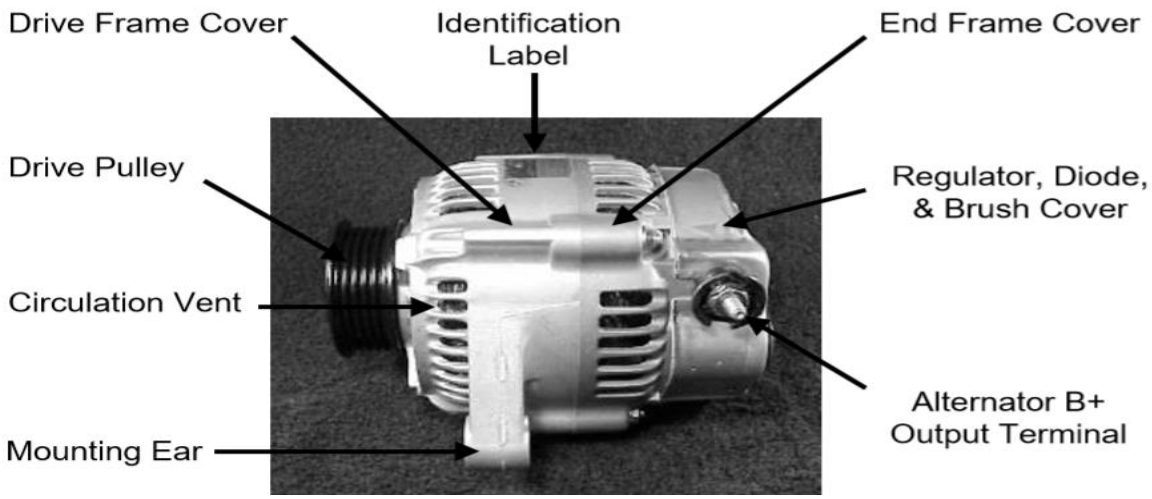


Fig. 5.8 Alternator Assembly parts

- **Stator**

Stator is the stationary parts of alternator / the house of the coil where emf is induced. It has a three-phase winding on a laminated pack

The stator is made with three sets of windings.

- Each winding is placed is a different position compared with the others.
- A laminated iron frame concentrates the magnetic field.
- Stator lead ends that output to the diode rectifier bridge.

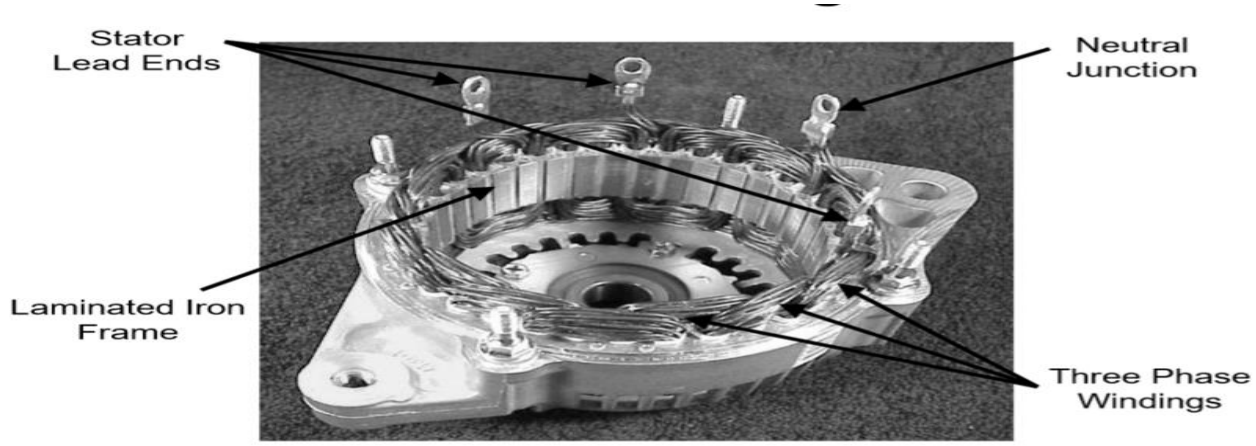


Fig 5.9 stator windings and its terminal

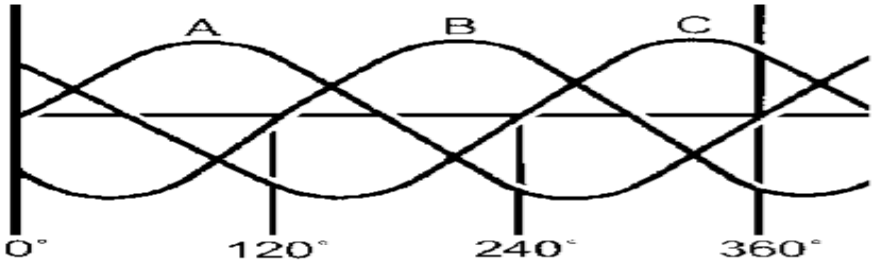


Fig. 5.10 EMF produced from the phase windings

The stator winding has three sets of windings. Each is formed into a number of evenly spaced coils around the stator core.

- The result is three overlapping single-phase AC sine wave current signatures A, B, C.
- Adding these waves together make up the total AC output of the stator. This is called three phase current.
- Three phase current provides a more even current output.

Cooling

Two internal fans positioned on the claw poles provide more effective cooling with lower noise and higher protection against accidental contact as well as higher output.

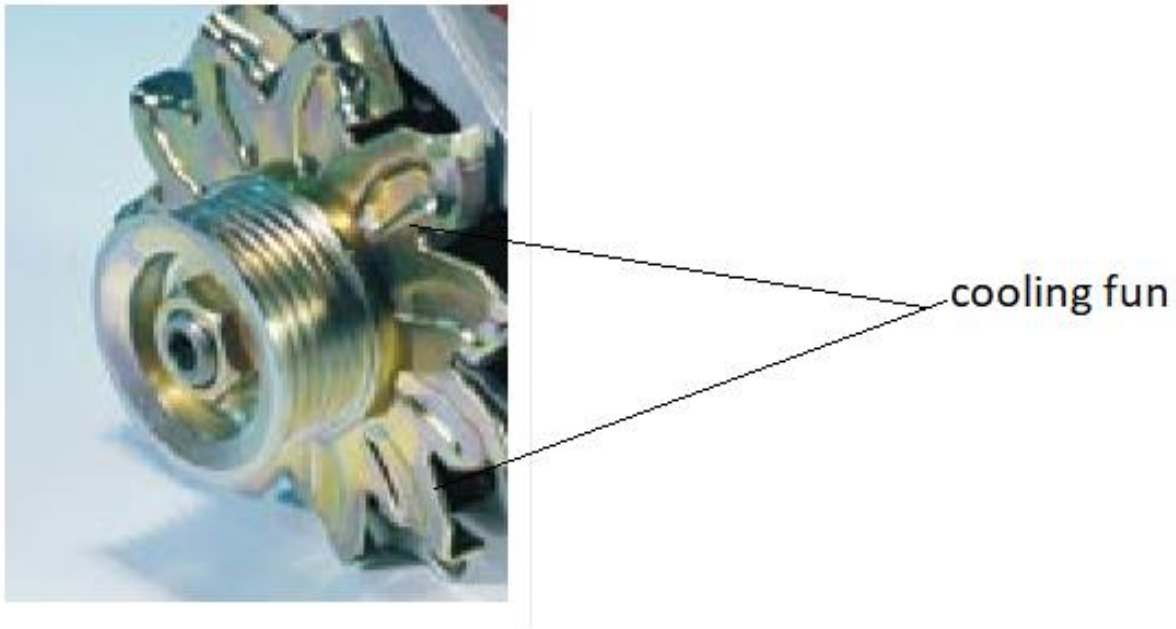


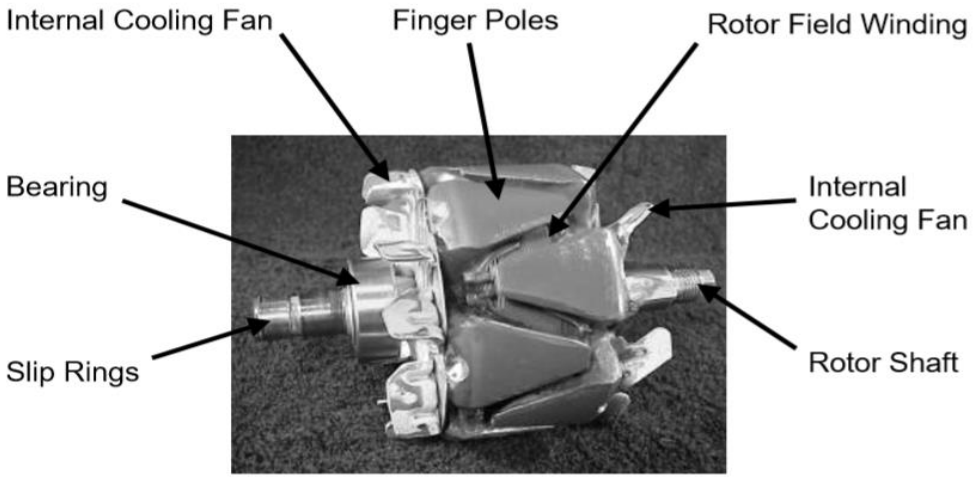
Fig 5.11.inside cooling fun of alternator

Rotor

Smaller slip rings assure higher brush durability, even at high speeds. Encapsulated slip rings offer increased durability of the alternator. A basic rotor consists of a iron core, coil winding, two slip rings, and two claw-shaped finger pole pieces.

• Some models include support bearings and one or two internal cooling fans.

• The rotor is driven or rotated inside the alternator by an engine (alternator) drive belt.



Fig,5.12 Rotor assembly and its components

Diode Rectifier:

Diode Rectifier is electronic device that converts Ac to DC i.e. it rectifies AC to DC. In alternator it is Sandwich construction of the rectifier with press fit Zener diodes provides for low temperatures of the rectifier diodes.

Diodes are used as one-way electrical check valves. Passing current in only one direction, never in reverse.

- Diodes are mounted in a heat sink to dissipate the heat generated by the diodes.
- Two diodes are connected to each stator lead. One positive the other negative.
- Because a single diode will only block half the AC voltage.
- Six or eight diodes are used to rectify the AC stator voltage to DC voltage.
- Diodes used in this configuration will redirect both the positive and negative polarity signals of the AC voltage to produce DC voltage. This process is called 'Full - Wave Rectification'.

The Diode Rectifier Bridge is responsible for the conversion or rectification the AC voltage into DC voltage.

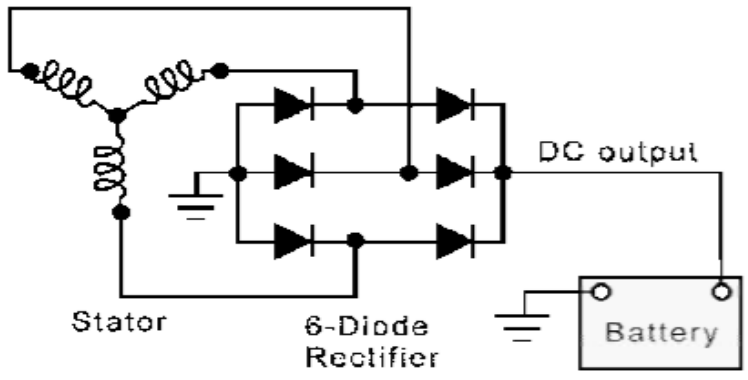


Fig.5.13 diode terminal connection to three phase winding of star-(Y)connection

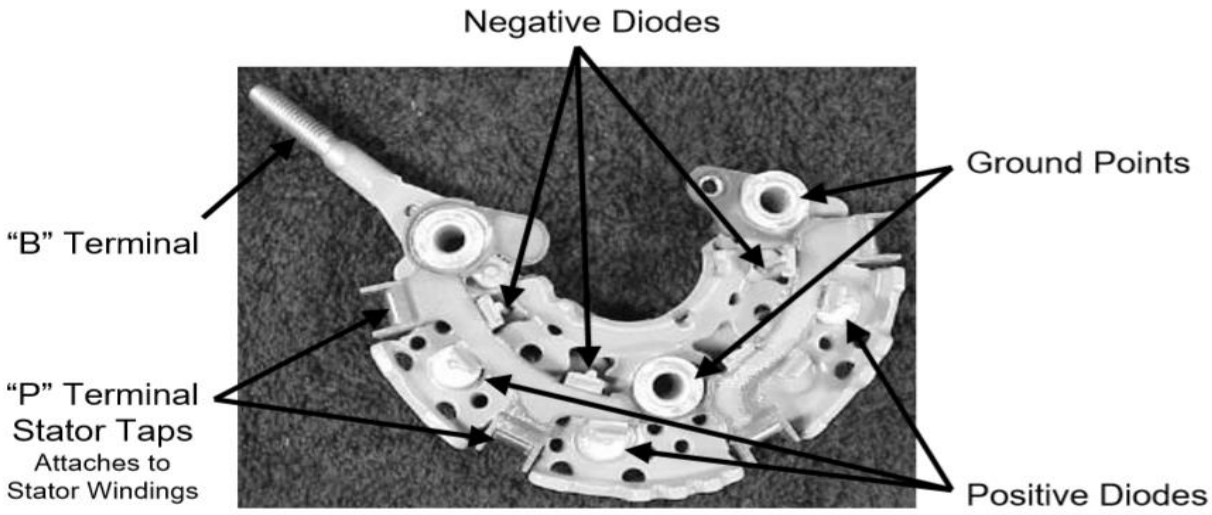


Fig5.14 diode rectifier bridge assembly in alternator

Automatic Voltage Regulator

The regulator monitors battery voltage and controls current flow to the rotor assembly. The regulator will attempt to maintain a pre-determined charging system voltage level.

- When charging system voltage falls below this point, the regulator will increase the field current, thus strengthening the magnetic field, which results in an increase of alternator output.
- When charging system voltage raises above this point, the regulator will decrease field current, thus weakening the magnetic field, and results in a decrease of alternator output.

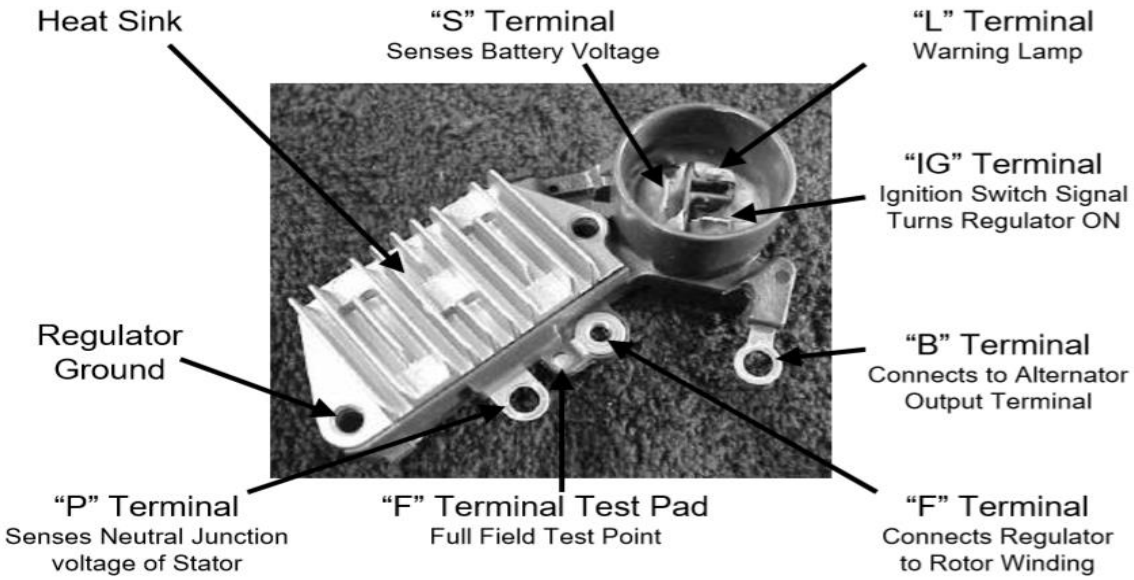


Fig 5.15 electronic voltage regulator of Alternator

Alternator terminal identification and Charging System

Fig5.16 alternator terminal identification

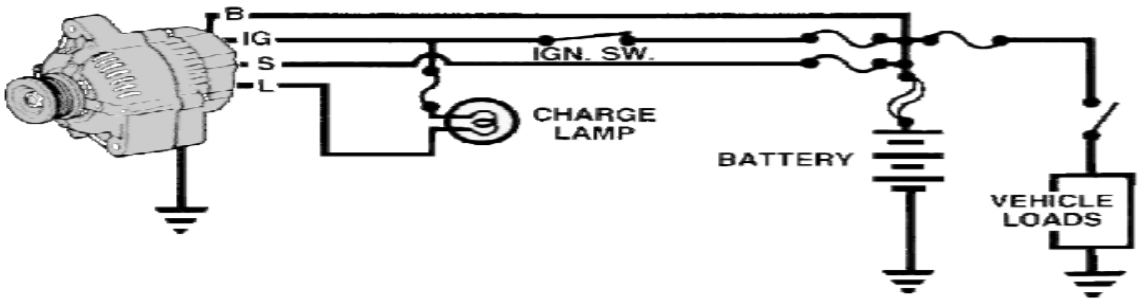


Fig.5.17 alternator charging system

Four wires connect the alternator to the rest of the charging system.

- B is the alternator output wire that supplies current to the battery.
- IG is the ignition input that turns on the alternator/regulator assembly.

- S is used by the regulator to monitor charging voltage at the battery.
- L is the wire the regulator uses to ground the charge warning lamp.

Thermostat

Thermostat is electronic switching device used to control heating or cooling of temperature or it regulates the flow of heat transfer fluids as needed, to maintain the correct temperature.

Fig5.18. different types of thermostat

Self-Check -5	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1.One of the following is used to lead acid charge battery

A/ Rectifier B/circuit breaker C/ Alternator D/ A &C

2. The main purpose of lead acid battery in deasil generator is

A/ for starting engine B/ for regulating alternator C/ for charging system D/ all

3.The electronic device used to covert AC to Dc is

A/ transistor B/diode C/ resistor D/ filed coil

4. What is the main purpose of automatic voltage regulator?

A/ it regulate the voltage to predetermined values B/ it makes the voltage

5. Diode Rectifieris electronic device that converts_____

A. AC to DC B. Dc to AC

Note: **Satisfactory rating - 4 points** **Unsatisfactory - below 4points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-5

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. 2. 3. 4. _____5 _____

Information Sheet-6	Resolving the Coordination requirements that affected by the work

6.1 Introduction to resolving(isolation)

Workers performing service or maintenance on machinery and equipment may be exposed to injuries from the unexpected energization, startup of the machinery or equipment, or release of stored energy in the equipment**.**

To reduce these injure we have to followed some resolving or isolation mechanisms

6.1.2 Lockout and tag out

These procedures used to safeguard workers from the unexpected startup or release of stored energy during service or maintenance activities like

- Lubricating
- Cleaning
- Unjamming machines and equipment

They prevent machines or equipment from becoming energized because they are positive restraints that no one can remove without a key or other unlocking mechanism

Lockout is when a lockout device is applied to equipment and machinery before working on equipment.

Lockout devices hold energy isolating devices in a safe or “OFF” position

Fig. 6.1 machine/equipment in lockout

- **Tagout**is warning devices that authorized workers fasten to energy isolating devices to warn other workers not to start the machine while it is being serviced or undergoing maintenance.

- **Tagout devices** are easier to remove and provide less protection than lockout devices.

Fig 6.2Tagout devices

- When both lockout and tagout are used, it is known as LOTO

Fig 6.3 machine in LOTO

When both lockout and tagout are used, it is known as **LOTO**. There are three levels of LOTO training

- **Authorized worker:**lock out and tag out machines or equipment to perform servicing and maintenance

Fig 6.4 Authorized worker lock out the machine

- **Affected worker:**operate and use machines or equipment that is under LOTO**, t**hey do not perform LOTO or service and maintenance on machines or equipment.

Fig 6.5 Affected worker do not perform LOTO or service and maintenance on machines

- **Other worker:**may be in the area where LOTO procedures are happening.
  They are informed about
  - The LOTO procedures,
  - Equipment that is being serviced or undergoing maintenance
  - Locks or tags put into place to prevent the startup of the machine or equipment

Self-Check -6	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1._____ procedures should be used to safeguard workers from the unexpected startup or release of stored energy during service or maintenance activities.

A. Stop workB. Lockout and tagoutC. Confined spaceD. Energization

2. _____ are warning devices that let other workers know not to start the machine while it is being serviced or undergoing maintenance.

A. LocksB. SignsC. TagsD. Energy isolating devices

3. _____ are positive restraints that no one can remove without a key or other unlocking .

A. Lockout devicesB. Warning tagsC. Product labelsD. Energy isolating

4.When both lockout and tagout are used, it is known as _____.

A. OSHAB. NFPAC. LOTOD. ANSI

5. ___workers lock out and tag out machines or equipment to perform servicing and maintenance.

A. OtherB. AuthorizedC. AffectedD. Unqualified

6. _____ workers operate and use machines or equipment that is under LOTO, but do not perform LOTO or service and maintenance on machines or equipment.

A. OtherB. AffectedC. AuthorizedD. Unqualified

7. _____ workers may be in the area where LOTO procedures are happening.

A. OtherB. AffectedC. AuthorizedD. Unqualified

Note: **Satisfactory rating - 7points** **Unsatisfactory - below 7points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-6

Score = _____

Rating: _____

Name: _____Date: _____

Answers

1. 2. 3. 4. ____5 _____6 _____7 _____

Information Sheet-7	Preparing work area

7.1 Preparing work area for electrical generator installation and maintenance work

Location of the generator set this is one of the first decisions to be made, as it affects all other aspects of the installation, such as:

- Length of electric wiring
- Shade construction
- Site preparation:
- Access to the site
- Trenches
- Site preparation materials needed
- Fuel supply pressure
- Automatic transfer switch location and connections
- Site preparation materials needed
- Fuel supply pressure
- Automatic transfer switch location and connections
- Tools and materials required

7.2Space requirement for generator set that helps for maintenance

7.2.1Electrical room space requirements

The space requirements for standby and emergency power system do not rank at the top of an architect's design list. consequently, service personnel can find themselves in tight quarters when these power systems are jammed into areas. Building service equipment must have an advocate early in design process.

7.2.2 Basic room requirements

Minimum requirements set fire protection is that a person must be able to complete service(maintenance) duties with enclosure doors open and for two people to pass one another. If maintenance must be done at rear of the cabinet, similar access space must be available.

7.2.3 Gen set space needs

Caterpillar recommends floor space between an engine and parallel well space or another gen set should not be less than the width of the engine. overhead, there should be enough space allocated to allow convenient removal of cylinder heads, manifolds, exhaust piping and any other equipment for service. consider specifying enough room for a chain hoist or overhead crane. Space fore and aft of the engine should allow camshaft removal.

Batteries to start gen sets should be kept as near as possible to the engine to avoid energy robbing cables. The fuel tank should locate near gen sets to prevent long fuel line runes which can tax fuel pumps. Access to this equipment for service must also be considered in the design phase.

7.2.4 Switchgear considerations

Controls and switchgear are best housed in a separate air- conditioned room next to the gen set with a window into the engine room. Switchgear that can't be a separate room should be located to take advantage of incoming air to cool the switchgear.

7.2.5 Consider remote options

Many times, buildings demand for emergency power increase so dramatically that the standby facility out grows the space it originally allocated. consider the following remote options

- Remote radiators. Radiators mounted on rooftop or inconspicuously at ground level outside can open up floor space and help lower room temperature when gen sets are in operations.
- Remote switchgear; switchgear placed in another service area near the gen set room opens floor space and helps keep operates out of high decibel areas when gen sets are in operation.

Self-Check -7	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts.

1. The space requirements for standby and emergency power system do not rank at the top of an architect's design list.
   A. True B. False
2. Batteries to start gen sets should be kept as near as possible to the engine to avoid energy robbing cables
   A. True B. False
3. Location of the generator set can affect the installation of
   A. Length of electric wiring
   B. Shade construction
   C. Automatic transfer switch location and connections
   D. Tools and materials required
   E. All
4. The fuel tank of generator should locate near gen sets to prevent long fuel line runes which can tax fuel pumps.
   A. True B. False.

Note: **Satisfactory rating - 4points** **Unsatisfactory - 4below 4points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-7

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1.
2.
3.
4. ____

Operation Sheet 1	Identifying and clarifying Work requirements from work orders

Steps to prepare maintenance work order for generator maintenance

Step #1: identify the task

Step #2: create maintenance request

Step #3: prioritize and schedule work order

Step #4: assign and complete the work

Step #5: close and document the work order

Step #6: analyze and/or rework the work order

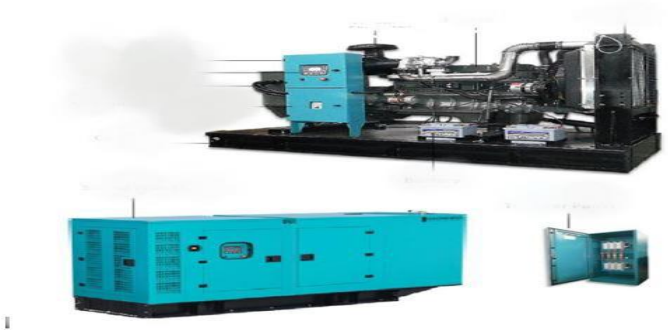
Operation Sheet 2	**determining, obtaining and inspecting the size, type and quantity of materials**

Steps to Identify parts and function of generator components.

Step 1. identify tools and apply PPE

Step 2. Identify and demonstrate generator major parts, types and explain the working principle of components and explain generator functions.

Identification 1. Show and name the parts of these generator that shown in the figure blow



Identification 2.- circuit breaker

The following detailed are should undertake for identification.

- number of poles
- Rated voltage
- Rated current
- Rated frequency
- Operating voltage

Identification 3. Fuse

- type and rating of fuse

Identification 4.Battery

Identification 5. Alternator

- ratings size
- number of poles
- Identify parts:
  - A rotating field winding called rotor.
  - A stationary induction winding called the stator.

- A diode assembly called the rectifier bridge.
- A control device called the voltage regulator.
- internal fans to promote air circulation.

Operation Sheet 3	**Resolving the Coordination requirements that affected by the work**

Steps to Prepare LOTO device for equipment

Step #1: Prepare the equipment shutdown by: -Gathering all written LOTO procedures and by identifying the location of energy isolation devices

Step #2: Shutdown equipment -using normal controls

Step #3: Isolate the equipment (generator to be maintain) by turning all energy isolation devices to the “OFF” or closed position.

Step #4: Apply LOTO devices, by having the authorized worker put a lock, tag, or both on each energy isolation device Step

step#5: Release all stored energy and set up the machine or equipment so that it cannot collect energy

Step #6: Confirm equipment isolation by trying to start up the machine or equipment using normal operating controls.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Giving the necessary equipment's and PPEs you are required to perform the following tasks within 3 hours

Task 1. Prepare maintenance work orderfor generator maintenance

Task 2. Identify parts and function of generator components

Task 3. Prepare LOTO device for equipment

Instruction Sheet 2	Learning Guide # 30: Carry out maintenance

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

- Confirming the required isolations in accordance with site requirements
- Maintaining equipment using appropriate plans, drawings and texts in accordance
- Maintaining equipment in conjunction with others involved in, or affected by,
- Carrying out Reset and/or adjustments
- Carrying out Maintenance and resets/adjustments
- Permitting and carrying out final job inspection

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

- Confirm the required isolations in accordance with site requirements
- Maintain equipment using appropriate plans, drawings and texts in accordancewith the work plan.
- Maintain equipment in conjunction with others involved in, or affected by, the work in accordance with the work plan
- Carry out Reset and/or adjustments to ensure equipment operates within requirements in accordance with the work plan.
- Carry out Maintenance and resets/adjustments
- Permit and carry out final job inspection relinquished in accordance with the work plan

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 6”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2,3,4,5 and 6” in each information sheets on pages 54,61,68,76, 79 and 82 .

5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1, 2 and 3 on pages”83,90 and 92. And LAP test page 93. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Confirming the required isolationsin accordance with site requirements

1.1 Isolate Testing and measurement instrument for generator maintenance

Test equipment are necessary for determining proper set-up, adjustment, operation, and maintenance of electrical systems and control panels of generator.

Some of the testing and measuring instrument for generator maintenance are meggering, relay testing, circuit breaker trip testing, alternating current (AC) high-potential (Hipot) tests, high voltage direct current (HVDC) ramp tests, battery load tests insulation resistance/continuity tester: simple ohm meter, Megger, Wheatstone bridge

- **Voltmeters**

For measuring differences of potential (voltage) between two points in an electrical circuit. The instrument is connected in parallel with the circuit being measured. Ranges vary from a few tenths' volt to a few thousand volts. Instruments are capable of measuring both A.C. and D.C. voltage.

- **Ohmmeters**

For measuring the electrical D.C. ohm resistance of a circuit, circuit part, or component. Calibrated from zero ohms to infinite. Measures either series or parallel resistance.

- **Ammeters**

Capable of generating calibrated voltages from zero to several thousand for purpose of testing the integrity of insulation on wiring (usually buried int he earths).

- **High potential testers (HI-POT)**

Capable of generating calibrated voltages from zero to several thousand for purpose of testing the integrity of insulation on wiring (usually buried in the earth).

HI-POT tests- Purpose of this test is to detect breakdown of wiring insulation through holes or cracks in insulation due to damage or manufacturing defects.

Basically, a high D.C. voltage is applied between the conductor and ground; the voltage gradually increased at a definite rate of time and held at a maximum for a specified length of time.

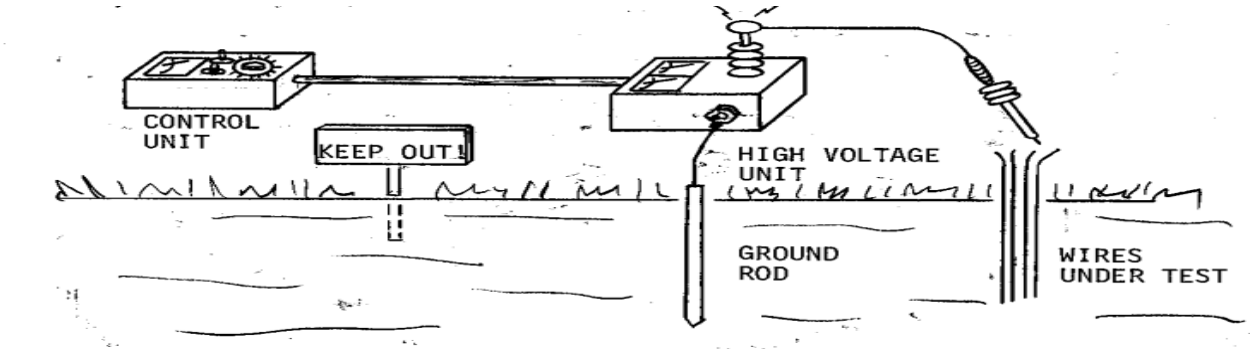


Fig 1.1 how to breakdown of wire using HI-POT tests

- **Megger**

  Used for measuring generator insulation resistance.

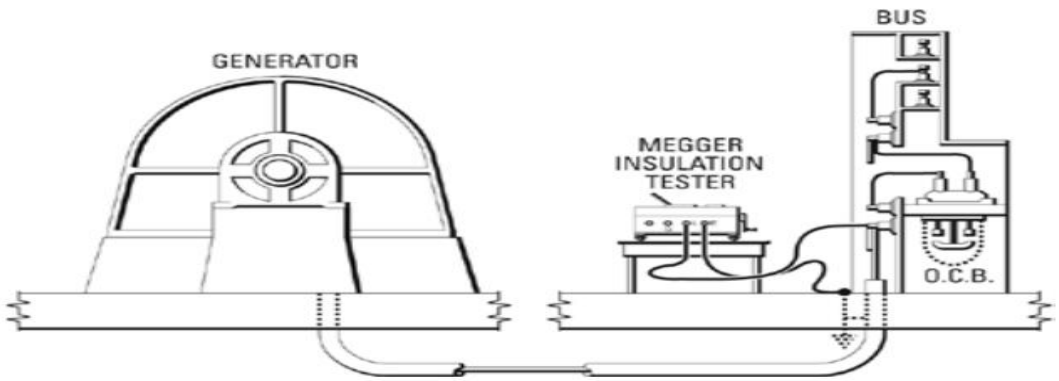


Fig 1.2 portable megger

With this connection, the insulation resistance will be that of the generator stator winding and connecting cable combined. To test either the stator winding or the cable itself, the cable must be disconnected at the machine

- **A multimeter**

A multimeter is a device used to measure voltage, resistance and current in electronics & electrical equipment. It is also used to test continuity between two points to verify if there is any break in circuit or line.

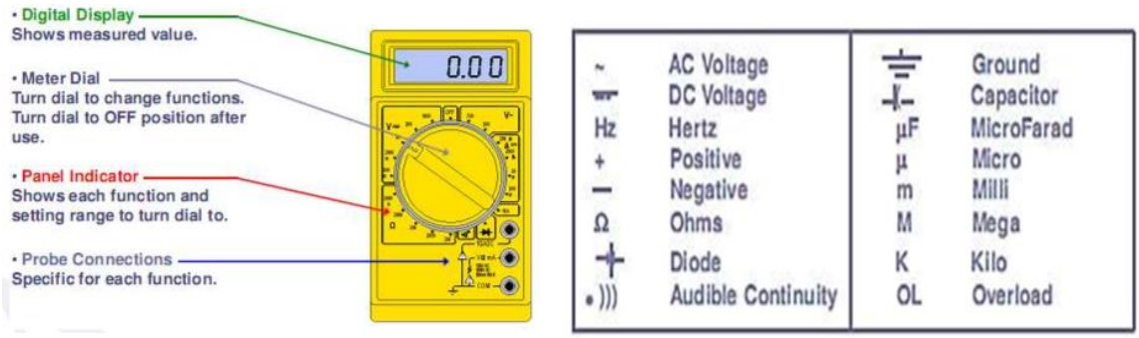
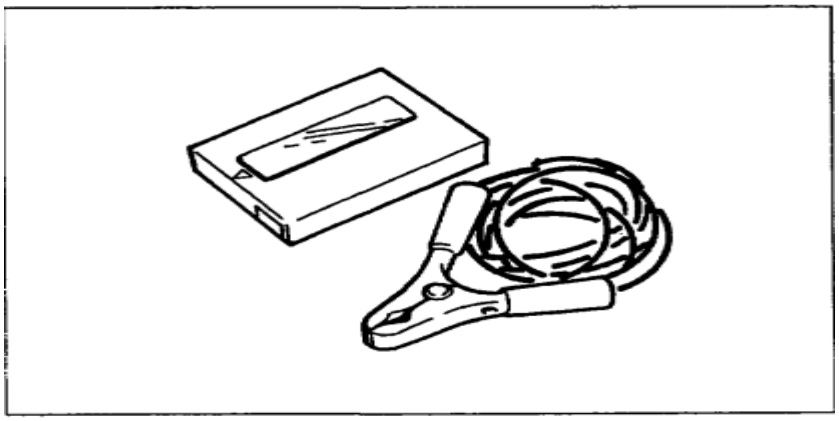


Fig.1.3 A. multimeter B. symbols found on multimeter and schematics.

- **Engine tachometer**

There are various types of tachometers, such as contactless type, contact type, and strobe type. The contactless type is recommended.



1.3 Foundations and Vibration Isolation

The generator set is supplied on a rigid base frame that precisely aligns the alternator and engine and needs only be bolted down to a suitably prepared surface

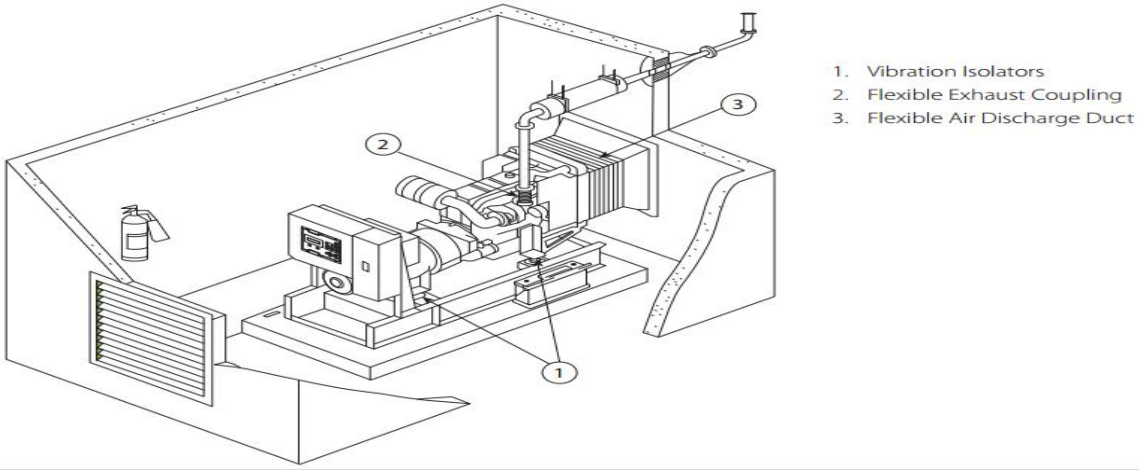


Fig1.1Typical installation highlighting vibration reduction techniques

1.3.1 Foundation

A reinforced concrete pad makes the best foundation for the generator set. It provides a rigid support to prevent deflection and vibration. The ground or floor below the foundation should be properly prepared and should be structurally suited to carry the combined weight of the foundation pad and the generator set. (If the generator set is to be installed above the ground floor the building structure must be able to support the weight of the generator set, fuel storage and accessories.)

1.3.2 Vibration Isolation

To minimise engine vibrations being transmitted to the building, the generator set is fitted with vibration isolators. On small and medium sized generator sets these isolators are fitted between the engine/alternator feet and the base frame. This allows the frame to be rigidly bolted to the foundation. On larger generator sets the coupled engine/alternator is rigidly attached to the base frame and the vibration isolators are supplied loose for fitting between the base frame and the foundation.

Vibration isolation is also required between the generator set and its external connections. This is achieved by the use of **flexible connections in the fuel lines,exhaust system**, r**adiator air discharge duct, electrical conduit for control and power cable**s and other externally connected support systems,

1.4. Isolating Fault to the Generator (TROUBLESHOOTING)

Table 1.1 some electrical generator troubleshooting

Fault	Symptom (probable cause)	Remedy
No AC output.	Condenser failed.	1.Check condenser NOTE: If you do not have measuring equipment, install a known-good condenser. Start the generator and check ac output. If the generator ac output is normal, the fault was in the original condenser. 2.Short the condenser leads across each other to discharge the condenser. NOTE: To make sure you get a good reading, discharge the condenser before checking capacitance.
	Stator fault.	. Check Stator
	Rotor fault.	Check rotor.
AC voltage too high or too low.	Engine speed too high or too low.	Check engine speed.
Engine Fails to Start	Engine does not crank when start signal is given, either manually via run key or automatically via a remote signal	Check all emergency stop push buttons are released 2. Check the stop button light is not on 3.check there are no shutdown events active. Reset, if required, after remedying the indicated fault 4. Refer to your local dealer
engine stops due to	“low oil pressure “in	check oil level

low oil pressure	event log. red shutdown led illuminates	refer to your local deale
engine stops due to high coolant temp	“high coolant temp” in event log. red shutdown led illuminates	1.check coolant level in the radiator. refer to safety section before removing the radiator cap 2. refer to your local dealer
generator set does not stop when in auto mode	generator set does not stop after remote start signal is removed	check that the generator set stops when the emergency stop push button is depressed or the stop key is held down for 5 seconds and the cooldown time is skipped

Self-Check -1	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts.

1. Test equipment are necessary for determining proper set-up, adjustment, operation, and maintenance of electrical systems and control panels of generator

A. True B. False

2. which of the following tests used in generator maintenance

A. meggering, relay testing, circuit breaker trip testing

B. circuit breaker trip testing, alternating current (AC) high-potential (Hipot) tests

C. All

3.which of the following instruments use in generator maintenance

A. meggerB. multi-meterC ENGINE TACHOMETERD..All

4. To minimise engine vibrations, the generator set must be fitted with vibration isolators.

A. TrueB. False

Note: **Satisfactory rating - 4 points Unsatisfactory - below 4 points**

Answer Sheet-1

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. 2. 3. 4

Information Sheet-2	Maintaining equipment using appropriate plans, drawings and texts

2.1 Maintenance

Maintenance is the totality of all measures directed towards controlling (preservation and restoration) of the performance of a plant.

Maintenance systems are **dynamic** because they are influenced by other factors within the system. For example: intuition, judgment and budget.

Maintenance is performed:

I. to eliminate system failures and hazards

II. In order to ensure that equipment continues to work within the design tolerances and specifications.

2.1.2 Classification of Maintenance

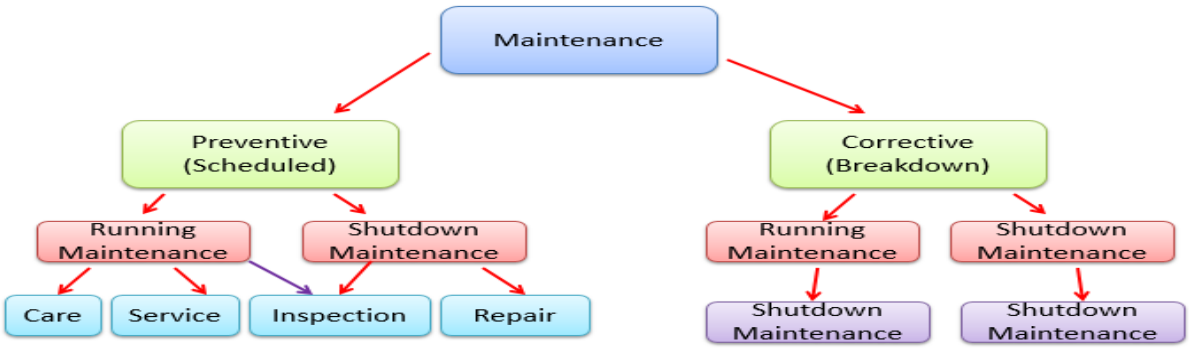


Fig 3.1 Classification of Maintenance

- **Preventive maintenance**

Preventive maintenance (also called “preventative” maintenance) is a systematic approach to building operations that aims to predict and prevent catastrophic equipment failures before they occur. To accomplish this goal, facilities personnel conduct routine inspections, maintenance and repairs on assets to ensure they work as the manufacturer

intended. Functional equipment allows facilities staff members to focus less on reactive maintenance and more on upcoming maintenance tasks or time-sensitive work orders

The following list features a few ways facilities teams can stay on top of preventive maintenance in their departments:

- Schedule and perform regular inspections of equipment
- Conduct regular cleaning of buildings, grounds and assets
- Lubricate moving parts to reduce wear-and- tear
- Adjust controls for optimal performance and energy efficiency
- Repair and replace any defective equipment parts

Preventive maintenance takes a **proactive approach** towards maintenance and involves four key action items: inspection, detection, correction and prevention. Let' s take closer look at how each concept is fundamental to a successful preventive maintenance program.

1. **Inspection:** Inspections are a necessary part of preventive maintenance and aid organizations in two ways. First, facility inspections ensure that equipment is safe to use. Regular inspections help prevent workplace injuries and provide a business with increased liability protection. Second, regular inspections protect property. Inspections ensure that equipment is functioning as the manufacturer intended.

2. **Detection:** Operating on a run- to-failure approach can end up costing a facility department significant money, which is why many facility managers choose to utilize a preventive approach to maintenance. Preventive maintenance helps facility managers detect problems early, when issues are still relatively easy and inexpensive to fix.
3. **Correction:** Preventive maintenance encourages facility managers to take a proactive approach towards equipment care and correct issues before they occur. If an issue (or potential issue) is detected, facility managers take steps to promptly address the problem before it worsens or shuts down operations.
4. **Prevention:** Facility managers can combine inspection records and maintenance notes to learn from past mistakes and correct repeated issues with equipment. Prevention of asset failure reduces stress and increases productivity for facilities teams. When equipment works as inspected, staff can focus on proactive (rather than reactive) maintenance tasks.

2.2. Maintenance Work

Before going to maintain the generator; the generator technicians must wear proper safety clothing in the work area per OHS. Workers must be trained and certified in use and care of personal protective equipment (PPE), insulating protective equipment (IPE. Personnel must follow safety procedures, conduct hazard analysis and attend job safety briefings in accordance with OHS safety requirements. Proper tools must also be used in accordance maintenance program. Regular maintenance is essential to keep equipment, machines and the work environment safe and reliable. Lack of maintenance or inadequate maintenance can lead to dangerous situations, accidents and health problems.

Maintenance activities include:

- İnspection
- testing
- measurement
- replacement
- adjustment
- repair
- upkeep
- fault detection
- replacement of parts

- servicing
- lubrication,
- cleaning

2.2.1Maintenance recommendations

Maintenance recommendations are based on industry standards and experience in Reclamation facilities. However, equipment and situations vary greatly, and sound engineering and management judgment must be exercised when applying these recommendations. Other sources of information must be consulted (e.g., manufacturer's recommendations, unusual operating conditions, personal experience with the equipment, etc.) in conjunction with these maintenances' recommendations.

2.3. Maintenance and Test Procedures

Generally, maintenance activities fall into three general categories:

- **Routine Maintenance –** Activities that are conducted while equipment and systems are in service. These activities are predictable and can be scheduled, staffed, and budgeted. Generally, these are the activities scheduled on a time-based, run-time-meter-based, or a number of operations schedules. Some examples are visual inspections, infrared scans, cleaning, functional tests, measurement of operating quantities, lubrication, oil tests, governor, and excitation system alignments.

  Table 3.1 maintenance schedule sample

TABLE 5-1. MAINTENANCE SCHEDULE

MAINTENANCE ITEMS	SERVICE TIME						
	See Engine Schdl.	Daily or after 8 Hours	Weekly or after 50 Hours	Monthly or after 100 Hours	6 Months or after 250 Hours	Yearly or after 500 Hours	4000 – 45000 Hours
General Genset Inspection	X[1]	X[2]					
Check Coolant Heater		X					
Check Oil Level		X					
Check Coolant Level		X					
Check Fuel Level		X					
Check Charge Air Piping		X					
Check Air Cleaner (Clean if required)			X[3]				
Check Battery Charging System			X				
Drain Water and Sediment from Fuel Tank			X[5]				
Drain Exhaust Condensate Trap				X			
Check Starting Batteries				X			
Change Air Cleaner Element					X[3]		
Check Radiator Hoses for Wear & Cracks					X		
Test Generator Insulation Resistance						X[7]	
Grease generator bearing (P7)							X
Drain Fuel Filter(s)	X[1]						
Check Anti-freeze and DCA Concentration	X[1]						
Change Crankcase Oil and Filter	X[1, 6]						
Check Drive Belt Tension	X[1]						
Change Coolant Filter	X[1]						
Clean Crankcase Breather	X[1]						
Change Fuel Filters	X[1]						
Clean Cooling System	X[1]						
Test Rupture Basin Leak Detect Switch						X[8]	

Maintenance Testing – Activities that involve the use of test equipment to assess condition in an offline state. These activities are predictable and canbe scheduled, staffed, and budgeted. They may be scheduled on a time, meter, or number of operations basis but may be planned to coincide with scheduled equipment outages. Since these activities are predictable, some offices consider them “routine maintenance” or “preventive maintenance.” Some examples are meggering, relay testing, circuit breaker trip testing, alternating current (AC) high-potential (Hipot) tests, high voltage direct current (HVDC) ramp tests, battery load tests.

2.4 What Kind of Maintenance Does A Generator Require?

The best generator maintenance recommended by the manufacturer, but, at a minimum, all generator maintenance plans should include regular and routine.

- Inspection and removal of worn parts.
- Checking of fluid levels, including coolant and fuel.
- Inspection and cleaning of the battery.

- Conducting of a load bank test on the generator and automatic transfer switch.
- Checking of the control panel to ensure accuracy of readings and indicators.
- Changing of the air and fuel filters.
- Inspection of the cooling system.
- Lubrication of parts as needed

Self-Check -2	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts.

1.Maintenance is the totality of all measures directed towards controlling (preservation and restoration) of the performance of a plant.

A. True B. False

2. Maintenance systems are **dynamic** because they are influenced by other factors within the system.

A. True B. False

3.maintenace activity can be influenced by

A. intuition B. judgment c. budget D. all

4 which of the activity is Maintenance activities

A.inspection, testing, measurement
B.replacement, adjustment, repair
C. fault detection, replacement of parts, servicing
D.All

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-1

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. 2. 3. 4. 5.

Information Sheet-3	Carrying out Reset and/or adjustments

3.1Generator installation, factors handling and storage

3.1.1 Important factors in the effective and safe installation of the generator set.

Selecting a location for the generator set can be the most important part of any installation procedure. The following factors are important in determining the location:

- Adequate ventilation.

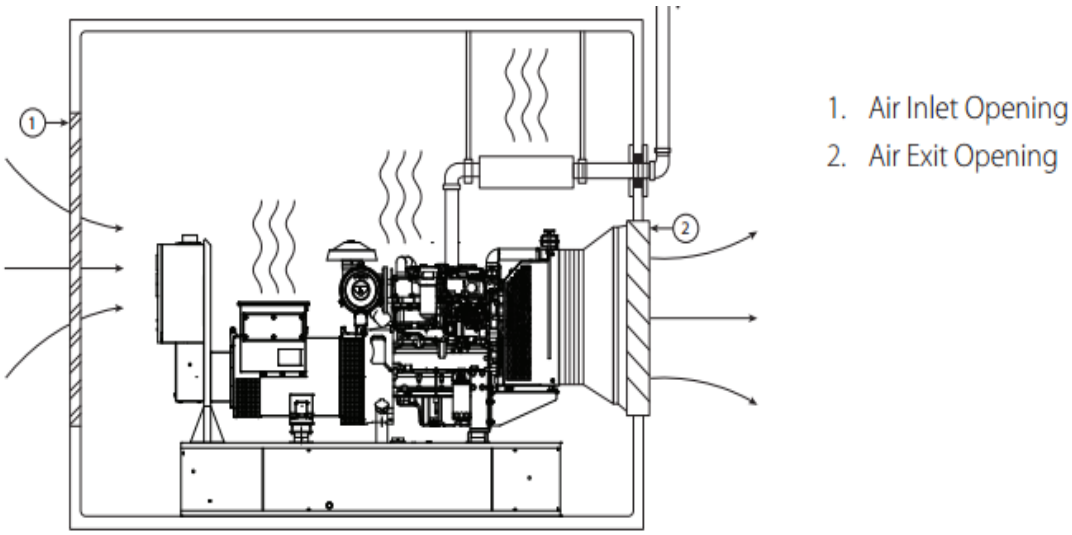


Fig.4.1Typical installation showing generator set ventilation

- Protection from the elements such as rain, snow, sleet, wind driven precipitation, flood water, direct sunlight, freezing temperatures or excessive heat.
- Protection from exposure to airborne contaminants such as abrasive or conductive dust, lint, smoke, oil mist, vapour, engine exhaust fumes or other contaminants.
- Protection from impact from falling objects such as trees or poles, or from motor vehicles or lift trucks.
- Clearance around the generator set for cooling and access for service: at least 1-meter (3ft 3in) around the set and at least 2 meters (6ft 6in) headroom above the set. (See Figure 4b)
- Access to move the entire generator set into the room. Air inlet and outlet vents can often be made removable to provide an access point.
- Limited access to unauthorized personnel

If it is necessary to locate the generator set outside of the building, the generator set should be enclosed in a weatherproof canopy or container-type housing which is available for all sets.

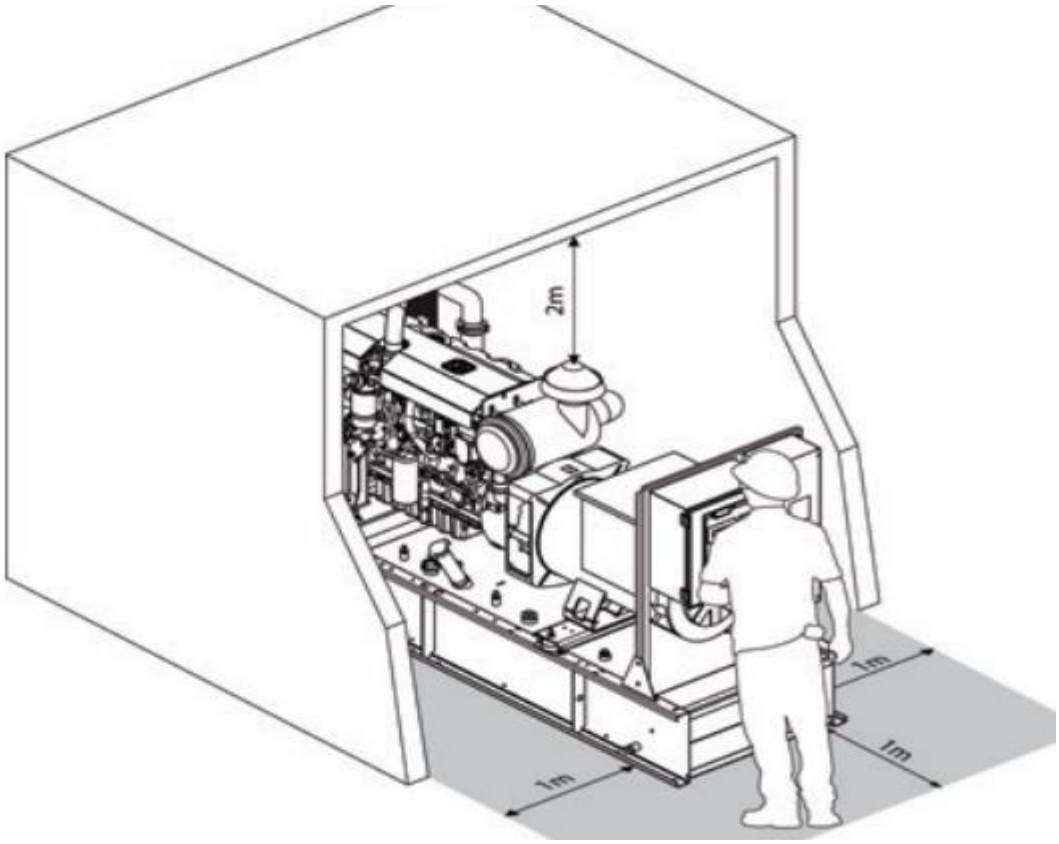


Fig 4.2 Typical installation showing generator set access and operator workstation

3.1.2 Outdoor Installation

Installation and handling of generator is greatly simplified when the generator set has been equipped with an enclosure.

Two basic types may be fitted. The first type is a close-fitting canopy enclosure. This will be both **weatherproof** and **sound attenuated**. The other enclosure type is a **walk-in type container**, similar to a shipping container. It may be weatherproof or sound attenuated. These enclosures provide a self-contained generator set system that is easily transportable and requires minimal installation. They also automatically give protection from the elements and protection from unauthorized access.

The following considerations must be taken into account when temporarily installing the generator set

- Locating the generator set where it will be protected from damage and away from the exhaust fumes of other engines or other airborne contaminants such as dust, lint, smoke, oil mist or vapors.
- Ensure the generator set is not positioned in such a way that it will obstruct the entrance or exit to the area where the it is situated.

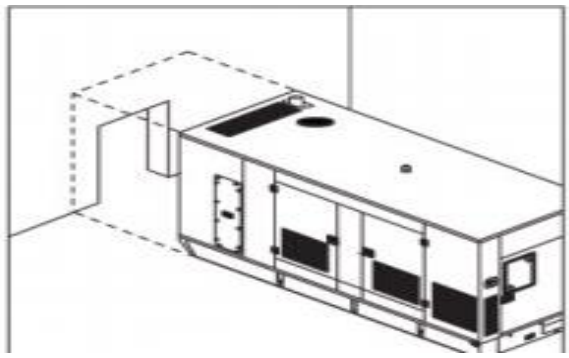


Fig 4.3

- Locating the generator set on firm, level ground which will not subside or be otherwise affected by the vibration caused by the operation of the generator set.
- Ensuring that fumes from the exhaust outlet will not be a hazard especially when wind is taken into account.

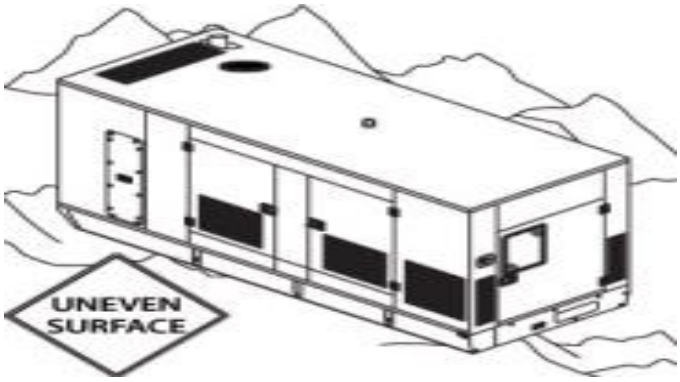


Fig 4.4

- Ensure there is enough area around the generator set for access and serviceability.

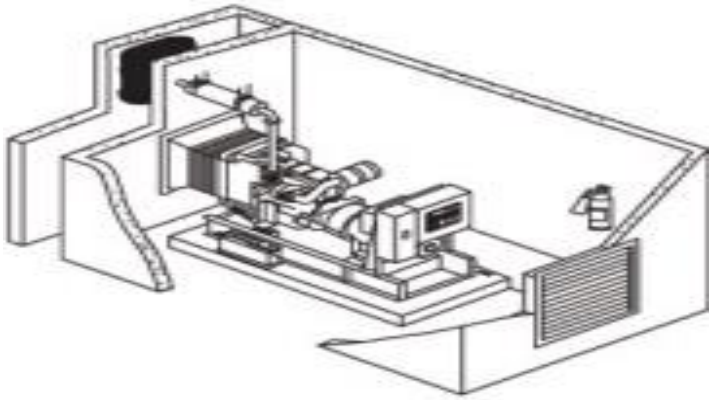


Fig 4.5

- Electrical grounding of the generator set at all times, in accordance with local regulations.

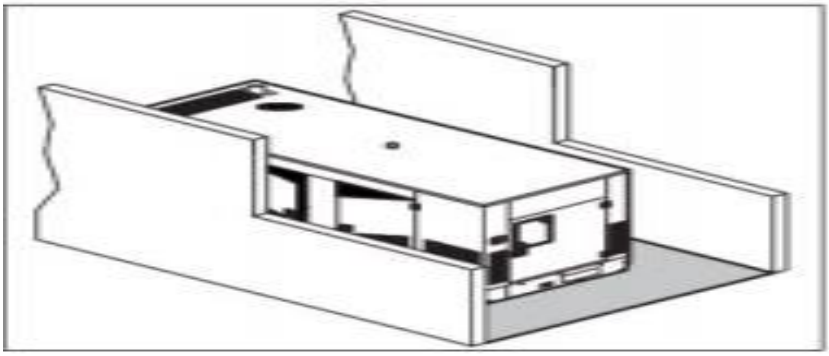


Fig. 4.6

- Providing access to refill the fuel tank when required.

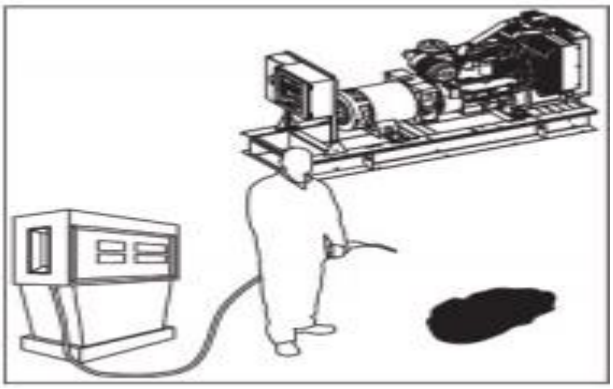


Fig 4.7

- Protecting electrical cables installed between the generator set and the load. If these are laid on the ground ensure they are boxed in or covered to prevent damage or injury to personnel.

3.1.2.1 Positioning of Walk-in Containers

Proper installation of the container is required if successful generation of power is to be achieved. The following information must be considered in the selection of the operating site for the container. The containerised generator set must be placed on a flat surface in order to maintain proper alignment. Containers can be successfully installed on a concrete plinth or level, natural surface. The foundation must bear the static weight of the module plus any dynamic forces from engine operation

3.1.3 Moving the Generator set

The generator set base frame is specifically designed for ease of moving the set. Improper handling can seriously damage components.

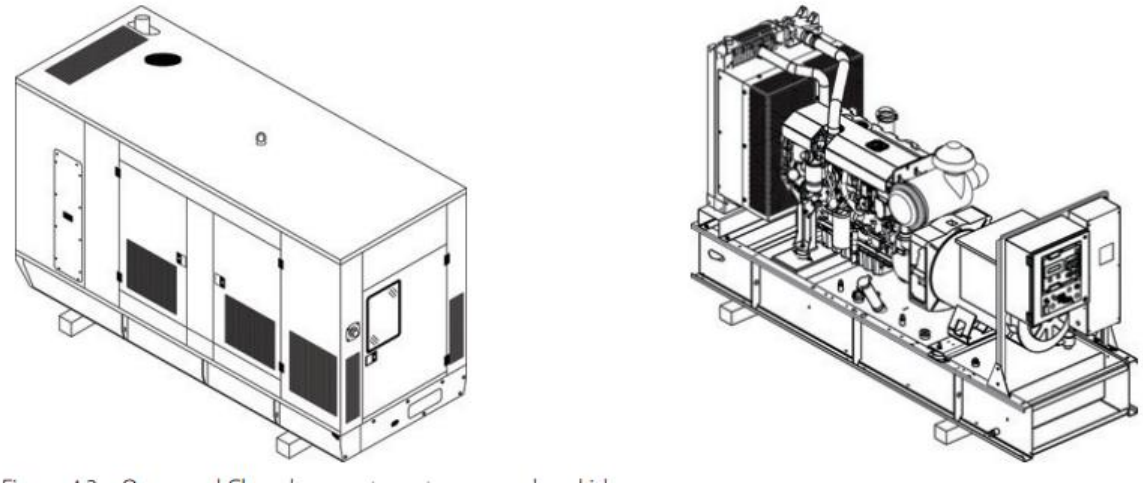


Fig 4.8 pen and Closed generator sets on wooden skids

Using a forklift, the generator set can be lifted or carefully pushed/pulled by the base frame. If pushing, do not push the base frame directly with fork.

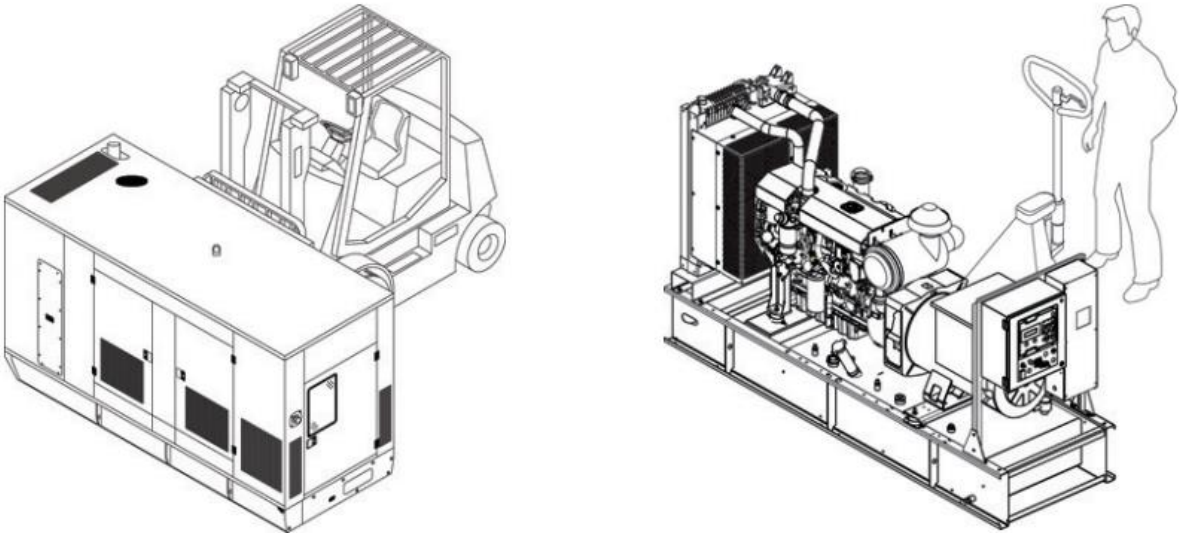


Fig 4.8 Transporting a generator set using a forklift truck and forklift trolley

- **Storage**

Long term storage can have detrimental effects on both the engine and alternator. These effects can be minimised by properly preparing and storing the generator set.

- **Engine Storage**

The engine should be put through an engine “preservation” procedure that includes cleaning the engine and replacing all the fluids with new or preserving fluids. Please consult your local Dealer for more information on engine storage.

- **Alternator Storage**

When an alternator is in storage, moisture tends to condense in the windings. To minimise condensation, store the generator set in a dry storage area. If possible, use space heaters to keep the windings dry.

- **Battery Storage**

While the battery is stored, it should receive a refreshing charge every 12 weeks (8 weeks in a tropical climate) up to a fully charged condition

Self-Check -3	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts.

1.Selecting a location for the generator set is important for any installation procedure.

A. TrueB. False

2. which of following factors are important in determining the location generator installation

A. Adequate ventilation.

B. Access to move the entire generator set into the room.

C. Limited access to unauthorized personnel

D. all

3. Generator engine should be put through an engine “preservation” procedure that includes cleaning the engine and replacing all the fluids with new or preserving fluids.

A. true B. False

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-1

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. 2. 3. 4. 5._____.

Information Sheet-4	Carrying out Maintenance and resets/adjustments

4.1IntroductionGenerator maintenance

A good maintenance programme is the key to long generator set life. Maintenance and service should only be carried out by qualified technicians. Records of this work should be kept to aid in developing an efficient maintenance programme. In general, the generator set should be kept clean. Do not permit liquids such as fuel or oil film to accumulate on any internal or external surfaces or on, under or around any acoustic material, if fitted. Wipe down surfaces using an aqueous industrial cleaner. Do not use flammable solvents for cleaning purposes.

4.2 carryout generators Components Maintenance

4.2.1 Battery Maintenance

Warning:

- I Ensure personnel have been trained in the handling and proper use of batteries. Always wear the correct personal protection equipment (PPE) when handling batteries.
- I Battery maintenance checks should also be completed as part of your routine maintenance inspections.
- I Always wear the appropriate PPE when handling electrolyte. If splashed with electrolyte, immediately flush the affected area with clean water and seek medical advice.
- I Never add undiluted sulphuric acid to a battery.
- I Keep batteries upright to prevent electrolyte spillage. Electrolyte is a dilute sulphuric acid and is harmful to the skin.
- I Use tools with insulated handles when removing or fitting the battery. Never place tools or metal objects across the battery terminals.
- I During charging, the battery gives off explosive gases. Keep the battery in a well-ventilated area and away from naked flames and sparks. Smoking is also prohibited.

Generator set batteries, by law, must not be disposed of with household waste.

Fig5.1

Batteries contain hazardous materials and in the charged state, each cell contains electrodes of lead metal (Pb) and lead (IV) dioxide (PbO2) in an electrolyte of about 33.5% w/w (6 Molar) sulphuric acid (H2SO4). In the discharged state both electrodes

turn into lead (II) sulphate (PbSO4) and the electrolyte loses its dissolved sulphuric acid and becomes primarily water. It can be damaging to the environment to send these to landfill, burning batteries can also cause atmospheric pollution.

Dealing with lead acid batteries can be hazardous so it is important to follow all safety guidelines.

Batteries are an essential part of the generator set and should be maintained appropriately.

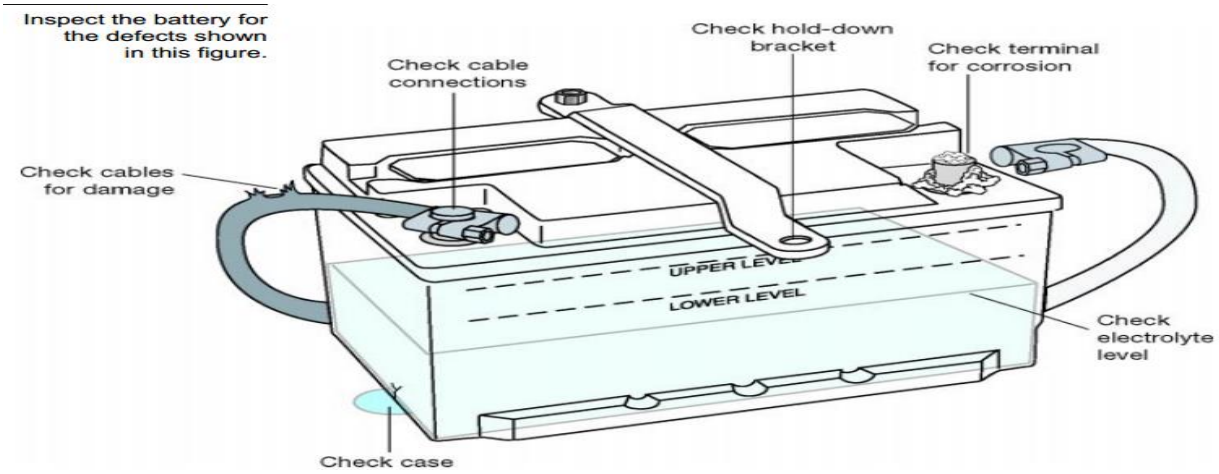


Fig 5.2

- Keep the battery area clean and dry and ensure any vent caps are tight (if fitted).
- Clean the battery case with one of the following cleaning solutions:
  - ✓ A mixture of 0.1 kg (0.2 lb) of baking soda and 1 L (1 qt) of clean water
  - ✓ A mixture of 0.1 L (0.11 qt) of ammonia and 1 L (1 qt) of clean water
- Thoroughly rinse the battery case with clean water.
- All battery connections must be kept clean and tight. Use a fine grade of sandpaper to clean the terminals and the cable clamps.

- Clean the items until the surfaces are bright or shiny. Do not remove material excessively. Excessive removal of material can cause a poor connection between the clamps and the battery terminals.
- Coat the clamps and terminals with grease or other terminal protector to prevent corrosion
- The electrolyte level should be covering the plates/grids (1/2 inch / 13 mm) within the battery to maximize full charge transfer. If the liquid level is below the plates/grids, only add distilled water; never add battery acid to top up the volume, as the addition of extra acid will destroy the grids.

Battery Removal and Fitting

- Battery acid can burn clothing and skin or cause blindness if it leaks. Please wear protective clothing when inspecting a battery prior to its disconnection / transportation.
- Ensure the battery to be fitted is filled with the correct levels and mixture of electrolyte and is fully charged.
- If vents are fitted, ensure they are firmly in place.
- Before removing a battery, carry out a thorough inspection of its condition. Use a torch if visibility is poor to check all sides of the battery for any marks, dents or leaks.
- If the battery has any severe dents or leaks please contact your local Dealer for assistance. DO NOT attempt to remove the battery
- Disconnect the battery safely before inspecting it (see below).
- Disconnect any battery charging circuitry before fitting the battery.
- When removing a battery for whatever reason always ensure all load is removed before disconnecting the battery so that no sparks are created.
- Disconnect the negative cable first followed by the positive cable to avoid short circuit against any metal framework, then remove the hold down clamp or strap securing the battery base. The battery can be heavy so please be careful when lifting and carrying the battery. Seek assistance if required.
- When refitting the battery, ensure the terminal posts are correctly aligned with the cables to avoid wrong connection and place the new battery into the hold-down tray and reattach the hold-down clamp or strap. Attach and tighten the positive battery cable to the positive terminal first. Then attach and tighten the negative battery cable to the negative terminal.

- Keep the battery terminals clean and free from corrosion and lightly smear the connections with petroleum jelly.
- Ensure battery terminals are tight as loose battery terminals can reduce battery life and are a fire hazard.
- Ensure the positive terminal on each battery is covered correctly.
- When fitting a battery and / or battery charger please ensure they are appropriately matched. Please consult a qualified technician if unsure.
- During transport, please ensure that battery terminals are covered to remove the possibility of a short circuit.
- Keep the battery upright at all times

Battery Fluid Levels

A hydrometer can tell you the battery's state of charge.

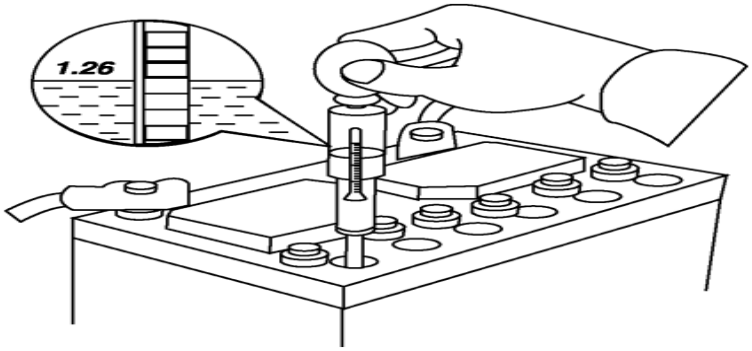


Fig .5.3Battery Fluid Levelstest

4.2.2 Alternator Maintenance

Alternator Preventative Maintenance: - There is no routine maintenance required on the alternator, however observe the following recommendations:

- Periodically inspect the alternator winding condition and carry out general cleaning.
- Periodically inspect the cable connections between the alternator and the circuit breaker.

4.2.3 Engine routine care and maintenance

Routine care and maintenance are given to and engine during normal use. It is provided to keep the engine operating at its peak efficiency and to prevent under wear of engine parts.There are for basic points to consider: Oil supply, cooling system, Spark plug (for petrol engine) or injector (for diesel engine) and air cleaner.

Crank Mechanism component servicing

- **Cylinder Block services**

✓ Clean thoroughly the cylinder block using either hot or cold chemical cleaning.

✓ Inspect for any sign of damaging.

✓ If the there is no damage, measure the bore for nominal diameter, taper and ovality using dial bore gauge or **telescopic guage or micro-meter**. If they are within specified limit use the cylinder again otherwise replace it.

✓ Check the cylinder for flatness using **straight gauge and filler gauge**.

- **Crankshaft servicing**

✓ Clean thoroughly the crank shaft and inspect for any damage or wear.

✓ Check for any form of discolorations around the bearing journal and thrust faces. It indicates caused by overheating and which may need replacement or recondition.

✓ Check journal bearing any form of damage for reconditioning or replacement.

✓ Check for straightness using two v-blocks.

✓ Measure journal diameter and ovality, journal taperness and thrust face wear using outside micrometer, compare with the specification, if out of specification recondition or replace it.

✓ If a crank shaft is found to be within the wear specification, but slight surface scratching on journals, polish so as to remove the scratch marks.

✓ Grind the crank shaft for the next under size and change the bearings**.**

- **Piston servicing**

✓ Clean thoroughly the piston using suitable solution.

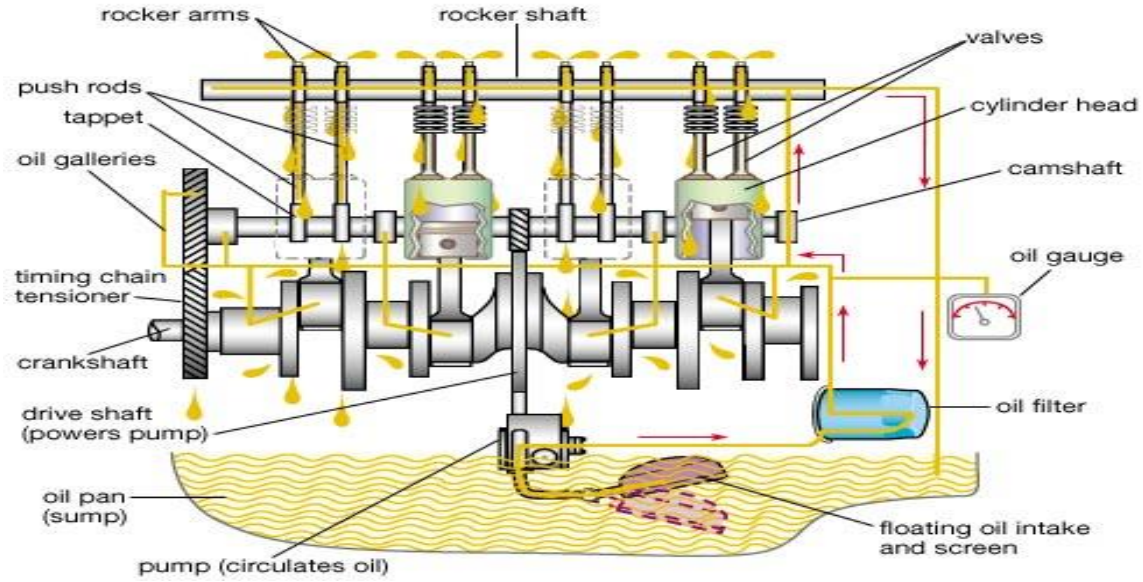
✓ Clean ring groves using ring groove tool.

✓ Examine the cleaned piston for cracks especially for skirts and crown and for damaged or broken ring lands.

✓ Scored or cracked pistons should be replaced.

✓ The top ring grove worn the most because of exposed to greater heat.

✓ Ring groves wears should be check using gauges and if it is out of specification it has to be replaced.



- **Connecting rod serving**

✓ Check for cracks, alignment, boring bore wear and big end housing distortion.

✓ Critical area to be looking seriously along the shank of the connecting rod above the big end bore and below the piston pin bore.

✓ If the connecting has been damaged in any way, it should be replaced. Piston rings

✓ Whenever piston rings are removed from the piston, regardless of how much work they have done, they should be replacing. Take care of that insufficient ring gap can cause rings bind to the cylinder wall during engine operation, resulting in damaged to both cylinder and rings.

Ring sticking caused by the formation of carbon deposit in and around the ring groove, which restrict the outward movement of the ring, thereby preventing a proper seal between the ring and the cylinder wall. This is caused by:

- Improper grade and quality of oil used;
- Incorrect oil and filter change intervals;
- Using inferior quality of oil filters;
- Low engine operating temperature.

Ring breakage is determined to efficient cylinder sealing and can be caused by the following:

- Excessively worn ring groove and rings;
- Overstressing of the ring during installation on the piston;

- The ring sticking a wear edge at the top of the cylinder during operations;
- Excessive cylinder combustion pressure.
- Faulty work can also be responsible for piston and ring failures.

Self-Check -4	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts.

1.A good maintenance programme is the key to long generator set life.

A. True B. False

2. Battery acid can burn clothing and skin or cause blindness if it leaks

A. True B. False

3.Which of the following is true about maintenance of generator.

A. Maintenance and service should only be carried out by qualified technicians.

B. Records of generator maintenance work should be kept.

C. Do not use flammable solvents for cleaning purposes of generator component.

D.All

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-1

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. 2. 3. _____

Information Sheet-5	carrying out final job inspection

5.1Operational Check

Check the equipment(generator) during operation and observe the following indications:

- Unusual noises or noisy operation may indicate excessive bearing wear or faulty bearing alignment. Shut down and investigate.
- Equipment overheats or smokes. Shut down and investigate.
- Equipment brushes spark frequently. Occasional sparking is normal but frequent sparking indicates dirty commutator and/or brush or brush spring defects. Shut down and investigate.

Table 6.1 Generator Inspection Checklist

Inspect	**Check For**
Brushes	Amount of wear, improper wear, spring tension
Commutator	Dirt, amount of wear, loose leads, loose bars
Collector rings	Grooves or wear, dirt, carbon and/or copper accumulation, greenish coating (verdigris)
Insulation	Damaged insulation; measure and record insulation resistance
Windings	Dust and dirt, connections, loose windings or connections
Bearings	Loose shaft or excessive endplay, vibration (defective bearing)
Bearing housing	Lubricant leakage; dirt or sludge in oil (sleeve bearings)
Ventilation and cooling	Obstruction of air ducts or screens; loose or bent fan blades

Before starting up the generator you have to:

- check the generator **by eye (visual inspection).** Make sure that there is no fuel, oil, water leaking and broken, cracked, loose parts. Any warnings and alarms(if thee generator have sensor) should not be displayed on the control module. If you think you have a problem related with generator, do not operate the generator without eliminating the problem.
- There should be no foreign substances around and on the generator that may be fall down and taken by radiator fa.
- check the oil level. The oil level should be close to the maximum level.
- check the coolant level.
- check that there is not a situation that will prevent the generator air intake and outlet
- check that air filter is clean.

- Make sure the battery cable is tightened
- For the generators will be used in automatic mode, the output circuit breaker must be in the ON position
- For the generator will be used in manual mode, while starting the generator output circuit breaker should be
- in the OFF position after that it should be brought to the ON position before loading the generator.
- Check that the emergency stop button is not pressed. If it is pressed, unscrew the hold

To Starting up the generator:

It is recommended to refer generator Instruction manual for Starting up the generator.

- For example, for ETT-55E generator model I get from its instruction manual to starting up the generator (refer www.ett.com.tr)
- For the generator will be used in automatic mode, press the AUTO button on the control module and observe that the LED on the button is lighting. After this procedure, the generator is ready to run and will be operated automatically when electricity fails. The generator will stop automatically when electricity comes back. There is no need for further action.
- For the generator will be used in manual mode, firstly be sure that generator is not connected to the load, press the RUN button on the control module and observe that the LED on the button is lighting and generator is running. After warming up the generator, bringing the output circuit breaker in the ON position and power the load.

After starting up the generator: you have to

- check whether there is a strange noise except the sound of the engine.
- check whether excessive vibration on generator
- check that there are no leaks in the fuel, oil and cooling system
- check for leaks in the exhaust system.

check that the output voltages of the generator are phase - phase, phase - neutral and the frequency a. Please stop the generator and service, if an extreme deviation can be read in one of the phase voltage or absence of voltage or abnormal frequency.

Self-Check -5	Written test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two point.

1. Before starting up the generator what we do

   A. check the generator by eye (visual inspection)

   B. check the oil level.

   C. check the coolant level.

   D. All

   D. All

2. To Starting up the generator it is recommended to refer generator Instruction manual

A. True B. False

3. After starting up the generator what we do

   A. check whether there is a strange noise except the sound of the engine.

   B. Check whether excessive vibration on generator

   C. check that there are no leaks in the fuel, oil and cooling system

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-1

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. 2. 3. _____

Information Sheet-6	Permitting and carrying out final job inspection

6.1Generator permit checklist

Required Permit Applications:

- Electrical Permit
- Building Permit
- Plumbing Permit

Permit Review Stops:

- Structural
- Mechanical (only if powered by diesel fuel or gasoline)
- Electrical
- Zoning
- Plumbing

6.2 Requirements for Generator Permits and Inspections

6.2.1 Portable generators

Electrical Permit:

- One line drawing for wiring installation with conductor & conduit size.
- Manufacturer's specifications for transfer switch.

6.2.2 Standby generators

Zoning Review:

- Outside placement must meet zoning for accessory construction.
- Sketch generator and trench location on COPY of a site plan.

Plumbing Permit: For gas hook-up

- One-line isometric drawing showing pipe size, material and run distance.
- If CSST is being used, bonding method must be indicated on the electrical permit.
- Indicate fuel source. Indicate whether installation is above or below ground.

Electrical Permit: For Generator and Transfer Switch

- One line diagram for wiring installation with conduit size.
- Load calculations for whole house generators with automatic transfer switches.
- Manufacturer's specifications for generator.
- Manufacturer's specifications for transfer switch [for both manual and automatic].

Electrical Inspections:

- All breaker panel, transfer switch, junction box and generator covers must be removed for inspection.
- Electrical contractor and the approved plans must be on site for inspection.
- If the electrical contractor is not on site for inspection, the Building Department must be notified in writing that all covers have been installed before a Certificate of Approval will be issued.

Self-Check -6	Written test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two point.

1.which of the following is Required Permit Applications for generator installation

A. Electrical Permit B.Building Permit C**.** Plumbing Permit D. All

2.which of the following is Electrical Permitfor Generator and Transfer Switch

A.One line diagram for wiring installation with conduit size.

B. Load calculations for whole house generators with automatic transfer switches.

C. Manufacturer's specifications for generator.

D. All

3.which of the following is Zoning Review Permitfor Generator and Transfer Switch

A. One line drawing for wiring installation with conductor & conduit size.

B. Manufacturer's specifications for transfer switch.

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

You can ask you teacher for the copy of the correct answers.

Answer Sheet-1

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. 2. 3. _____

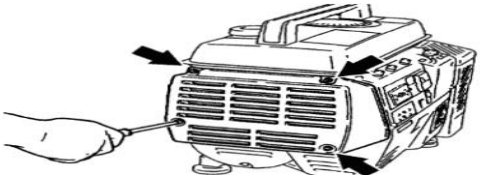
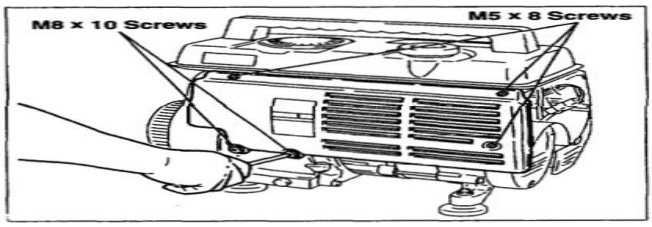
Operation Sheet 1	Carrying out Maintenance and resets/adjustments

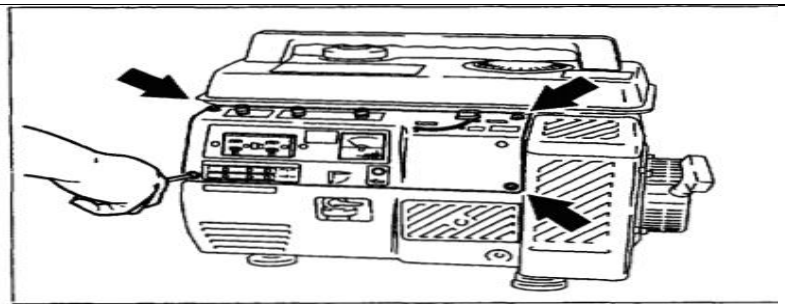
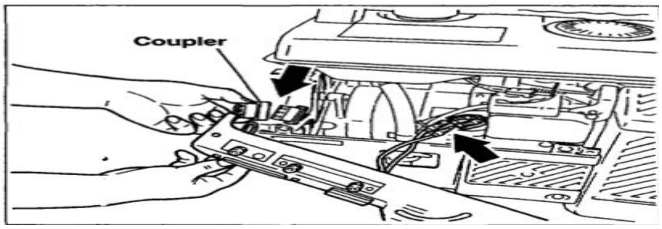
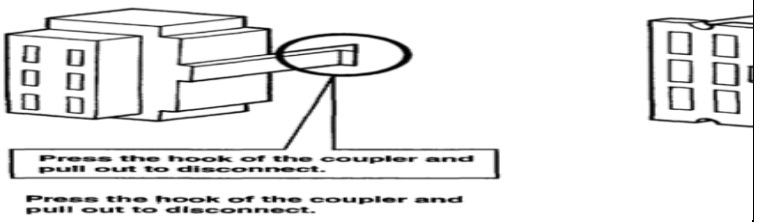
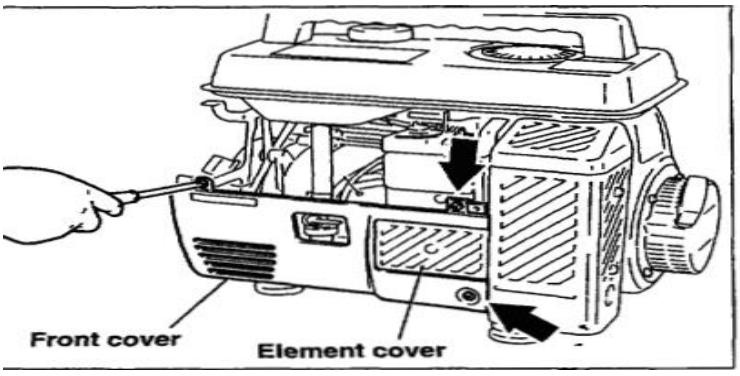
Steps to Disassembly and assembly simple generator

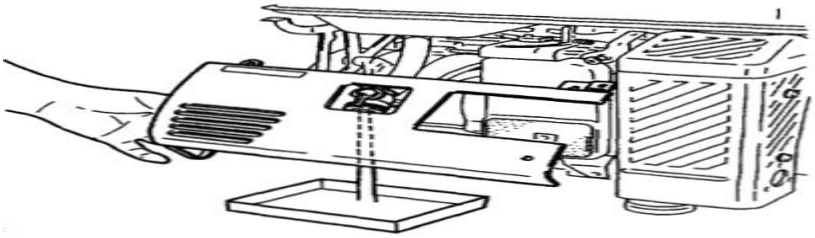
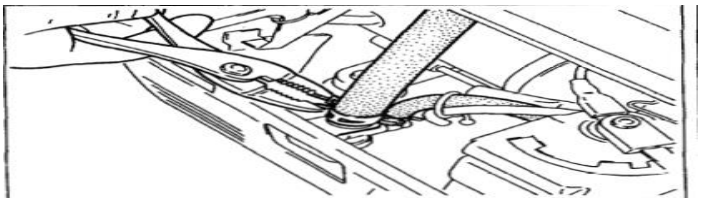
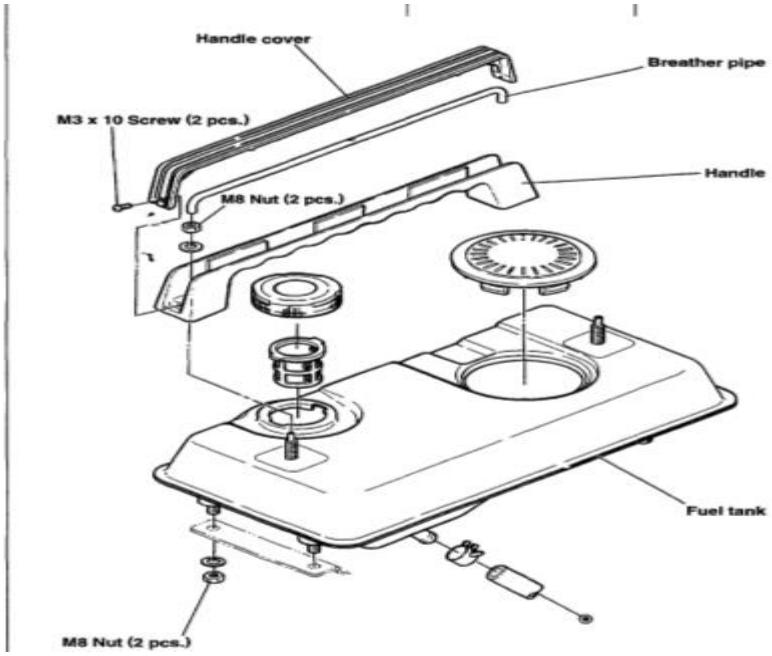
Step 1.Preparation and precautions

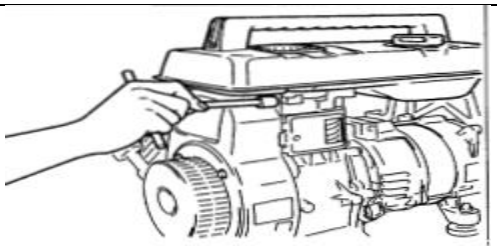
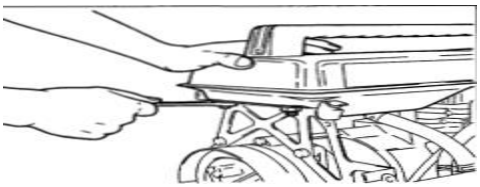
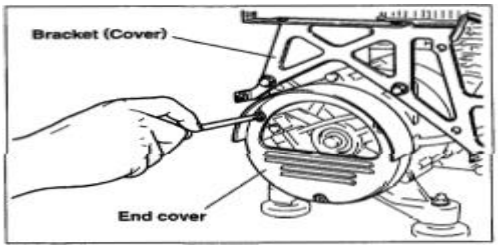
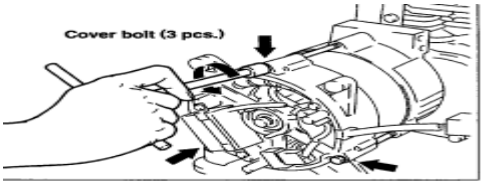
- Be sure to memorize the location of individual parts when disassembling the generator so that the generator can be reassembled correctly. Tag the disassembled part with the necessary information to facilitate easier and smoother reassembling.
- For more convenience, divide the parts into several groups and store them in boxes.
- To prevent bolts and nuts from being misplaced or installed incorrectly, place them temporarily back at their original position.
- Handle disassembled parts with care; clean them before reassembly using a neutral cleaning fluid.
- Use all disassembly /assembly tools properly, and use the proper tool for each specific job.

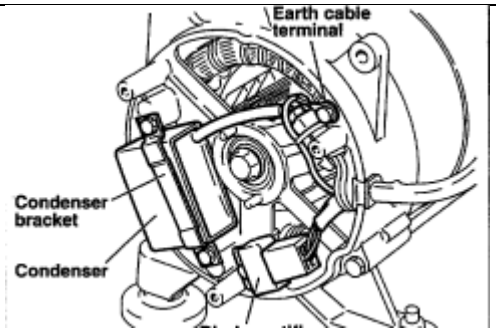
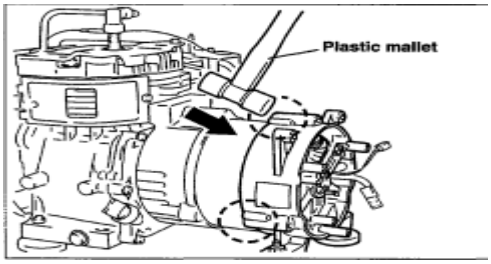
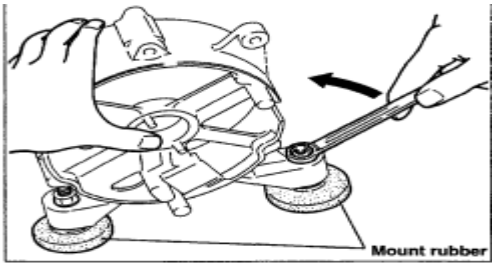
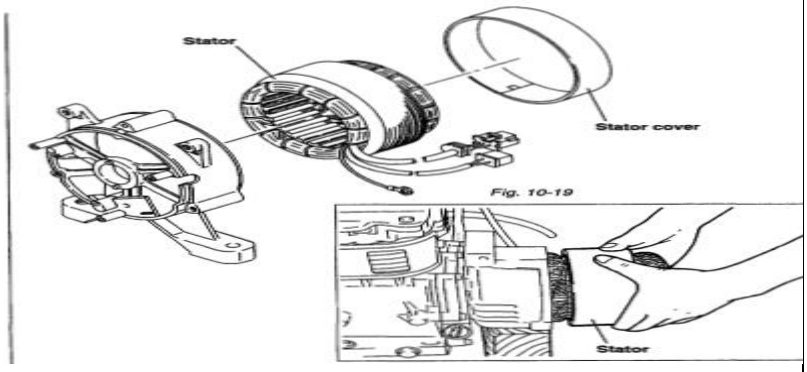
Step2. carry out disassembly procedures below

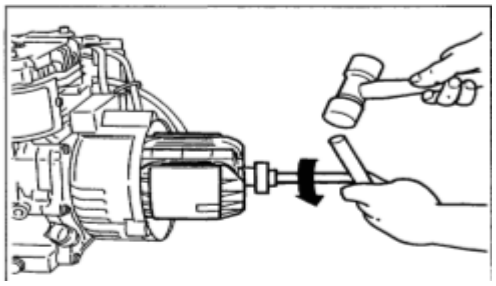
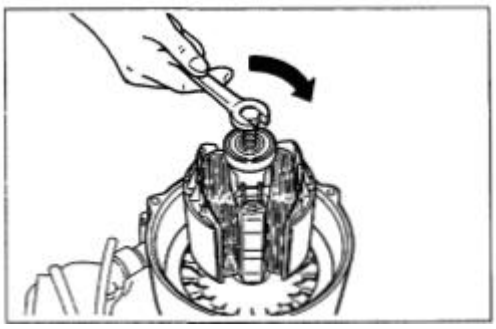
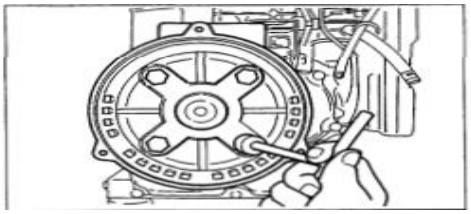
step	Part remove	Description	Tool
1	Side cove	1) Remove the side cover by unscrewing 	screw driver
2.	Rear cove	Remove the rear cover by unscrewing 	screw driver
3	Control bane	(1) Pull the knob off the control lever and remove the control panel by unscrewing	Plus, drive

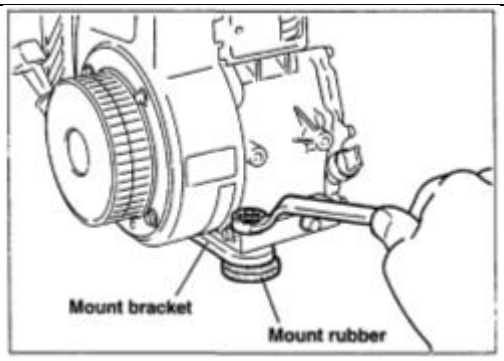
			
4.	Couplers and plugs (DiIscon-nection)	Disengage the couplers of stator wires 6P couplers (Yellow, Red, Green/ hook. Yellow, Brown, White)  Disengage the connectors of oil warning lamp (option  	
5.	Front cove	Remove the element cover by Unscrewing& Remove the front cover by unscrewing  	Driver
6.	Fuel pipe and plug (Discon-	• **Discharge fuel from the tank**. 1. Shut the fuel strainer. ,2. Remove the strainer cup. ,3. Put a vessel to receive fuel under the strainer and open the fuel cock	Pliers

	nection)	to discharge fuel. 4. Attach the strainer cup to the strainer body  • **Disconnect fuel hose from the strainer**. Loosen the hose clamp on top of the strainer and pull out the fuel hose from the strainer 	
7.	Fuel tank handle	1.Remove the handle cover by unscrewing ,2. Pull off the breather pipe. . Remove the handle body by taking off the two M8 nuts 	Driver
8.	Fuel tank	1) Remove the two M6X 12 flange bolts from the blower housing.	box wrench

		 (2) Remove the fuel tank by taking off the two M8 nuts from the bottom of the tank. 	
9	Bracket (Cover)	Remove the bracket cover from the generator by loosening the two M8 X 30 bolts. (see fig 10)	box wrench
10	End cover	Remove the end cover from the generator by unscrewing  fig 10	
11	Rear bracket	1) Loosen and take out the three M6 cover bolt.  2.. Remove condenser from rear bracket. 3. Remove the connector of the diode rectifier and then remove the earth cable terminal from the rear bracket	

		 4.Remove the rear bracket, tapping it evenly with a plastic mallet  Remove mount rubbers from rear cover 	
12	Stator	1.Remove the stator cover. (See Fig.below.) 2. Pull off the stator from the front cover Never tap on the tapping the core. with a plastic mallet. winding and the lead. 	

13	rotor	(1) Take off the through bolt. Apply a box wrench on the head of through bolt. Hit the wrench handle with a hammer counter-clockwise to looser  3. Put the engine on the working table recoil starter side down 4. Screw the bolt into the thread of the rotor shaft. 5. Torque the bolt using a socket wrench until the rotor comes off loos 	
14	Front bracket	Remove the front bracket, which is mounted on the main bearing cover of the engine. 	
15	Mount rubber	Remove mount bracket from engine. Remove mount rubbers from mount bracket.	box spanner

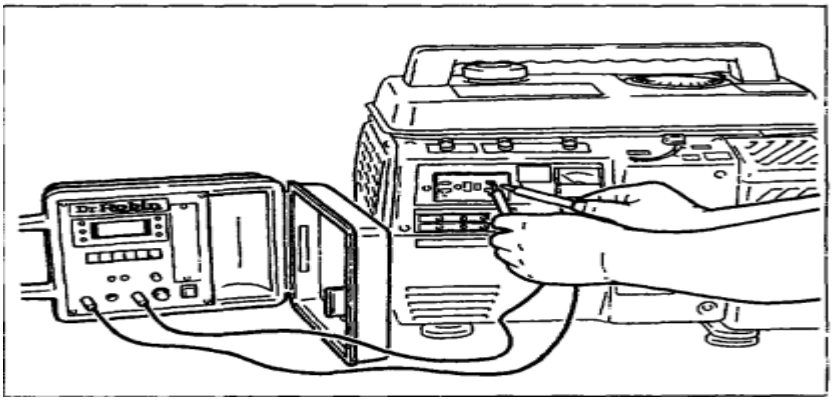
- To ASSEMBLY please go in reveres procedures and way of disassemble procedures’

Operation Sheet 2	Confirming the required isolations in accordance with site requirements carrying out final job inspection

Steps to Measure insulation resistance of generator parts

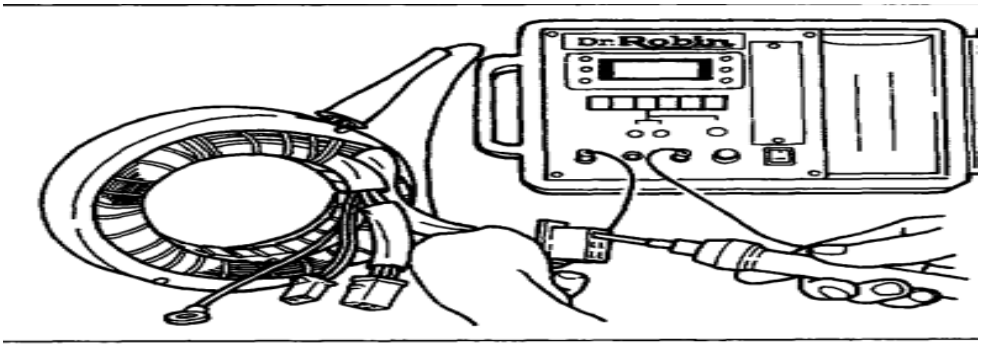
Step 1.identify tools and PPE

Step 2. Connect a megger tester to one of receptacle output terminals and the ground terminal, then measure the insulation resistance. If the insulation resistance less than 1 megohm, disassemble the generator and measure the insulation resistance of the stator, rotor and control panel individually.



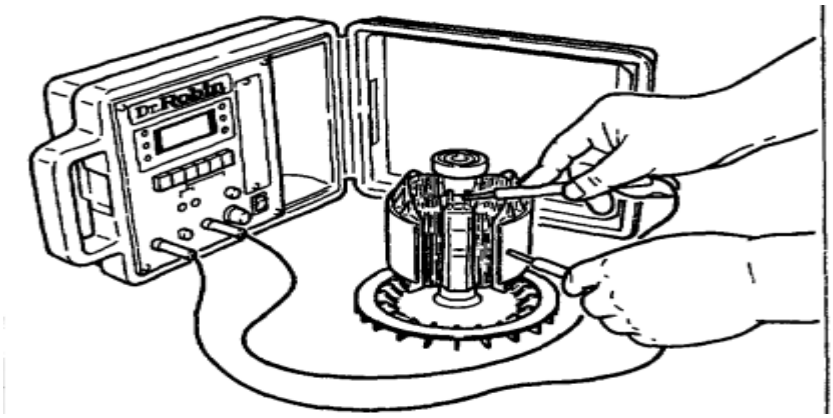
Step 3. To Measure the insulation resistance of STATOR

- Measure the insulation resistance between BROWN lead and the core.
- Measure the insulation resistance between YELLOW lead and the core.
- Measure the insulation resistance between BLACK lead and the core.



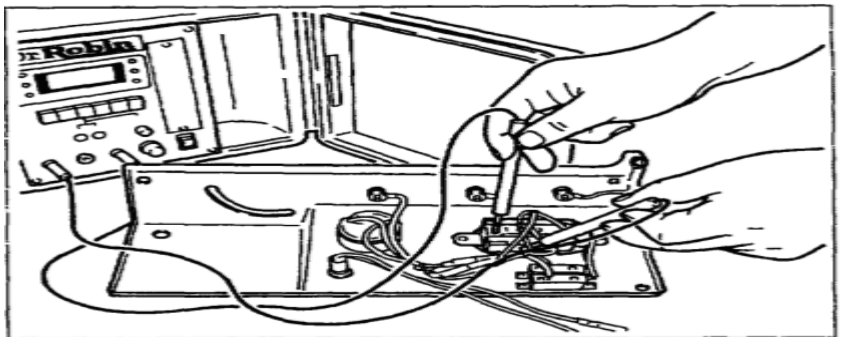
Step 4. Measure the insulation resistance of ROTOR

Measure the insulation across one of the soldered terminals of the rotor and the core.



Step 4. Measure the insulation resistance CONTROL PANEL

Measure the insulation resistances between the live parts and the grounded parts.



Any part where the insulation resistance is less than 1M8 has faulty insulation, and may cause electric leakage and electric shock. Replace the faulty part

Operation Sheet 3	Carrying out Maintenance and resets/adjustments

Steps to Perform generator maintenance

Step #1identify tools and PPE

Step #2- maintenance troubleshooting

- Troubleshoot or identify the cause and effect according to table 1.1

Step #3- availability parts and accessories

- Checks that must change items are available in the store
- Purchase to replace broken material of electrical generator
- Fixing, loose fasting /maintain as per generator manual procedures as necessary

Step #4- functionality test

Test the whole generator components - meggering, relay testing, circuit breaker trip testing, alternating current (AC) high-potential (Hipot) tests, high voltage direct current (HVDC) ramp tests, battery load test

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Giving the necessary equipment's and PPEs you are required to perform the following tasks within 8 hours

Task 1. Isolate Testing and measurement instrument for generator maintenance

Task 2. Disassembly and assembly simple generator

Task 3. Perform generator maintenance.

Instruction Sheet 3	Learning Guide # 31: Complete the work

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

- completing and notifying work in accordance with site/enterprise requirements
- cleaning, restoring and securing work in accordance with site/enterprise procedures
- Maintaining and storing Plant, tools and equipment in accordance with site/enterprise procedures
- Finalizing work completion details in accordance with site/enterprise procedures

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

- complete and notify work in accordance with site/enterprise requirements
- clean, restore and secure work in accordance with site/enterprise procedures
- Maintain and store plant, tools and equipment in accordance with site/enterprise procedures
- Finalize work completion details in accordance with site/enterprise procedures

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 4”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2,3 and 4” in each information sheets on pages 92,94,96 and 98
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1on pages 99.and do the LAP Test on page 100”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	completing and notifying work

1.1Maintenance Log and Reporting

Maintenance Log- shows necessary status information of the generator set and used as input for next maintenance

Maintenance work Report should consist of the amount of work done and the location of work /machinery as well as the resource used. normally, these are completed at the end of each day or at the end of each job if more than one activity is performed during day.

The daily work reports should be reviewed by the supervisors promptly to ensure that they were completed properly and to determine if the performance standards were substantially followed.

Table 1.1 maintenance log form sample

Equipment Maintenance Log

Name of Equipment		**Manufacturer's contact details:**	
Label:		**Date of purchase:**	10/15/2016
Serial number:		**Person responsible for equipment:**	
Manufacturer:		**Date put into service:**	10/23/2016

Date:	Maintenance Description	Maintenance performed by:	Date of validation before put into service:	Validation performed by:	Next maintenance planned on (date):	Remarks:

Self-Check -1	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth one point

1. Maintenance work Report should consist of the amount of work done and the location of work /machinery as well as the resource used.

A. True B. False

2. The daily work reports should be reviewed by the supervisors.

A. True B. False

3. Maintenance work Report consist of:

A. the amount of work done and C. the resource used

B. the location of work /machinery D. all

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

You can ask you teacher for the copy of the correct answers.

Answer Sheet-7

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. 2. 3.

Information Sheet-2	cleaning, restoring and securing work

2.1. Introduction clearing, restoring and securing work area

Work area clearing is the process of removing rubble, debris and, in some cases, other materials which have been deposited due to an incident, or event making an area unsafe or unusable. The ultimate aim of work site clearing is to return of the site or area to its former condition or use prior to the incident

After maintain electrical generators, care should be taken in clearing, restoring and the securing work area:

Workers should know that the job is not complete until the tools are cleaned and stored in a designated location.

- Used tools and equipment's should be collected and cleaned properly according to organizational cleaning procedures
- Clear tools and equipment from work area.
- Locking storage cabinets and restricting access to storage areas will prevent unauthorized handling of stored items and minimize the possibility of theft
- Store reusable materials and equipment in an appropriate location.
- Restore the work areas to a safe condition in accordance with agreed requirements and schedules

Cleaning

- Clean the tools immediately after use.
- Wash the tools using water. A wire brush may be useful to loosen the soil stuck to the blades.
- Avoid the risk of spreading pathogens while the tools are being cleaned.
- Coat the blades with light oil like WD-40 on areas prone to rust.

Storage

- Store tools in a dry, sheltered environment. Place tools on a rack for easy safety and easy access.
- Place similar tools close together so that workers can see easily the available tools

Self-Check -2	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two point

1. Destroying tools and equipment's after completing your task.

A. True

B. False

2. Restore the work areas to a safe condition in accordance with agreed requirements and schedules

A. True

B. False

3. Store reusable materials and equipment in an appropriate location.

A. True

B. False

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

You can ask you teacher for the copy of the correct answers.

Answer Sheet-7

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. 2. 3.

Information Sheet-3	Maintaining and storying Plant, tools and equipment

3.1 Introduction to Maintaining and storying Plant, tools and equipment

An effective maintenance program should aim to minimize these effects by keeping equipment clean and dry, keeping connections tight and minimizing friction.

Tools that are unsafe/faulty can be categorized in to two: those having minor faults such as loose handle, rusted hinges, damaged blade, bent ends & dirt edges, dismantled casing, missing screws etc… and those fully damaged include broken teeth, broken blade, tool with missing parts, worn tools, burned elements, open circuits inside the tool, frayed or damaged flexible cords etc...

The method of identifying faulty and functional tools is done either by visual inspection or by performing different tests using test instruments

Tools and equipment are visually inspected before use and electrically tested by a competent person as necessary Visual checks are carried out as follows:

Tools/appliance

- On/off switch is working correctly
- No signs of damage to casing
- No loose parts or missing screws
- Live parts are properly guarded so as not to be inadvertently accessible
- Ensure equipment is disconnected when not in use

Maintenance of generator maintenance tools and equipment

- Keep metal blades of all tools sharp and well-oiled.
- Check for loose and worn out parts on tools regularly, and replace if necessary.
- Identify damaged tools and store them in a designated location to allow either the supervisor or maintenance person to arrange for their repair.

Self-Check -3	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two point.

1.Tools and equipment are visually inspected before use and electrically tested by a competent person as necessary Visual checks are carried out as follows:

A. True B. False

2. Among the following tool faulty which one is categorized as fully damaged

A. loose handle, B. rusted hinges,

C. damaged blade D. open circuits inside the tool,

3.Tools and equipment must inspect before use.

A. True B. False

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

You can ask you teacher for the copy of the correct answers.

Answer Sheet-7

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. 2. 3.

Information Sheet-4	Finalizing work completion details

4.1Maintenance Forms and Records

A written record of generator inspections, tests, exercising, operation and repairs must be maintained on the premises and be available for review by the fire inspector on request. This record must, at a minimum, include: the date of the report, name(s) of the person(s) providing the service, identification of unsatisfactory conditions and corrective action taken (including parts replaced), and any testing of repairs recommended by the manufacturer.

- Record maintenance information and test data for generators on Service-approved forms and checklists.
- Forms serve as an **equipment inspection guide** or **checklist in** order to maintain the generators in optimum working condition.
- **Retain records** for the Service-defined period of time and make available to, as requested.

4.2 Work completion details

- **plant and maintenance records**

Plant and maintenance records are the set of documentation that constitute of written statements (or table format) of overall intentions and directions as defined or given by the organization. It contains the entire information from the stage of receiving maintains (or inspecting) to knowing of the maintenance result.

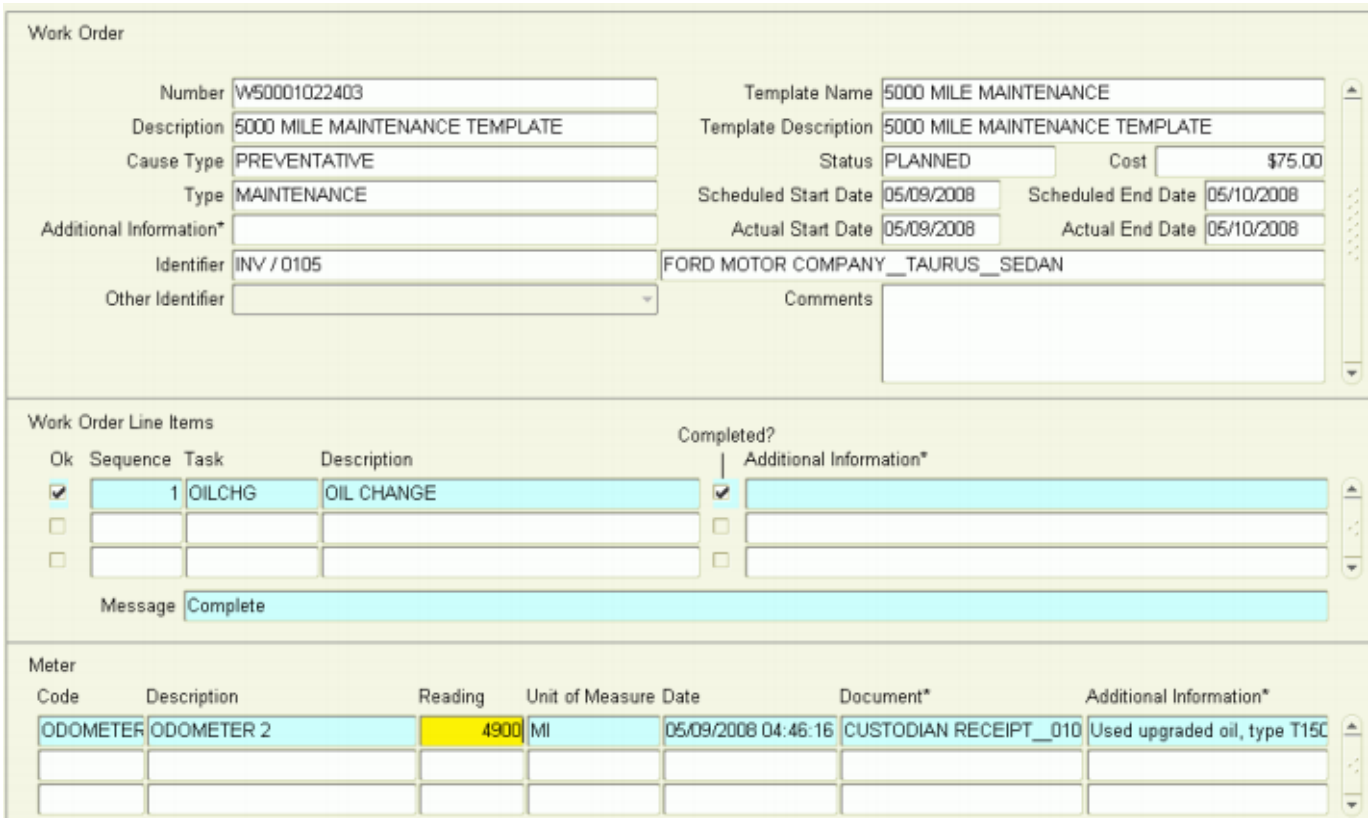


Fig 4.1 sample maintenance record

Self-Check -4	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two point.

1. Plant and maintenance records contains the entire information from the stage of receiving maintains (or inspecting) to knowing of the maintenance result.

A. True B. False

2. Plant and maintenance records are the set of documentation about maintenance.

A. True B. False

3. Retain maintenance records is important for the maintenance work as it request.

A. True B. False

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

You can ask you teacher for the copy of the correct answers.

Answer Sheet-7

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. 2. 3.

Operation Sheet 1	Maintaining and storying Plant, tools and equipment

Steps to store portable generator for periods of 6 months or longer.

Step #1: Carefully drain fuel from the fuel tank; fuel left in the fuel tank will eventually deteriorate making engine starting difficult.

Step #2: Remove the carburetor float chamber and also drain the carburetor.

Step #3 Change engine oil.

Step #4 Check for loose bolts and screws, tighten if necessary.

Step #5 Clean generator thoroughly with oiled cloth. Spray with preservative if available. never use water to clean generator!

Step #6 Pull starter handle until resistance is felt, leaving handle in that position.

Step #7 Store generator in a well-ventilated, low humidity area.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Giving the necessary equipment's and PPEs you are required to perform the following tasks within 3 hours.

Task 1. 1.prepare generator maintenance forms and records

Task 2. Maintain and store generator maintenance tools and equipment appropriately.

List of Reference Materials

1. K.L. Narayana, P. kannaiah “Textbook of Machine Drawing”, New age international publishers “third edition
2. Tsurumi’s Operation, Service, and Repair Manual. http: www.tsurumipump.com/
3. Honeywell Portable Electrical Generator Service Manual www.honeywellgenerators.com
4. B.L Theraraja and A.K. Theraja “a text book of Electrical technology”, volume I
5. V.K., Mehta, Rohit Mehta “Principles of Electrical Book”
6. Lindle R. Higgens and R. Keith Mobley “Maintenance Engineering HandbooK” sixth edition
7. Robin power equipment “service manual model R1300 generator with wmission certified engine” PUB -GS1185, Rev. 4/98
8. Reclamation managing water in west “Maintenance scheduling for electrical equipment” Facilies instructions, standards, and Techniques volume 4-1B, Rev.2005
9. M. Akay,J. B. Andersonand R. J. Baker “operation andmaintenance of largeturbo-generators”a john Wiley & sons, Inc., publication 2004

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