Ethiopian TVET-System

Electro Mechanical Equipment Operation and Maintenance

Level II

Based on Feb, 2017G.C.Occupational standard

Module Title: - Operating and monitoring electrical generator

TTLM Code: - EIS EME2 TTLM 0620V1

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This module includes the following learning Guides

LG37: Plan and prepare work

LG Code:-EIS EME2 M10 Lo1-LG37

LG38: Operate Generator

LG Code:-EIS EME2 M10 Lo2-LG38

LG39: Inspect and monitor generator operation

LG Code:-EIS EME2 M10 Lo3-LG39

LG40: Analyze generator faults

LG Code:-EIS EME2 M10 Lo4-LG40

LG41: Complete documentation

LG Code:-EIS EME2 M10 Lo5-LG41

Instruction Sheet 1	Learning Guide 37: Plan and prepare work

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

- Identifying safety issues and standard operating procedures
- Identifying work, and type of start requirements
- Understanding generators operating principles
- Identifying generator types and operating characteristics
- Ascertaining the generators running-up and loading schedule
- Carrying out localized inspection, pre operational tests and field preparation for service
- Establishing operational prerequisites

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 –

- Identifying Safety issues to comply with enterprise/site requirements
- Identifying Work, and type of start requirements from relevant personnel and documentation
- Ascertaining the engine running-up and loading schedule from relevant documentation and in accordance with enterprise/site requirements
- Carrying out localised inspection, pre operational tests and field preparation for service in accordance with manufacturer and enterprise/site procedures
- Establishing operational prerequisites in accordance with manufacturer and enterprise/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 10,15,20,27 and 40.
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 28 and do the LAP Test on page__. 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 safety issues and standard operating procedures

Introduction

Safety is the state of being "safe" (from French sauf), the condition of being protected from harm or other non-desirable outcomes. Safety can also refer to the control of recognized hazards in order to achieve an acceptable level of risk.

Workplace hazards are any aspect of work that cause health and safety risks and have the potential to harm.

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

The most common workplace hazards

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

1. physical hazards – the most common workplace hazards, including vibration, noise and slips, trips and falls;
2. ergonomic hazards – physical factors that harm the musculoskeletal system, such as epetitive movement, manual handling and poor body positioning;
3. chemical hazards – any hazardous substance that can cause harm to your employees;
4. biological hazards – bacteria and viruses that can cause health effects, such as hepatitis, HIV/AIDS and Legionnaire's disease.

Common health risks

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

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

How to prevent workplace hazards

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

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

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

Safe Operating Procedures

Safe Operating Procedures (SOPs) (or Safe Working Procedures (SWP)) are operational documents created locally to describe the safest and most efficient way to perform a certain task, carry out an operation or operate a machine/tool. Safe Operating Procedures will normally come from a risk assessment as an administrative control. Written Safe Operating Procedures are an essential part of a safe system of work and are an important part of an overall occupational health and safety program. Safe Operating Procedures provide information necessary to guide all staff and students to perform tasks safely and reliably. Safe Operating Procedures also assist in the training and orientation of new staff and students in the hazards of the specific process or activity. Lastly Safe Operating Procedures are a valuable tool in assessing the level of understanding or competency regarding on-the-job training.

Safe Operating Procedures Policy

Safe Operating Procedures are required for any routine, repeated activity or process associated with amedium to high risk outcome from a risk assessment (hazardous work). Medium to high risk in this context means any activity or process where an injury may occur if the process is not performed in the prescribed manner.

Before carrying out hazardous work the following must occur:

• A risk assessment is carried out

• A relevant Safe Operating Procedure is prepared, and

• User are trained on the Procedure.

Safe Operating Procedures shall consider and be prioritised according to their level of risk, specifically considering hazard exposure, frequency of exposure, and worker knowledge and experience. A higher priority shall be placed on tasks performed by students and other inexperienced workers.

Safe Operating Procedures shall be reviewed:

• whenever the task or activity changes

• when a new hazard is identified or becomes known: for example, new information in a Safety Data Sheet.

• When equipment or processes are not used for a period of time (over 6 months) and worker knowledge and experience may decline

• After an associated injury, near miss or illness

• Every three years.

- Responsibilities

The development and implementation (including training) of Safe Operating Procedures is the responsibility of the line supervisor or academic-in-charge where students are

involved. The Dean, Head of School, Director or Unit Head is responsible for maintaining an overall safe system of work that includes Safe Operating Procedures.

All staff, visitors and students are expected to familiarise themselves with and comply with the Safe Operating Procedures that exist in their area of work. Failure to comply with Safe Operating Procedures may lead to disciplinary action and/or withdrawal of rights to carry out work in the area.

Developing Safe Operating Procedures

Methodology	Resources / Tools
Step 1: Preparation	Safe Operating Procedures shall: • be written by a person with sound, hands on experience and knowledge of the activity and process • involve the persons who will be using the Instructions • as far as practicable, involve consultation with the Health and Safety Representative of the area. • involve a review of manufacturer or supplier's manual or working instructions (where they exist)
Step 2. Consider what is needed to be done or available before the task or process is carried out	This may include: • the issuing of permits or carrying out isolations • if the work is done by a variety of people, are there any training, licence or skill requirements that need to be checked each time? • the availability of equipment • the use of personal protective equipment

Step 3. Observe the task or process	Where possible use a third person to observe and record the steps. For a new process, a dry run or trial is often the best way to identify potential problems. For example with a lab procedure, observe staff stepping through the process

Working Environment

- Install ventilation extraction systems in hot work areas.
- Fit localized lighting on machines to enable operators to comfortably view work pieces.
- Suspend electrical power lines and air lines.
- Round-off edges and corners of benches, equipment or fittings.
- Install safety barriers to protect pedestrians from vehicles or mobile plant.
- Install mirrors and flashing lights to warn of approaching vehicles or mobile plant.
- Fit reverse warning beepers and lights to mobile plant for example, forklifts.
- Install hand rails on ramps and steps.
- Install non-slip floor surfaces.
- Install good lighting along walkways.

Plant or Machinery

- Enclose very noisy plant or machinery in sound-proof barriers or relocate in separate area from the majority of workers.
- Guard moving parts of the plant or machinery (fixed or adjustable guards, photo-electric, pressure sensing mats).
- Interlock guards with power supply (power supply is automatically switched off when guard is opened or removed).
- Make guards difficult to remove or machinery difficult to disable.
- Install two – hand controls.
- Provide feeder tables or rollers.

- Use clamps, supports, guides or stops to position workpieces.
- Fit lock out switches to all plant and machinery to disconnect power supply while being cleaned, serviced or repaired.

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What are the most common workplace hazards?(3 points)
2. How to prevent workplace hazards (3 points)
3. Write at list three Common health risks (4 points)

Note: **Satisfactory rating - 6points** **Unsatisfactory - below 6points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1. ----------
2. ----------
3. ----------

Information Sheet-2	Identifying work, and type of start requirements

Introduction

Identifying work and Work instruction is the most detailed description of a task. Its main purpose is to explain step by step how to do a specific task. A work instruction is a tool provided to help someone to do a job correctly. This simple statement implies that the purpose of the work instruction is quality and that the target user is the worker. Unfortunately, in many workplaces, today's identifying work and work instructions have little connection with this fundamental focus.

2.1. Different types of works to be identified in generator maintenance such as

- Operating concept
- Diesel Generator Routine General Inspection
- Reading the blue prints and sketches,
- Installs and maintains the generator wiring,
- Repairs electrical faults in generators, alternators, pumps, and low voltage switchboards.
- Read and interprets mechanical drawings.
- Installs generator sets ranging from 4 to 1000 KVA for complete generating stations
- Inspects maintains and repairs generator sets and diesel driven pumps
- Overhauls and rebuilds generators Perform other duties as required.

A diesel generator is the combination of a diesel engine with an electric generator (often an alternator) to generate electrical energy. This is a specific case of engine-generator.

A diesel compression-ignition engine often is designed to run on fuel oil, but some types are adapted for other liquid fuels or natural gas.

Operating concept

In generator maintenance the first thing is knowing about the concept of how to operate generators and maintenance services are provided, indicating the locations in which such services could be provided, optimal fuel efficiency and maximum machine life.

The operator knows whether the generator is operated manual switchover control panel or automatic switchover control panel for single machine control, and also, panels for full synchronization control.

Climatological Conditions

The generators, and associated panels shall be able to operate under various climatic (i.e. tropical, semi tropical and arid) conditions and must therefore be constructed to work in difficult conditions i.e. in ambient temperatures varying between minus -15°C to plus 60°C, in altitudes from sea level up to 2,500 meters above sea level, in relative humidity conditions of up to 100%, and in sandy, dusty and/or heavy windy environment.

Diesel Generator Routine General Inspection

Before you attempt to diagnose a generator problem, check the engine to make sure that it has been

serviced and is operating correctly. Perform proper maintenance and tune-up procedures before evaluatingthe generator. Ensure the engine remains at a stable rpm when electrical loads are applied.

During the running of the diesel generator, the exhaust system, fuel system, DC electrical system and engine require close monitoring for any leaks that can cause

hazardous occurrences. As with any internal combustion engine, proper maintenance is essential

Figure 1.1 generator set

1. Lubrication Service

The engine oil must be checked while shutting down the generator at regular intervals using a dipstick. Allow the oil in the upper portions of the engine to drain back into the crankcase and follow the engine manufacturer's recommendations for oil classification and oil viscosity. Keep the oil level as near as possible to the full mark on the dipstick by adding the same quality and brand of oil.

2. Cooling System

Check the coolant level during shutdown periods at the specified interval. Remove the radiator cap after allowing the engine to cool, and, if necessary, add coolant until the level is about 3/4 in.

3. Fuel System

Diesel is subject to contamination and corrosion within a period of one year, and therefore regular generator set exercise is highly recommended to use up stored fuel before it degrades. The fuel filters should be drained at the designated intervals due to the water vapor that accumulates and condenses in the fuel tank.

4. Testing Batteries

Weak or undercharged starting batteries are a common cause of standby power system failures. The battery must be kept fully charged and well-maintained to avoid dwindling by regular testing and inspection to know the current status of the battery and avoid any

start-up hitches of the generator. They must also be cleaned; and the specific gravity and electrolyte levels of the battery checked frequently.

• Testing batteries: Merely checking the output voltage of the batteries is not indicative of their ability to deliver adequate starting power. As batteries age, their internal resistance to current flow goes up, and the only accurate measure of terminal voltage must be done under load. On some generators, this indicative test is performed automatically each time the generator is started. On other generator sets, use a manual battery load tester to attest the condition of each starting battery.

• Cleaning batteries: Keep the batteries clean by wiping them with a damp cloth whenever dirt appears excessive. If corrosion is present around the terminals, remove the battery cables and wash the terminals with a solution of baking soda and water (¼ lb baking soda to 1 quart of water.

• Checking specific gravity: In open-cell lead-acid batteries, use a battery hydrometer to check the specific gravity of the electrolyte in each battery cell. A fully charged battery will have a specific gravity of 1.260. Charge the battery if the specific gravity reading is below 1.215.

• Checking electrolyte level: In open-cell lead-acid batteries, verify the level of the electrolyte at least every 200 hr of operation. If low, fill the battery cells to the bottom of the filler neck with distilled water.

5. Routine Engine Exercise

Regular exercising keeps the engine parts lubricated and prevent oxidation of electrical contacts, uses up fuel before it deteriorates, and helps to provide reliable engine starting. Engine exercise is recommended to be executed at least once a month for a minimum of 30 min. loaded to no less than one-third of the nameplate rating.

6. Keep your Diesel Generator Clean

Oil drips and other issues are easy to spot and take care of when the engine is nice and clean. Visual inspection can guarantee that hoses and belts are in good condition.

7. Exhaust system inspection

In case there are leaks along the exhaust line which usually occurs at the connection points, the welds and the gaskets; they should be repaired immediately by a qualified technician.

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. One of the following is not true about identifying works in generator maintenance.

A/ about operating generator B/ about maintenance service C/ about capacity of generator D/ A and B E/ D and C

2. visual inspection of generator maintenance includes

A/ physical inspection of the generator B/ mechanical inspection

C/ electrical inspection D/ all of the above

3. Why we inspect generators before and after starting?

A/ To increase the life expectance of generator B/ To reduce the problem that causes faults C/ A and B D/ none

4. What is the importance of battery in generator set?

A/ for starting purpose B/ for cooling purpose C/ for rectification D/all

5. the materials used to check the specific gravity of battery is called

A/ barometer B/ hydrometer C/ thermometer D/ all of the above

Note: **Satisfactory rating –6 points** **Unsatisfactory - below 6 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1._____

2._____

3._____

4._____

5._____

Information Sheet-3	Understanding generators operating principles

Introduction

Generators – Working principle, Types & Advantages

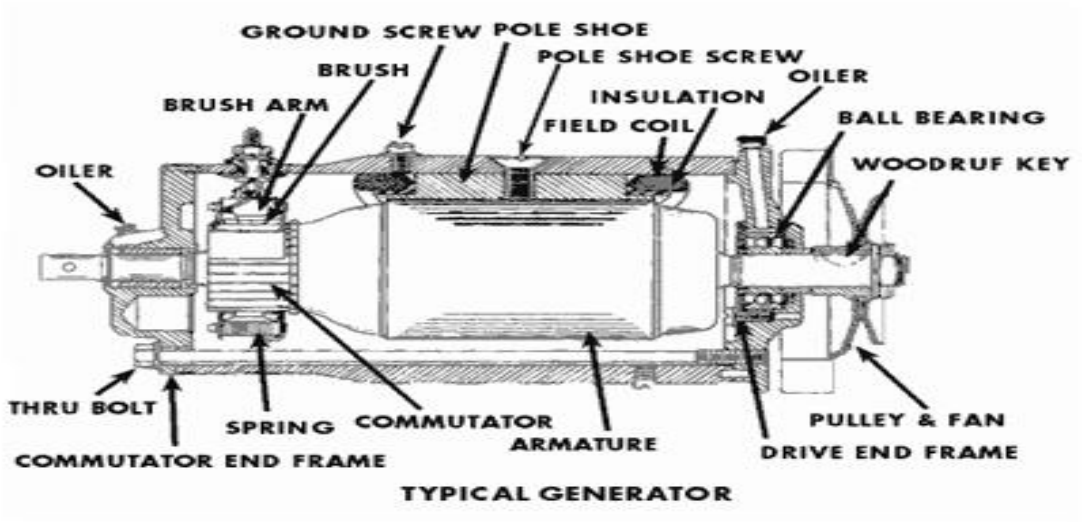
Generator is a machine that converts mechanical energy into electrical energy. It works based on principle of **Faraday law** of electromagnetic induction. The **faradays law** states that whenever a conductor is placed in a varying magnetic field, EMF is induced and this induced EMF is equal to the rate of change of flux linkages. This EMF can be generated when there is either relative space or relative time variation between the conductor and magnetic field. So the important elements of a generator are:

- **Magnetic field**
- **Motion of conductor in magnetic field**

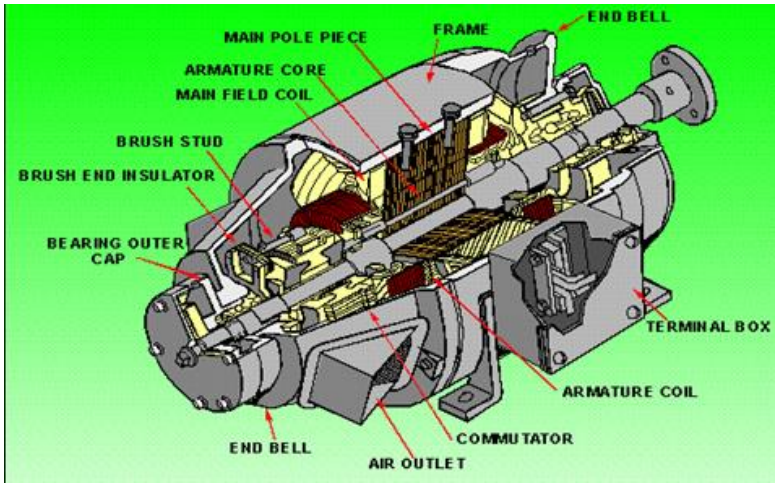
Working of Generators:

Generators are basically coils of electric conductors, normally copper wire, that are tightly wound onto a metal core and are mounted to turn around inside an exhibit of large magnets. An electric conductor moves through a magnetic field, the magnetism will interface with the electrons in the conductor to induce a flow

of electrical current inside it.



The conductor coil and its core are called the armature, connecting the armature to the shaft of a mechanical power source, for example an motor, the copper conductor can turn at exceptionally increased speed over the magnetic field



The point when the generator armature first starts to turn, then there is a weak magnetic field in the iron pole shoes. As the armature turns, it starts to raise voltage. Some of this

voltage is making on the field windings through the generator regulator. This impressed voltage builds up stronger winding current, raises the strength of the magnetic field. The expanded field produces more voltage in the armature. This, in turn, make more current in the field windings, with a resultant higher armature voltage. At this time the signs of the shoes depended on the direction of flow of current in the field winding. The opposite signs will give current to flow in wrong direction.

Types of Generators:

The generators are classified into types.

- AC generators
- DC generators

AC Generators:

These are also called as alternators. It is the most important means of producing electrical power in many of the places since now days all the consumers are using AC. It works based on principle of the electromagnetic induction. These are of two types one is induction generator and other one is synchronous generator. The induction generator requires no separate DC excitation, regulator controls, frequency control or governor. This concept takes place when conductor coils turn in a magnetic field actuating a current and a voltage. The generators should run at a consistent speed to convey a stable AC voltage, even no load is accessible.

Synchronous generators are large size generators mainly used in power plants. These may be rotating field type or rotating armature type. In rotating armature type, armature is at rotor and field is at stator. Rotor armature current is taken through slip rings and brushes. These are limited due to high wind losses. These are used for low power output applications. Rotating field type of alternator is widely used because of high power generation capability and absence of slip rings and brushes.

voltage induced in any one phase is displaced by 120º from the other two. These can be connected either delta or wye connections. In Delta Connection each coil end is connected together to form a closed loop. A Delta Connection appears like the Greek

Letter Delta (Δ). In Wye Connection one end of each coil connected together and the other end of each coil left open for external connections. A Wye Connection appears as the letter Y.

These generators are packaged with an engine or turbine to be used as a motor-generator set and used in applications like naval, oil and gas extraction, mining machinery, wind power plants etc

Advantages of AC Generator:

- These Generators are generally maintenance free, because of absence of brushes.
- Easily step up and step down through transformers.
- Transmission link size might be thinner because of step up feature
- Size of the generator relatively smaller than DC machine
- Losses are relatively less than DC machine
- These Generator breakers are relatively smaller than DC breakers

DC Generators:

DC generator is typically found in off-grid applications. These generators give a seamless power supply directly into electric storage devices and DC power grids without novel equipment. The stored power is carries to loads through dc-ac converters. The DC generators could be controlled back to an unmoving speed as batteries tend to be stimulating to recover considerably more fuel.

Classification of DC Generators

D.C Generators are classified according to the way their magnetic field is developed in the stator of the machine.

- permanent-magnet DC generators
- Separately-excite DC generators and

- Self-excited DC generators.

Permanent magnet DC generators do not require external field excitation because it has permanent magnets to produce the flux. These are used for low power applications like dynamos.

Separately-excite DC generators requires external field excitation to produce the magnetic flux. We can also vary the excitation to get variable output power. These are used in electro plating and electro refining applications. Due to residual magnetism present in the poles of the stator self-excited DC generators can able to produce their own magnetic field ones it is started. These are simple in design and no need to have the external circuit to vary the field excitation. Again these self-excited DC generators are classified into shunt, series, and compound generators.

These are used in applications like battery charging, welding, ordinary lightening applications etc.

Advantages of DC Generator:

- Mainly DC machines have the wide variety of operating characteristics which can be obtained by selection of the method of excitation of the field windings.
- The output voltage can be smoothed by regularly arranging the coils around the armature .This leads to less fluctations which is desirable for some steady state applications.
- No shielding need for radiation so cable cost will be less as compared to AC

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Write the working principle of generator (2points)
2. What are the two types of generator (2points)
3. Write the advantage of Ac and Dc generator (4points)

Note: **Satisfactory rating - 6points** **Unsatisfactory - below 6points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

1._____

_____

2._____

_____

3._____

_____

Information Sheet-4	Identifying generator types and operating characteristics

Introduction

Generator types

Based on the kind of prime mover, or power turning the rotor	
• Water-turbine generator • Steam turbine generator • Motor-generator, Diesel generator, Gasoline generator • Wind-turbine generator • Atomic power generator	
Based on construction	
1. rotating armature stationary field The armature rotates in a stationary magnetic field. Is similar in construction to the dc generator. A rotating armature requires slip rings and brushes to conduct the current from the	2. rotating field stationary armature Have a stationary armature winding and a rotating-field.

armature to the load. The armature, brushes, and slip rings are difficult to insulate, and arc-overs and short circuits can result at high voltages.

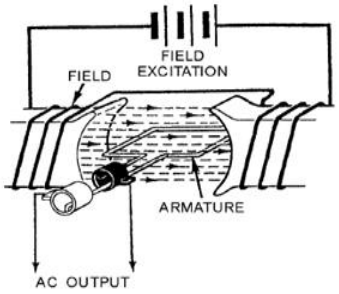


Figure 21a

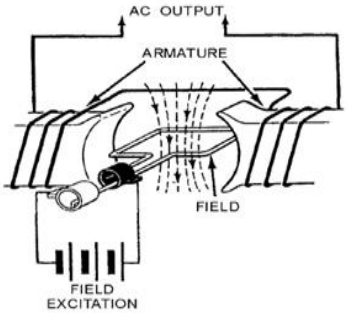


Figure 21b

Depending upon the rotor type

1. Salient pole type

In salient pole type of rotor consist of large number of projected poles (salient poles) mounted on a magnetic wheel. Construction of a salient pole rotor is as shown in the figure below. The projected poles are made up from laminations of steel. The rotor winding is provided on these poles and it is supported by pole shoes.

- These rotors have large diameter and shorter axial length.
- They are generally used in lower speed electrical machines, say 100 RPM to 1500 RPM. Number of salient poles is between 4 and 60.

2. Cylindrical type

Non-salient pole rotors are cylindrical in shape having parallel slots on it to place rotor windings. It is made up of solid steel. The construction of non-salient pole rotor (cylindrical rotor) is as shown in figure above. Sometimes, they are also called as drum rotor.

- They are smaller in diameter but having longer axial length.
- They rotors are used in high speed electrical machines, usually 1500 RPM to 3000 RPM.
- Their construction is robust as compared to salient pole rotors. Number of poles is usually 2 or 4.

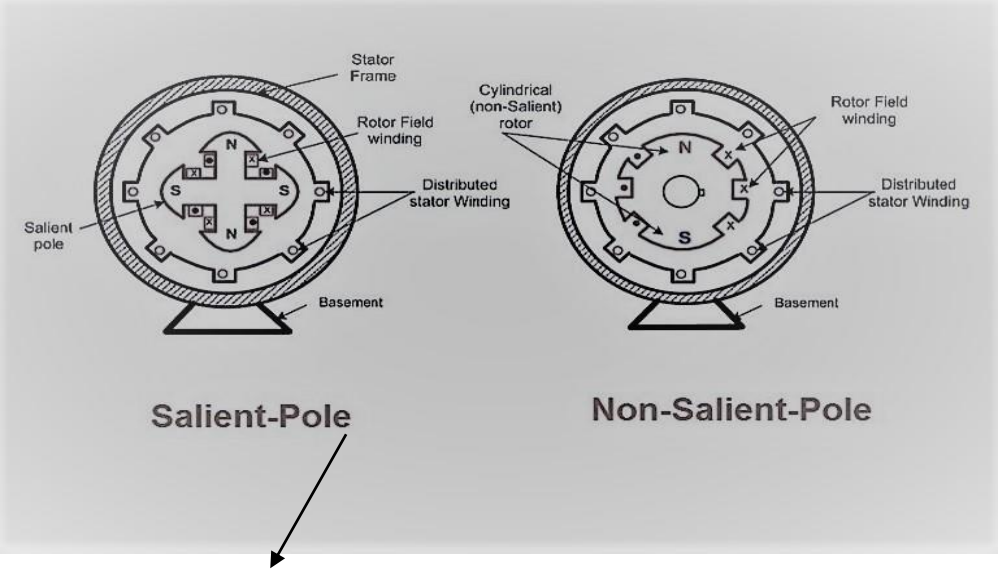


Figure 22: salient and cylindrical rotor types

Depending upon output Needed

1. Ac Generators
2. DC Generators

** any generator generates alternating current but according to the user's need this AC is converted to DC.

Main parts of a generator and their functions

Main parts of a generator are main parts that contribute for the proper output delivery of a generator. These include:

A. AVR (automatic voltage regulator): is an electrical regulator designed to automatically maintain a constant voltage level. It processes and amplifies input control signals to a level and form appropriate for control of the exciter.

When there is a sudden change in load in the generator, there should be a change in the excitation system to provide the same voltage under the new load condition. This can be done by the help of the automatic voltage regulator. The automatic voltage regulator equipment operates in the exciter field and changes the exciter output voltage, and the field current.

Figure 23: AVR

B. Exciter: is the source of electrical power for the field winding of generator and is realized as a separate DC or AC generator. The field coils in a generator produce the magnetic flux that is essential to the production of the electric power. The rotor is a rotating electromagnet that requires a DC (Direct Current) electric power source to excite the magnetic field. This power comes from an exciter.

C. Rectifier - electrical device, mainly consists of diodes that convert alternating current to direct current or at least to current with only positive value, a process known as rectification.

Figure 24: Rotating Rectifiers

D. Armature and Armature windings – is output-producing component of an electrical machine. In a generator, the armature windings generate electric current which provides power to an external circuit. It consists of many coils of wire that are large enough to carry the full-load current of the generator those coils are called armature windings. The armature can be on either the rotor or the stator, depending on the design, with the field coil or magnet on the other part

E. Field winding or field magnets – is the magnetic field producing component of electrical machine. The magnetic field in a generator can be provided by either wire windings called field coils (electromagnet) or permanent magnets. Field provided by electromagnet consists of coils of conductors within the generator that receive a voltage from a source (called excitation) and produce a magnetic flux. The magnetic flux in the field cuts the armature to produce a voltage. This voltage is ultimately the output voltage of the generator. In most of the cases field is stationary for a smaller voltage systems & Rotating for high voltage systems

Self-Check 4	**Written Test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. List the Main parts of a generator and their functions(6ponts)
2. Write types of generator Based on the kind of prime mover, or power turning the rotor
    A. Based on construction (3points)
    B. Depending upon the rotor type (3points)
    C. Depending upon output Needed (3points)

Note: **Satisfactory rating - 8points** **Unsatisfactory - below 8points**

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

Short Answer Questions

1. _____
   _____
2. _____
   _____
3. _____
   _____

Information sheet 5	**Ascertaining the generators running-up and loading schedule**

Introduction

Getting a generator that can handle all your power generation needs is one of the most critical aspects of the purchasing decision. Whether you are interested in prime or standby power, if your new generator can't meet your specific requirements then it simply won't be doing anyone any good because it can put undue stress on the unit and even damage some of the devices connected to it. Unfortunately, determining exactly what size of generator to get is often very difficult and involves a number of factors and considerations.

Making a choice amongst single phase, three phase, kW, KVA, welder, standby or motor starting generators can be mind-boggling. To prevent such confusion, this article was developed to help you get a better idea of how the sizing process works and some key things to keep in mind. This is not a substitute for a certified electrician, which we always suggest talking to before buying, but it should provide you with enough information to get a solid understanding of some of the key things that are involved.

GENERATOR POWER

Most generators produce AC voltage, very similar to the voltage available in your home.

The amount of power that a generator can produce is rated in watts (power).

For Example, an EM2500 generator produces a **MAXIMUM 2500** watts of power. This means the EM2500 could provide power to 25 one hundred watt light bulbs at the same time. The generator would then be at its **MAXIMUM** power output.

MAXIMUM AND RATED POWER

A generator should never be operated at its **MAXIMUM** power output for more than 30 minutes.

RATED power is a more reliable measure of generator power. It is the power that a generator can produce for long periods of time. Typically the **RATED** power is 90% of the **MAXIMUM** power.

LOADS

In the previous example, the light bulbs are the **LOAD** of the generator. The EM2500 generator can handle a **LOAD** of no more than 2500 watts maximum.

The light bulb example is called a **RESISTIVE** type load and the POWER it requires is pretty easy to understand. Other **RESISTIVE** types of **LOAD** are things like toasters, convection ovens, hot plates, curling irons, coffee makers, stereos and TV's. **RESISTIVE LOADS** are usually those that do not have electric motors.

Another load is the **REACTIVE** type and is a little more confusing. Typically, a **REACTIVE** load contains an electric motor. This type of load may require up to three times as much power (wattage) to **START** as it does to keep it running. Examples of **REACTIVE** type loads are air conditioners, refrigerators / freezers, furnace fans, well pumps, bench grinders and air compressors.

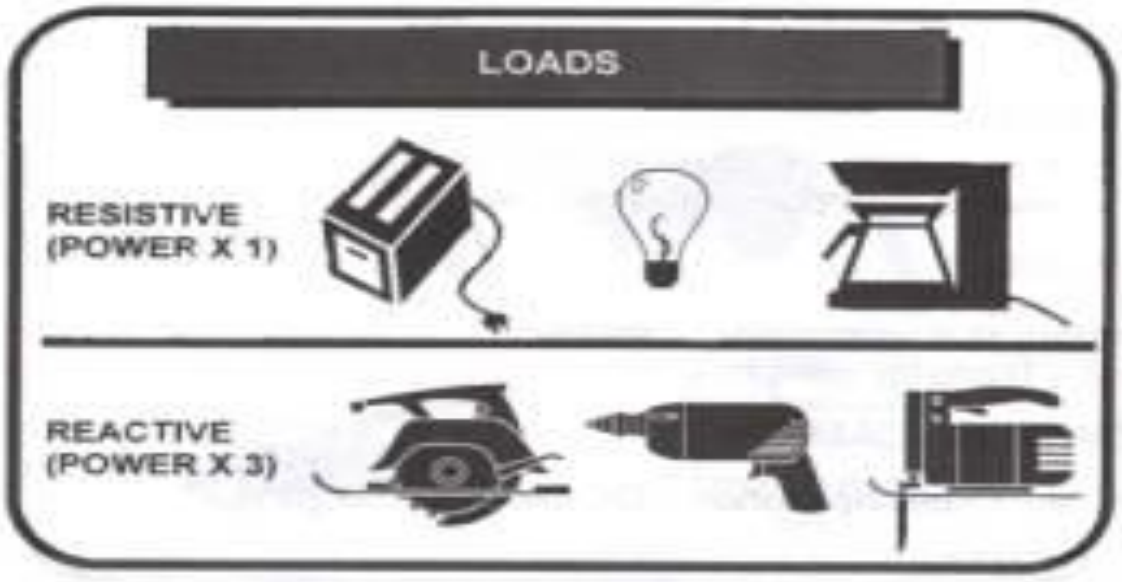


Figure 5.1 loads

REACTIVE LOADS

When determining the proper generator for REACTIVE type loads, you must consider three modes of operation:

- **STARTING -** The electric motor requires more power to start. The starting power required **can** be **THREE** times the running amount.

- **RUNNING -** The power required to run the electric motor after it has been started.
- **LOADED -** When the electric motor begins to work (saw begins cutting wood), its power requirement will increase. This is not applicable for most household appliances.

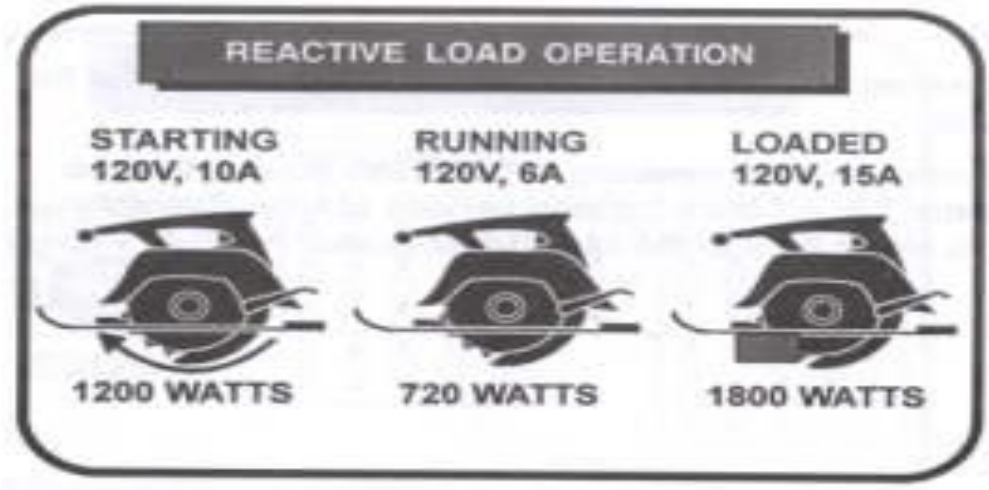


Figure 5.2 reactive load operation

LOAD POWER REQUIREMENTS

Here are a few ways to determine power requirements for various loads that are expected to be powered by a typical generator.

Method 1, using estimating charts, can be used to get a general idea of the generator size.

Method 2, reading the motor data tag, is more accurate since the data tag information is provided by the motor manufacturer. Data tag information does not always show **STARTING** power requirements for **REACTIVE** type loads.

LOAD CODE

Example: The data tag on our electric motor shows a code of L. Our motor is 1/3 Hp. An L code is 84 amps per Hp x 1/3 (motor Hp) = 28 amps to start the motor shown.

	AMPS PER HP TO		**AMPS PER HP TO**

CODE	START	CODE	START
A	26.0	L	83.3
B	29.5	M	93.3
C	33.3	N	104.0
D	37.4	P	116.6
E	41.6	R	133.3
F	46.6	S	149.9
G	52.4	T	166.6
H	59.0	U	186.6
J	66.6	V	more than 186.6

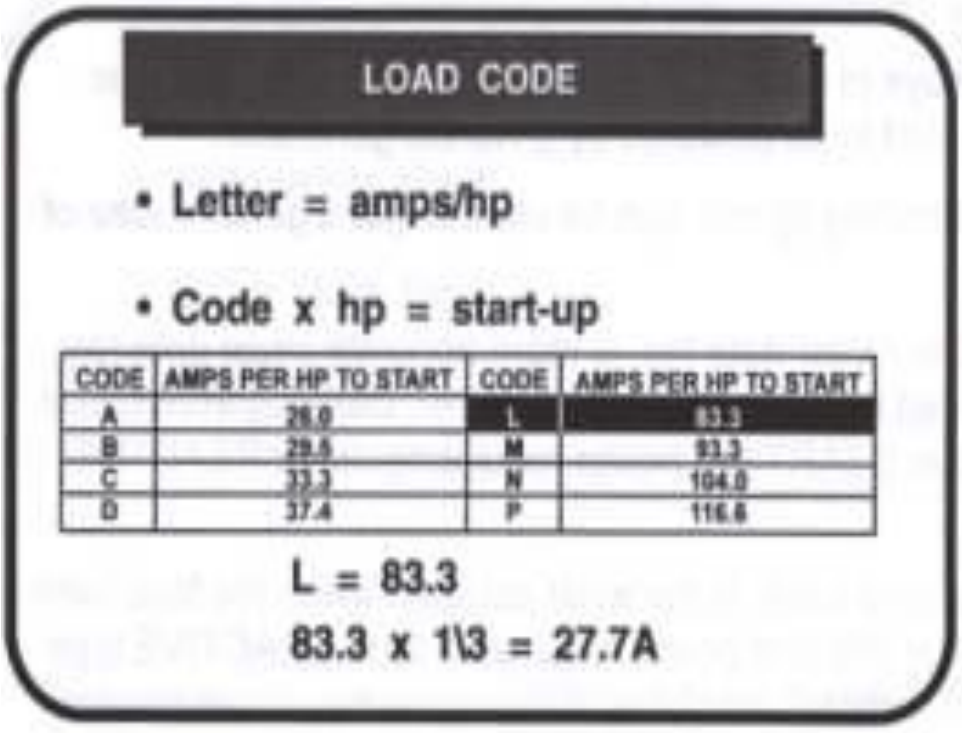


Table 5.1 load code

Self-Check 5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What is the first requirement new generator purchasing decision?
2. What are the two types of load?
3. What are the most important considerations on reactive loads?

Note: **Satisfactory rating - 8points** **Unsatisfactory - below 8points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

1. _____
   _____
2. _____
   _____
3. _____
   _____

Information sheet 6	Carrying out localized inspection, pre operational tests and field preparation for service

Introduction

Inspection testing and Maintenance is critical to the continued reliability of your emergency generator and must be performed in accordance with manufacturer's recommendations, instruction manuals, and the minimum requirements and the authority having jurisdiction. Routine maintenance, inspection and operational testing of the emergency generator and associated components must be overseen by a properly trained person. Evidence of such training should be kept in the designated employees' personnel file. In the absence of a properly trained person on-site, an outside vendor may need to be contracted to oversee the performance of all or part of these services.

Local inspection

To meet health care facilities must inspect their generators weekly. At a minimum, this weekly inspection should include a check of the following:

1. Fuel (check main and day tank fuel supply levels; day tank float switch; piping, hoses and connectors; operating fuel pressure; and for any obstructions to tank vents and overflow piping
2. Lubrication system (check for proper oil level and oil operating pressure; lube oil heater)
3. Cooling system (check coolant level, water pump(s), jacket water heater, belts, hoses, fan)
4. Exhaust system (check drain condensate trap and for possible leakage)
5. Battery system [look for possible corrosion; check specific gravity, electrolyte level and battery charger – maintenance-free batteries require routine visual inspection and maintenance in accordance with manufacturer's instructions]

6. Electrical system (conduct a general inspection of wiring and connections; check circuit breakers/fuses)
7. Prime Mover/Generator (Check for debris, foreign objects, loose or broken fittings; check guards and components; look for any unusual condition of vibration, leakage, noise, temperature or deterioration. **Figure 6.1 engine generator inspection check list**

ENGINE GENERATOR INSPECTION

SHEET NO. _____ OF _____

CUSTOMER _____ DATE _____ PROJECT NO. _____
ADDRESS _____ AIR TEMP. _____ REL. HUMIDITY _____
OWNER/USER _____ DATE LAST INSPECTION _____
ADDRESS _____ LAST INSPECTION REPORT _____
EQUIPMENT LOCATION _____
CIRCUIT IDENTIFICATION _____

ENGINE TYPE: ☐ GASOLINE ☐ DIESEL ☐ GAS TURBINE

MAKE _____ MODEL _____ SERIAL NO. _____ KS # _____
KVA _____ KW _____ VOLTAGE _____ F.L.A. _____
RPM _____ HZ _____ HP _____ TECH. BULL. # _____

1. ☐ Change oil and lube oil filters.
2. ☐ Remove unused oil from premises.
3. ☐ Change fuel oil elements.
4. ☐ Service crankcase breather.
5. ☐ Inspect air cleaner element, clean if required. If replacement is required, element(s) will be billed separately. Price of element(s) not included in contract price.
6. ☐ Check coolant level and maintain safe degree of protection. Engine mounted radiators only. (Remote radiators, cooling towers & heat exchangers serviced at user's request on a time and material basis.)
7. ☐ Check manifolds, brackets, mountings and flex connections.
8. ☐ Inspect fan belts, adjust if required.
9. ☐ Check pulley hub, bearings, lubricate if required.
10. ☐ Check operation of auxiliary water pump or fan motor.
11. ☐ Check operation of automatic louvers.
12. ☐ Repair minor fuel, coolant and lube oil leaks.
13. ☐ Check operation of jacket water heater(s).
14. ☐ Inspect generator, perform any routine maintenance as required.
    ☐ Megger
15. ☐ Inspect governor/actuator linkage.
16. ☐ Check battery electrolyte level and maintain to include:
    ☐ Temperature ☐ Specific Gravity ☐ Voltage
17. ☐ Check operation of charger and/or alternator.
18. ☐ Inspect fuel supply system for leaks or low level, inform owner of any discrepancies.
19. ☐ Drain condensation from day tank and check for any contamination. ONLY if day tank is equipped with a drain valve.
20. ☐ Check operation of transfer pump.
21. ☐ Check for correct generator output voltage & frequency, adjust if required.
22. ☐ Simulate & check operation of each safety shutdown and alarm device, relay type control panels only.
23. ☐ Check operation of generator control instrumentation; volts, amps, etc.
24. ☐ Test fault lamps & replace bulbs as required, panels with lamp test only.
25. ☐ Tank crankcase oil sample, owner to be notified of any discrepancies.
26. ☐ Submit report to owner
27. ☐ Auto start test.

REMARKS _____

SUBMITTED BY _____ EQUIPMENT USED _____

Pre operational testing

During the running of the diesel generator, the exhaust system, fuel system, DC electrical system and engine require close monitoring for any leaks that can cause hazardous occurrences. As with any internal combustion engine, proper maintenance is essential.

1. Lubrication Service

The engine oil must be checked while shutting down the generator at regular intervals using a dipstick. Allow the oil in the upper portions of the engine to drain back into the crankcase and follow the engine manufacturer's recommendations for API oil classification and oil viscosity. Keep the oil level as near as possible to the full mark on the dipstick by adding the same quality and brand of oil.

The oil and filter must also be changed at acclaimed time intervals. Check with the engine manufacturer for procedures for draining the oil and replacing the oil filter and their disposal is to be done appropriately to avoid environmental damage or liability.

2. Cooling System

Check the coolant level during shutdown periods at the specified interval. Remove the radiator cap after allowing the engine to cool, and, if necessary, add coolant until the level is about 3/4 in. Heavy-duty diesel engines require a balanced coolant mixture of water, antifreeze, and coolant additives. Inspect the exterior of the radiator for obstructions, and remove all dirt or foreign material with a soft brush or cloth with caution to avoid damaging the fins. If available, use low-pressure compressed air or a stream of water in the opposite direction of normal air flow to clean the radiator.

3. Fuel System

Diesel is subject to contamination and corrosion within a period of one year, and therefore regular generator set exercise is highly recommended to use up stored fuel before it degrades. The fuel filters should be drained at the designated intervals due to the water vapor that accumulates and condenses in the fuel tank.

Regular testing and fuel polishing may be required if the fuel is not used and replaced in three to six months. Preventive maintenance should include a regular general inspection that includes checking the coolant level, oil level, fuel system, and starting system. The charge-air cooler piping and hoses should be inspected regularly for leaks, holes, cracks,dirt and debris that may be blocking the fins or loose connections.

4. Testing Batteries

Weak or undercharged starting batteries are a common cause of standby power system failures. The battery must be kept fully charged and well-maintained to avoid dwindling by regular testing and inspection to know the current status of the battery and avoid any start-up hitches of the generator. They must also be cleaned; and the specific gravity and electrolyte levels of the battery checked frequently.

• Testing batteries: Merely checking the output voltage of the batteries is not indicative of their ability to deliver adequate starting power. As batteries age, their internal resistance to current flow goes up, and the only accurate measure of terminal voltage must be done under load. On some generators, this indicative test is performed automatically each time the generator is started. On other generator sets, use a manual battery load tester to attest the condition of each starting battery.

• Cleaning batteries: Keep the batteries clean by wiping them with a damp cloth whenever dirt appears excessive. If corrosion is present around the terminals, remove the battery cables and wash the terminals with a solution of baking soda and water (¼ lb baking soda to 1 quart of water). Be careful to prevent the solution from entering the battery cells, and flush the batteries with clean water when finished. After replacing the connections, coat the terminals with a light application of petroleum jelly.

• Checking specific gravity: In open-cell lead-acid batteries, use a battery hydrometer to check the specific gravity of the electrolyte in each battery cell. A fully charged battery will have a specific gravity of 1.260. Charge the battery if the specific gravity reading is below 1.215.

• Checking electrolyte level: In open-cell lead-acid batteries, verify the level of the electrolyte at least every 200 hr of operation. If low, fill the battery cells to the bottom of the filler neck with distilled water.

5. Routine Engine Exercise

Regular exercising keeps the engine parts lubricated and thwart oxidation of electrical contacts, uses up fuel before it deteriorate, and helps to provide reliable engine starting. Engine exercise is recommended to be executed at least once a month for a minimum of 30 min. loaded to no less than one-third of the nameplate rating.

6. Keep your generator clean

Oil drips and other issues are easy to spot and take care of when the engine is nice and clean visual inspection can guarantee that hoses and belts are in good condition. Frequent checks can keep wasps and other nuisances from nesting in your equipment. The more a generator is used and relied on the more it needs to be taken care of. However a generator set that is rarely used might not need a lot of care.

7. Exhaust system inspection

In case there are leaks along the exhaust line which usually occurs at the connection points, the welds and the gaskets, they should be repaired immediately by a qualified technician. Always make sure your units are serviced Especially 24 hrs before using your generators. For standby generators for example you need to have your units serviced 150hrs on average.

Self-Check 5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What is the importance of inspection?
2. What is pre operational testing?
3. The internal combustion engine, proper maintenance is essential on what? List at list 5.

Note: **Satisfactory rating - 8points** **Unsatisfactory - below 8points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

1. _____

_____

2. _____

_____

3. _____

_____

_____

_____

_____

Operation Sheet 1	Electric circuit

Equipment, Tools and Materials:

- Pliers
- Electric knife
- Screw driver
- Lamp holder
- Lamp
- Battery cell
- 2.5mm electric wire
- Circuit diagram

Procedure:

1. Wear PPE for safety
2. Look carefully the given diagram.
3. Identify the required tools and material.
4. Cut the electric wire and remove the insulation part
5. Check continuity of the wire

6. Connect one side both electric wires to the lamp holder negative and positive parts
7. Connect the other side to the battery negative and positive parts as shown on the diagram
8. Install lamps to the lamp holder
9. Test the installed circuit

Instruction Sheet 2	Learning Guide 38: Operate generator

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

- Understanding use of appropriate generators operating and diagnosing tools and equipment
- Using appropriate OHS
- Adjusting output
- Operating generator
- Observing generator operation
- Correcting abnormalities

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 –

- Output is adjusted to achieve required generator operating requirements and demand, observing operational requirements
- Generator is operated within limits of its design, regulators requirements, enterprise or site requirements
- generator operation is observed to detect deviations from required operating conditions
- Abnormalities are corrected in accordance with manufacturer and enterprise/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- 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 48,55,59,63,67, and 73
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 74 and do the LAP Test on page 75”. 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	Understanding use of appropriate generators operating and diagnosing tools and equipment

Introduction

Test equipment is necessary for determining proper set-up, adjustment, operation, and maintenance of electrical systems and control panels. The following is a general procedure for use of test equipment:

1.1 Electrical testing devices/equipments

Voltmeters are used in 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.

O**hmmeters** are used 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_ are used to for measuring magnitude of electrical current flow in an electrical circuit. When measuring D.C. currents, some types must be inserted in series with the circuit. A.C. ammeters are of two types. One requires that it be connected in series with the circuit; the other needs only to be clamped around the current carrying conductor. Ranges are from less than .0005 to over 100 Amperes, depending upon the instrument.

Circuit tester (Voltage tick): Simple and inexpensive, a circuit tester plugs into a conventional outlet and will tell you whether the circuit is “hot” (charged) or whether it’s properly grounded.

Fig_1.1_Circuit tester

Continuity tester: A small, battery-operated continuity tester. It can be used to determine whether wiring is broken and whether electrical circuits are complete.

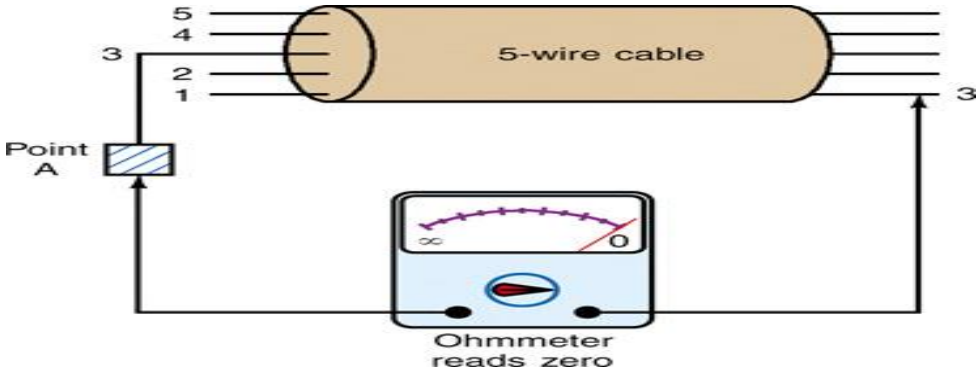


Figure Analog continuity tester

Fig2.2 digital Continuity tester

Multi-meter: You'll want to have a multi-meter on hand for making a variety of continuity checks, checking voltage, and other similar tasks. Multi-meters, which do the job of ohm meters, volt meters, and related tools, are sold at consumer electronics stores.

Fig 3.3 Multi-meter

1.2 electrical tools

Tools such as

Screwdrivers: You'll want an assortment of screwdrivers with insulated rubber grips. Be sure to get both flat-bladed and Phillips-head drivers.

Fig 4.4 Assorted screwdrivers

Lineman's pliers: A pair of these is the best tool to use for cutting heavy wire or cable and twisting wire ends together. To twist two wires together, hold them side by side with one hand, their stripped ends aligned, and point the blunt end of the pliers in line with them, clamp down, and twist in a clockwise direction.

Fig 5.5 Lineman pliers

Long-nose pliers: Long-nose pliers are great for bending small loops at wire ends or for cutting off wires (most include a wire-cutting section). Use the pointed end of the pliers to form a smooth, 3/4 circle at a wire's end, designed to circle around a screw terminal (always hook the wire onto the terminal with the end of the bend sweeping clockwise from the wire).

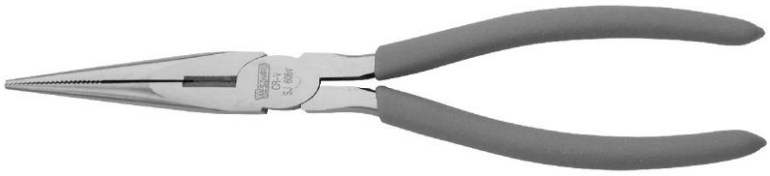


Figure: 6.6 Long-nose pliers

Wire stripper: Most electrical wires run inside a sleeve of insulation, a plastic, rubber or paper coating that prevents bare conductors from shorting against each other or shocking you. When splicing wires(connecting two or more wires together) or connecting them to devices, you must remove the insulation, a relatively simple job when you have the right tool—an inexpensive wire stripper.

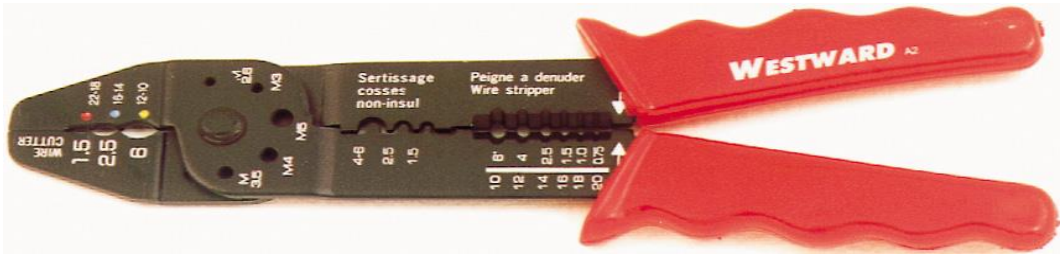


Fig 7.7 Wire stripper

The stripper should be set so that it cuts the insulation but doesn't nick the wire (or use the slot that matches the wire conductor's size). Hold the wire with one hand, bite into the insulation with the stripper, about 1/2" to 3/4" from the wire's end, rock the stripper back and forth, and pull the insulation off the end of the wire.

Self-Check 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each points (3points)

1. Write at list three electric testing devices.
2. Write the main important tools for generator work.
3. What is the use of long nose pliers?
4. What is the use of multi meter?

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

Answer Sheet

Score = _____

Name: _____ Date: Rating: _____

Short Answer Questions

1. _____

   _____

2. _____

   _____

3. _____

_____

4. _____

_____

Information Sheet-2	Using appropriate OHS

Introduction

Occupational health and safety (OHS) are generally defined as the science of the anticipation, recognition, evaluation and control of hazards arising in or from the workplace that could impair the health and well-being of workers, taking into account the possible impact on the surrounding communities and the general environment. This domain is necessarily vast, encompassing a large number of disciplines and numerous workplace and environmental hazards. A wide range of structures, skills, knowledge and analytical capacities are needed to coordinate and implement all of the "electrical-electronics work activities /machine installation" that make up national OSH systems so that protection is extended to both workers and the environment.

3.1. OHS guidelines

Occupational safety and health is 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.
- **Occupational safety and health programs and policies must aim at both prevention and protection**: - Efforts must be focused above all on primary prevention at the workplace level. Workplaces and working environments should be planned and designed to be safe and healthy.
- **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.
- **Health promotion is a central element of occupational health practice:-**Efforts Occupational health services covering all workers should be established. Ideally, all workers in all categories of economic activity should have access to such services, which aim to protect and promote workers' health and improve working conditions.
- **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.

3.1.1. **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 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.

All electrical work should be carried out by a qualified electrician. Under OHS laws, regular inspection according to Ethiopian building code of standard (EBCS)

3.2. SAFETY

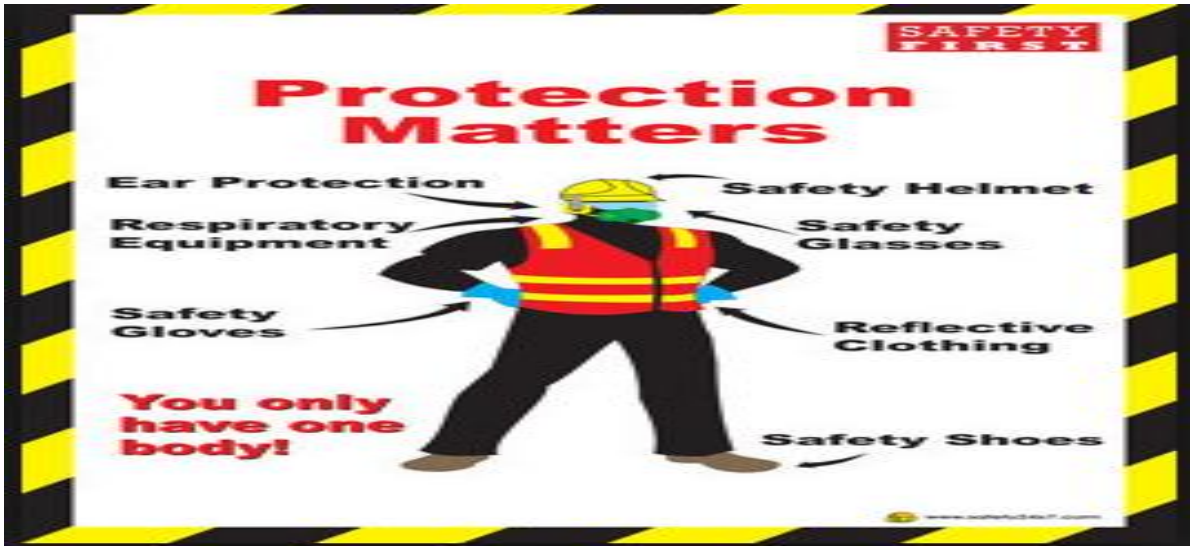


Fig 3.1 OSH personal protective equipment

3.2.1. General

The generator set is designed to be safe when used in the correct manner. Responsibility for safety, however, rests with the personnel who use the set. Before

performing any procedure or operating technique, it is the user's responsibility to ensure that it is safe to do so.

Warning:

- Read and understand all safety precautions and warnings before operating the generator set.
- Failure to follow the instructions, procedures and safety precautions may increase the possibility of accidents and injuries.
- Never start the generator set unless it is safe to do so.
- Do not attempt to operate the generator set with a known unsafe condition.
- If the generator set is unsafe, fit danger notices and disconnect the battery negative (–) lead so that it cannot be started until the condition is corrected.
- Ensure the generator set is protected from any unauthorized use, use signs were appropriate.
- Disconnect the battery negative (–) lead prior to attempting installation, repairs or cleaning on the generator set.
- Install and operate this generator set only in full compliance with relevant National, Local, or Federal Codes, Standards or other requirements.

3.2.2. Emergency Stop Button

The emergency stop button is in the OUT position for normal engine operation. Push the emergency stop button. The engine will not start when the button is locked. Turn the button clockwise in order to reset.

Warning

- Familiarize yourself with the location of the Emergency Stop Button. Emergency shutoff controls are for EMERGENCY use ONLY.
- DO NOT use emergency shutoff devices or controls for normal stopping procedure.
- Do not start the engine until the problem necessitating the emergency stop has been located and corrected.

3.2.3. Personal Protective Equipment

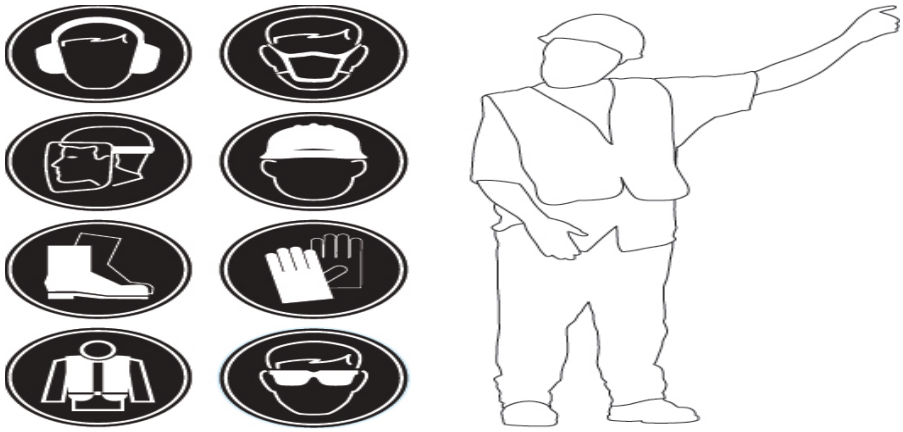


Figure 3.2. Typical PPE to be worn by an Operator /technician

- 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 jewelry that can snag on controls or on other parts of

  the engine.
- Ensure that all protective guards and all covers are secured in place on the engine.
- Never put maintenance fluids into glass containers. Glass containers can break.
- Use all cleaning solutions with care.
- Report all necessary repairs.

Unless other instructions are provided, perform the maintenance under the following conditions:

- The engine is stopped. Ensure that the engine cannot be started.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help

  prevent sparks.

- Do not attempt any repairs that are not understood. Use the proper tools. Replace any

equipment that is damaged or repair the equipment.

Fig 3.3. OHS warning sign

Self-Check -2	Written test and Multiple choose

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What is OHS and its importance in our work activities? (2pts)
2. Write the materials used in personal protective equipment's? (2pts)
3. What are the basic principles of OHS guide lines? (2 pts)
4. The importance of Emergency Stop Button in generator is?(2pts)
   A/ Break the engine during emergency B/ Stop the generator in cause of emergency C/Lock the engine soon D/ all of the above
5. What safety care in generator setting? (2 pts).

Note: **Satisfactory rating –6 points** **Unsatisfactory - below 6 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1._____

_____

2._____

_____

3._____

_____

Information Sheet-3	Adjusting output

Introduction

AVR (Automatic voltage regulator) is an instrument that adjusts voltage by means of automatic control device.

Voltage regulator (referred to as AVR) is designed for AC brushless generators with fundamental wave, harmonic compound excitation or permanent magnet generator excitation (PMG system).

Voltage regulator realizes the automatic regulation of generator output voltage by controlling the excitation current of generator AC exciter. Generator voltage regulator can be used for ordinary 60/50Hz as well as medium frequency 400Hz single or parallel generators.

An AVR is at the heart of devices often called power conditioners or power stabilizers. The typical power conditioner is an automatic voltage regulator combined with one or more other power-quality capabilities, such as:

1) Surge suppression

2) Short circuit protection (circuit breaker)

3) Line noise reduction

4) Phase-to-phase voltage balancing

5) Harmonic filtering, etc.

Power conditioners are typically used in low voltage (<600V) applications and sizes below 2,000KVA. In general, the AC automatic voltage regulator (AVR) is a device designed to regulate voltage automatically – that is, to take a fluctuating voltage level and turn it into a constant voltage level.

Working principle of AVR

The voltage regulator is an adjustment device that controls the generator output voltage within a specified range. Its function is to automatically control the generator voltage and keep it constant when the rotating speed of the generator changes, so as to prevent the generator voltage from being too high to burn out the electrical equipment and cause the battery to overcharge. At the same time, it also prevents the generator voltage from being too low, resulting in malfunctioning of electrical equipment and insufficient battery charge.

Since the transmission ratio of generator to engine is fixed, the speed of generator will change with the change of engine speed. The power supply of generator to electric equipment and charging to battery both require its voltage to be stable, so it is necessary to adjust the output voltage of generator if the voltage is kept at a certain value basically. A synchronous generator regulator that maintains the synchronous generator voltage at a predetermined value or changes the terminal voltage as planned.

When the terminal voltage and reactive power of the synchronous motor change, the output current of the exciter is automatically controlled according to the corresponding feedback signal to achieve the purpose of automatically regulating the terminal voltage or reactive power of the synchronous motor.

According to the working principle, the voltage regulator of alternator is divided into:

1. Contact type voltage regulator

Contact type voltage regulator was applied earlier, the regulator contact vibration frequency is slow, there is mechanical inertia and electromagnetic inertia, voltage regulation accuracy is low, contact is easy to generate sparks, large radio interference, poor reliability, short life, now has been eliminated.

2. Transistor regulator

With the development of semiconductor technology, transistor regulator is adopted. The advantages is high switching frequency of triode, no sparks, high adjusting precision, light weight, small volume, long life, high reliability, small radio interference and so on. Now it is widely used in medium and low grade car model.

3. IC regulator (Integrated circuit regulator)

In addition to the advantages of the transistor regulator, the integrated circuit regulator has an ultra-small size and is installed inside the generator (also known as a built-in regulator), which reduces the external wiring and improves the cooling effect. It is now widely used in Santana, Audi and other car models.

4. Computer controlled regulator

After the total load of the system is measured by the electric load detector, a signal is sent to the generator computer, and then the generator voltage regulator is controlled by the engine computer, and the magnetic field circuit is turned on and off in a timely manner, thereby reliably ensuring the normal operation of the electrical system, the battery is fully charged, and can reduce engine load and improve fuel economy.

Self-Check -3	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What is the function of AVR (Automatic voltage regulator(3points)
2. Write the Working principle of AVR (4points)
3. Write at list three working principle, the voltage regulator of alternator (3points)

Note: **Satisfactory rating 6 points** **Unsatisfactory - below 6 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1._____

_____

2._____

_____

3._____

_____

4._____

5._____

Information Sheet-4	Operating generator

Introduction

Operation of the generator is to mean that permitting or allowing a generator to give the task/service it is intended for. That is giving an electrical output which is needed for different applications. An operator who operates the gen-set should get operator training and understand operation of the Gen-set satisfactorily.

Manufacturing companies provide manuals for generator operation at standard/normal conditions and the operation will be affected if there are variations from listed normal conditions. So to avoid those problems related with the operation there should be pre starting inspections & tests, post starting observations & checks and correction/adjustment of outputs from given limits of operation. These can be seen under the following categories.

Inspection and pre-operational checks - All checks/inspections required for system components prior to/before energizing or operating the major system component (in this case generator).A visual inspection should take only a few minutes and can prevent costly repairs and accidents – For maximum generator set life, visually inspect the generator set before starting.

Pre or post operation adjustment and correction of deviations– adjustments that are needed to be set before and after starting of the generator within the limits of its design and enterprise or site requirements. And it refers also to correct deviations of the operation from manufacturer and enterprise/site procedures.

After performing the adjustments and correction of deviations, evaluation/check for the proper functionality of the generator should be done.

Post starting tests/check or performance test -Testing conducted to evaluate the compliance of a system or component (in this case generator) with specified

performance. This is to mean that checking or observing the operation and delivered output is as per the specified performance.

When operating a diesel generator, you should read and follow the safety instruction that come with the generator. It is wise to seal those instructions in plastic and keep them with the generator. There are many safety considerations that must be understood and followed to ensure safe, effective operation of your emergency generator.

Safety Operation Manual

1. Don't use a generator indoors unless it's designed and installed properly for indoor operation.
2. Make sure generator is properly sized to the loads you are energizing.
3. Be sure you have a properly sized and properly wired transfer switch. Make sure the transfer switch is in the auxiliary power position before operating the generator.
4. Be sure all wiring is adequate and in good condition. Never use an undersized or frayed power cord to connect the generator to the transfer switch. If generator power cord becomes hot during use, replace it with larger size wire. Arrange and secure generator power cord to avoid tripping hazards.
5. Make sure the generator is properly grounded.
6. Do not remove or modify any safety devices on the generator or related equipment.
7. Always provide plenty of ventilation for the generator.
8. Always start a generator under no load. When it is up to proper operating speed and is producing electricity at the desired voltage and frequency, you can begin adding load. Start largest loads first whenever possible.
9. Never overload the generator. Overloading can cause severe damage to the generator and to the engine or tractor used to drive it.
10. Keep all children away from the generator at all times. Generators become very hot during normal operation. Post warning signs about hot surface dangers.

11. Keep the generator dry to reduce danger of electrical shock and equipment failure.
12. Shut off all electric loads on the generator, and allow the generator to spin a few minutes before shutting it off.
13. Never refuel the tractor or engine powering the generator while it is running. Shut the engine off and allow it to cool before adding fuel. Check all engine fluids each time you refuel. Check for fuel leaks often.
14. Be sure the generator is well secured. Check all mounting bolts to see that they remain tight. Replace any broken mounts.
15. Do not operate voltage sensitive equipment (computers, entertainment equipment) with a generator unless they are protected by a voltage surge protection device.
16. Besides, make yourself fully aware of the sound your generating system makes under normal operation. If you hear unusual sounds, shut the generator down safely and inspect for problems.
17. If operating continuously during a prolonged outage, shut the generator down at least once every 24 hours to allow it to cool and to inspect for equipment problems.
18. Do not touch or lean against hot exhaust pipes or engine components.
19. Do not clean air filter with gasoline or other types of low flash point solvents.
20. Do not operate the genset without a functional exhaust system.
21. Do not fill fuel tank near an open flame, while smoking, or while engine is running.
22. Do not fill tank in an enclosed area with poor ventilation.
23. Do not operate with the fuel tank cap loose or missing.

Attention: In addition to the above safety operation, you should keep in mind of the following instructions.

1). The area around the generator must be clean and free of clutter and any combustible material that can be hazardous.

2). The equipment must be regularly inspected and defective or damaged parts must be replaced in a timely manner.

3). The unit should not be opened or dismantled while it is functioning. Moving or hot parts should not be tampered with. Battery cables should be disconnected before proceeding to work on the generator to eliminate any possibility of an accidental start-up.

Self-Check -4	Written test and choose

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Write at list five safety operational manual (5points)
2. When is the post starting tests/check or performance test done?(2ponts)
   A. Before starting the generator
   B. After the generator is started
   C. After the generator is stopped
3. List down main checks and inspections before generator starting?(3points)

Note: **Satisfactory rating 6points** **Unsatisfactory - below 6points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1._____

_____

2._____

_____

3._____

_____

4._____

5._____

Information Sheet-5	Observing generator operation

Introduction

Generators don't actually create electricity. Instead, they convert mechanical or chemical energy into electrical energy. They do this by capturing the power of motion and turning it into electrical energy by forcing electrons from the external source through an electrical circuit. A generator is essentially an electrical motor working in reverse.

Some electrical generators, such as those at Hoover Dam, for example, are huge and provide enormous amounts of energy by transferring the power created by water turning turbines into electricity. Residential and commercial generators, however, are much smaller and rely on more traditional fuel sources like diesel, gas, and propane to create mechanical power that can then be forced into a circuit and induce an electrical current.

Once an electrical current has been established, it is directed through copper wires to power external machines, devices, or entire electrical systems.

Modern generators can be attributed to Michael Faraday's principle of electromagnetic induction. Faraday discovered that when a conductor moves in a magnetic field, electrical charges could be created and directed to create a flow of current. At its most basic, an electrical generator is nothing more than an electromagnet – moving wire near a magnet to direct the flow of electricity. It's similar to how a pump pushes water through a pipe.

Features of electric generators

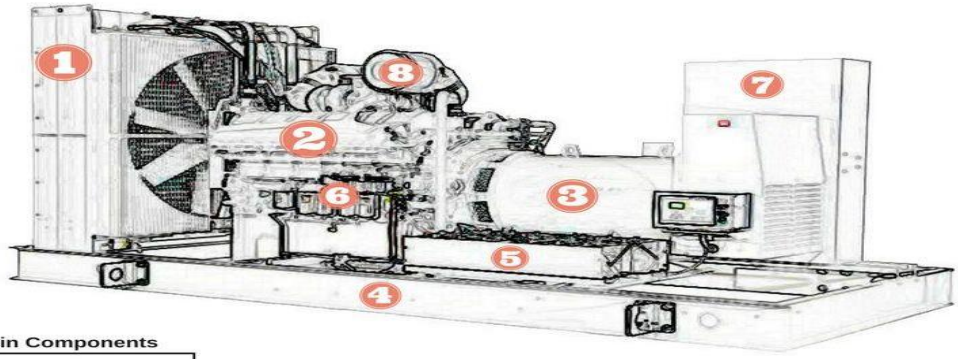
- Power: Electric generators with a wide range of power output capacity are readily available. Low as well as high power requirements can be met easily by choosing an ideal electric generator with matching power output.

- Fuel: Multiple fuel options such as diesel, petrol, natural gas, LPG, etc. are available for electric generators.
- Portability: There are generators available in the market which have wheels or handles fitted on them so that they can be moved from one place to another easily.
- Noise: Some generator models have noise reducing technology, which allows them to be kept at close proximity without any noise pollution problems.

Applications of electric generators

- Electric generators are useful for homes, shops, offices, etc. which face frequent power outages. They act as a backup to ensure that the appliances receive uninterrupted power supply.
- In distant areas, where electricity from the main line cannot be accessed, electric generators act as the primary source of power supply.
- When working on project sites where electricity cannot be accessed from the grid, electric generators can be used for powering machinery or tools.

The Parts Of An Electrical Generator



Main Components

1. Radiator
2. Engine
3. Alternator
4. Skid / Frame
5. Batteries
6. Oil Filters
7. Control Panel
8. Air Filter

Here are nine parts to a generator and they all play a role in getting power to where it is needed most. The parts of a generator are:

1. Engine. The engine supplies energy to the generator. The power of the engine determines how much electricity a generator can provide.

2. 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.

3. Fuel System. The fuel system makes it possible for the generator to produce the energy needed. The 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.

4. 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.

5. 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.

6. 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, as often as every 8 hours of operation.

7. Battery Charger. Batteries are used to start up the generator. The battery charger is a fully automatic component that ensures the battery is ready to go when needed by supplying it with a constant low-level of voltage.

8. 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.

9. Main Assembly / Frame. This is the body of the generator. It is the part that we see; the structure that holds it all in place.

Kind Of Fuel Do Electrical Generators Need

Today's electrical generators are available in many different fueling options. Diesel generators are the most popular industrial generators on the market. Residential generators more commonly include: natural gas generators or propane generators, while the smaller portable generators typically run on gasoline, diesel fuel, or propane. Some generators are bi-fuel capable – running on both gasoline and diesel.

Self-Check -5	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What Are The Parts Of An Electrical Generator? (2points)
2. What Kind Of Fuel Do Electrical Generators Need? (2points)
3. Write the Applications of electric generators (3points)
4. Write the Features of electric generators (3points)
5. What is the function of main Gen-set parts?

Note: **Satisfactory rating 6 points** **Unsatisfactory - below 6points**

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Answer sheet

1._____

_____

2._____

_____

3._____

_____

4._____

Information Sheet-6	Correcting abnormalities

Introduction

A generator is subjected to electrical stresses imposed on the insulation of the machine, mechanical forces acting on the various parts of the machine, and temperature rise. These are the main factors which make protection necessary for the generator or alternator. Even when properly used, a machine in its perfect running condition does not only maintain its specified rated performance for many years, but it does also repeatedly withstand certain excess of overload.

Preventive measures must be taken against overloads and abnormal conditions of the machine so that it can serve safely. Even ensuring an efficient design, construction, operation, and preventive means of protection – the risk of a fault cannot be completely eliminated from any machine. The devices used in generator protection, ensure that when a fault arises, it is eliminated as quickly as possible.

An electrical generator can be subjected to either an internal fault or external fault or both. The generators are normally connected to an electrical power system, hence any

fault occurred in the power system should also be cleared from the generator as soon as possible otherwise it may create permanent damage in the generator.

The number and variety of faults occur in a generator are huge. That is why generator or alternator is protected with several protective schemes. Generator protection is of both discriminative and non-discriminative type. Great care is to be taken in coordinating the systems used and the settings adopted to ensure that a sensitive, selective and discriminative generator protection scheme is achieved.

Types of Generator Protection

The various forms of protection applied to the generator can be categorized into two manners,

1. Protective relays to detect faults occurring outside the generator.

2. Protective relays to detect faults occurring inside the generator.

Other than protective relays, associated directly with the generator and its associated transformer, there are lightning arrestors, over speed safe guards, oil flow devises and temperature measuring devises for shaft bearing, stator winding, transformer winding and transformer oil etc. Some of these protective arrangement are of non-trip type i.e. they only generate alarm during abnormalities.

But the other protective schemes ultimately operate master tripping relay of the generator. This should be noted that no protective relay can prevent fault, it only indicates and minimizes the duration of the fault to prevent high temperature rise in the generator otherwise there may be permanent damage in it.

It is desirable to avoid any undue tresses in the generator, and for that it is usual practice to install surge capacitor or surge diverter or both to reduce the effects of lightning and other voltage surges on the machine. The protection schemes usually applied to the generator are discussed here below in brief.

Protection against Insulation Failure

The main protection provided in the stator winding against phase to phase or phase to earth fault, is longitudinal differential protection of generator. Second most important protection scheme for stator winding is inter turn fault protection.

This type of protection was considered unnecessary in previous days because breakdown of insulation between points in the same phase winding, contained in the same slot, and between which a potential difference exists, very rapidly changes into an earth fault, and then it is detected by either the stator differential protection or the stator earth fault protection.

A generator is designed to produce relatively high voltage in comparison to its output and which therefore contains a large number of conductors per slot. With increasing size and voltage of the generator, this form of protection is becoming essential for all large generating units.

Stator Earth Fault Protection

When the stator neutral is earthed through a resistor, a current transformer is mounted in the neutral to earth connection. Inverse time relay is used across the CT secondary when the generator is connected directly to the bus bar. In case of generator feeds power via a delta star transformer, an instantaneous relay is used for the same purpose.

In the former case, the earth faults relay is required to be graded with other fault relays in the system. This is the reason why inverse time relay is used in this case. But in the latter case, the earth fault loop is restricted to the stator winding and primary winding of the transformer, hence, there is no need of grading or discrimination with other earth fault relays in the system. That is why Instantaneous Relay is preferable in the case.

Rotor Earth Fault Protection

A single earth fault does not create any major problem in the generator but if the second earth fault is occurred, however, part of the field winding will become short-circuited and resulting and unbalanced magnetic field in the system and consequently there may be major mechanical damage to the bearings of the generator. There are three methods available to detect the types of fault in the rot. The methods are

- Potentiometer method
- AC injection method
- DC injection method

Unbalanced Stator Loading Protection

Unbalancing in loading produces negative sequence currents in the stator circuit. This negative sequence current produces a reaction field rotating at twice of synchronous speed with respect to the rotor and hence induce double frequency current in the rotor. This current is quite large and causes overheating in the rotor circuit, especially in the alternator.

If any unbalancing occurred due to fault in the stator winding itself, that would be cleared instantaneously by the differential protection provided in the generator. If the unbalancing is occurred due to any external fault or unbalanced loading in the system, it may remain undetected or may persist for a significant period of time depending on the protection coordination of the system. These faults then be cleared by installing a negative phase sequence relay with the characteristics to match the withstand curve of the machine.

Protection against Stator Overheating

Overloading can causes overheating in the stator winding of the generator. Not only overloading, failure of cooling systems and insulation failure of stator laminations also cause overheating of the stator winding.

The overheating is detected by embedded temperature detectors at various points in the stator winding. The temperature detector coils are normally resistance elements which form one arm of the wheatstone bridge circuit. In the case of smaller generator normally below 30 MW, the generators are not equipped with embedded temperature coil but are usually fitted with thermal relay and they are arranged to measure the current flowing in the stator winding.

This arrangement only detects overheating caused by overloading and does not provide any protection against overheating due to failure of cooling systems or short circuited

stator laminations. Although over current relays, negative phase sequence relays, and devises for monitoring constant flow are also used to provide a certain degree of thermal overload protection.

Low Vacuum Protection

This protection usually is in the form of a regulator which compares the vacuum against atmospheric pressure, it is normally fitted to the generator set above 30 MW. The modern practice is for the regulator to unload the set via the secondary governor until normal vacuum conditions are restored. If the vacuum conditions do not improve below 21 inch the stop valves are closed and the main circuit breaker is tripped.

Protection against Lubrication Oil Failure

This protection is not considered essential since the lubrication oil is normally obtained from the same pump as governor oil and a failure of the governor oil will automatically make stop valve to close.

Protection against Loss of Boiler Firing

Two methods are available for detecting the loss of boiler firing. In the first method, normally opened (NO) contacts are provided with the fan motors which may trip the generator if more than two motors fail. The second methods use a boiler pressure contacts which unload the generator if boiler pressure falls below approximately 90%.

Protection against Prime Mover Failure

If the prime mover fails to supply mechanical energy to the generator, the generator will continue to rotate in motoring mode that means it takes electrical energy from the system instead of supplying it to the system.

In a steam turbine the steam acts as a coolant maintaining the turbine blades at a constant temperature. Failure of the supply will therefore result in overheating due to friction, with subsequent distortion of turbine blades.

The failure of steam supply can cause severe mechanical damage in addition of imposing a heavy motoring load on the generator. Reverse power relay is used for this purpose. As soon as the generator starts rotating in motoring mode, the reverse power relay will trip the generator set.

Over Speed Protection

While it is the general practice to provide mechanical over speed devices on both steam and hydro turbine, which operate directly on the steam throttle valve or main step valve, it is not usual to backup this devises by an over speed relay on steam driven sets.

It is, however, considered good practice on hydroelectric units, as the response of the governor is comparatively slow and the set is more prone to over-speed. The relay when fitted is usually supplied from the permanent magnet generator used for the control of governor.

Protection against Rotor Distortion

The cooling rates following shutdown, at the top and bottom of the turbine casing, are different and this uneven temperature distribution tends to cause destruction of the rotor. To minimize the disruption, it is common practice to turn the rotor at low speed during the cooling down period. In the view of the forces involved with large modern rotor, it is now standard practice to fit shaft eccentricity detectors.

Protection against Difference in Expansion between Rotating and Stationary parts During the running up period, the rate of heating of the rotor differs from that of the casing, due to the difference in mass. As a result, the rotor expands at a different rate to the casing and it is necessary to overcome this unequal expansion.

To this end, proposition is made on the larger machine for independent supplies of steam to be set to certain joints on the casing. It is desirable therefore to provide a means of measuring the axial expansion to assist the operator to feed the steam to the correct points and also to provide indication of any dangerous expansion.

The shaft axial expansion detector is basically similar to the equipment described for rotor distortion equipment, except that the detector magnets are fixed to the turbine casing.

Protection against Vibration

Vibration detectors are usually mounted on the bearing pedestals. The detector consists of a coil mounted on springs between U shaped permanent magnets. The voltage output from the coil, which is proportional to the degree of vibration, is passed from the coil into integrating circuits and then into interval indicating instrument.

Self-Check -6	**Written test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Write Types of Generator Protection and their functions (6ponts)
2. Write the three methods of to detect the types of fault in the rotor (3points)
3. What is the purpose of Generator Protection (3points)

Note: **Satisfactory rating 6 points** **Unsatisfactory - below 6 points**

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1._____

_____

2._____

_____

3._____

_____

4._____

5._____

Operation Sheet – 1	Generator operation

Use the appropriate tools and safety materials provided in the workshop to operate the Generator and do the following tasks.

A. Do not attempt to operate the generator without consideration of OH & S regulations

B. Ensure that the Generator set is located in the appropriate area that is free from any insecure items that could inhibit operation or cause injury, protected from sunshine/ rain/ dust, cooling air ventilation screens are clear.

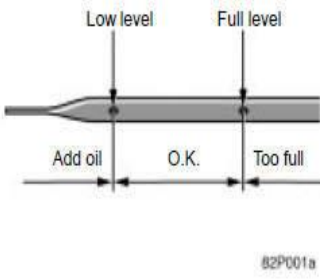
C. Proceed with the following steps before you start, to start & operate and stop or provided as follows

C1 - Pre-Start Checks

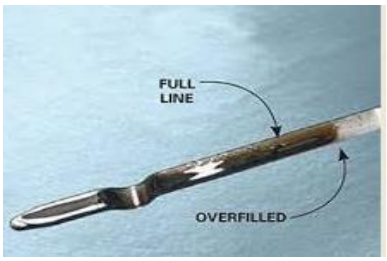
the following checks detailed below are the only tasks that an operator should undertake. Those checks should be performed prior to starting the generator set:

1. Ensure the Control Switch / Key Switch is OFF.
2. Loose fastenings / fixings, worn belts or loose connections. Fix as necessary.
3. The fan and exhaust guards must be at the correct positions and securely fixed. Repair damaged / loose guards or renew missing guards.
4. For any type of leak (coolant, lubricating oil or fuel), clean away the fluid. If a leak is observed, find the source and correct the leak. If a leak is suspected, check the fluid levels frequently until the leak is found and repaired.
5. Visually check the entire generator set for signs of leaks from the fuel system, cooling system or lubrication seals. Check the condition of all pipes for splits or signs of rubbing.
6. Check the engine oil and coolant levels – fill as necessary

- Engine is OFF and on level ground
- Open the engine hood and locate the engine oil dipstick.
- Pull out the dipstick and wipe the end clean with a rag.

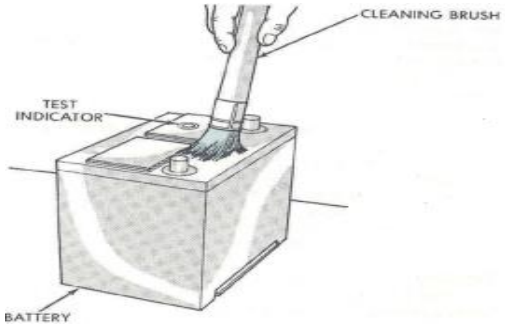


- Reinsert dipstick into the engine until it fully seats
- Pull out the dipstick again
- Read the end of the dipstick and get a correct oil level reading. Once you know the level you can add/change oil if needed or leave it if within specification

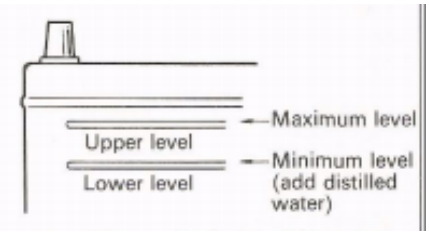


7. Check the fuel level – fill as necessary.
8. Check the condition & tension of the belt – tighten as necessary.
9. Check the battery terminals for corrosion – disconnect the battery terminal and clean using baking soda and water solution by keeping the solution not to enter in to the battery cells.

   Never touch both battery terminals with your bare hands at the same time!



10. Check the battery electrolyte level

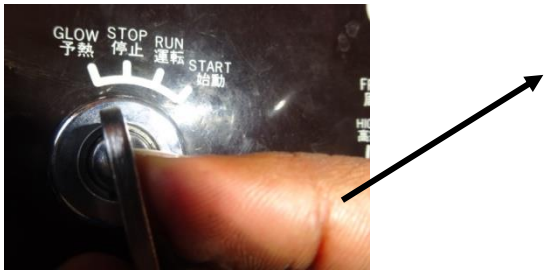


11. Check the control panel and the generator set for heavy accumulation of dust and dirt – clean as necessary, these can cause an electrical hazard or give rise to cooling problems.
12. Ensure the alternator output circuit breaker is in the “OFF” position.

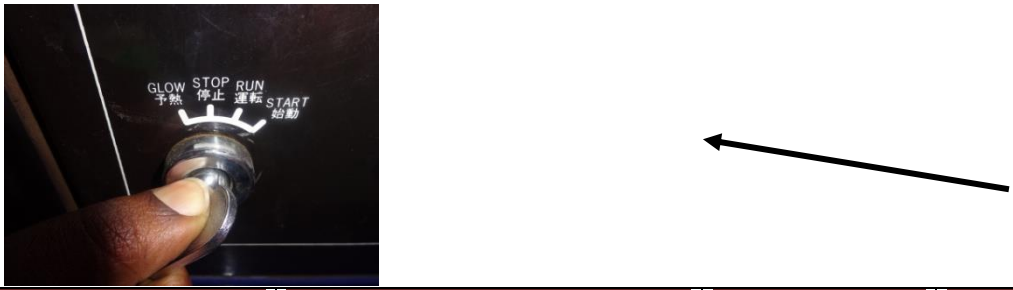
C2 - Starting the Engine; manual / electronic controlled

1. Ensure the control lever to ‘’IDLING’’ position or set it to ‘’IDLING’’ position

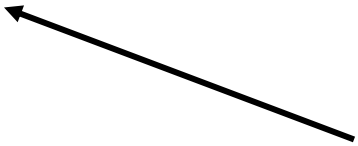
2. Turn the starter switch to ‘PREHEAT’ or ‘GLOW’ position to preheat the machine.



3. Immediately after the glowing the glow plug heater, turn the starter switch fully to ‘START’ position to crank/start up the engine. When the starter switch is turned to START the starter relay turns on the starter motor. This motor drives the starter gear ring via the pinion gear.



4. Once the engine has started up, leave the engine running to warm up it under unload for approx. 5 minutes which is necessary for smooth operation of the engine.
    - During warm up operation, examine the different parts of the equipment for any looseness, leakage of water, oil, fuel, and other irregularities.
5. when completing the startup, set the control lever to ‘’RUN’’ position



- By watching the voltmeter, turn the voltage regulator controlling knob to set the voltage output to the rated.
- be sure to operate the generator at a rated frequency, irrespective of the load capacity
- Keep the output terminal cover shut and locked whenever the machine is running
- Keep the door shut and locked whenever the machine is running
- make sure that fault indication/alarm lamps are off
- Check operation of all meters and gauges
- Check the charging alternator is charging the battery and the battery voltage reads
- Finally Switch the alternator output circuit breaker to “ON”

C3 - Shutdown:

- To shutdown the generator set, turn off the load by switching the Alternator Output Circuit Breaker to “OFF”.
- Allow the generator set to keep on ‘IDLING’ by setting the control lever ‘’IDLING’’ position run without load for 1-2 minutes to cool.
- Then turn the key switch to ‘STOP’ position. The generator set shuts down safely.
- In case of an emergency where immediate shutdown is necessary, stop using emergency stop (if the generator has an emergency stop) or use the key switch should be turned to ‘STOP’ position immediately without disconnecting the load (if the generator has no emergency stop)

D. Return the necessary tools used for pre and post operations and adjustments

- Now after you confirm that the generator starts the operation safely, keep clean the surrounding of a generator and return the tools used for operating the generator

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Total time allowed for doing the following task: 20 min

Instructions:

1. You are required to perform the following tasks:
    - Prepare the necessary tools and safety clothes
    - Operate the generator by following the necessary checks and within the specified enterprise standard procedures
    - Evaluate the generator operation.
2. Request your trainer for evaluation and feedback

Instruction Sheet 3	Learning Guide 39: Inspect and monitor generator operation

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

- Physically identifying generator to be monitored/inspected
- Performing tests
- Observing system
- Taking correct action
- Returning generator

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 –

- Generator to be monitored/inspected is physically identified
- Tests are performed using *tools* in accordance with defined procedures applicable to the operational test
- System is observed for correct operational response
- Correct action is taken using the appropriate tools and *consumables* when response is not in accordance with documentation, expected electrical output or personnel safety requirements
- generator is returned to required operational status upon completion of test and correction

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, and 5 in each information sheets on pages 84, 91, 98,105, and 107.
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_ and do the LAP Test on page _. 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	Physically identifying generator to be monitored/inspected

GENERATOR MONITORING & DIAGNOSIS

Evaluate components with high risks of failure to anticipate forced outage Power plant performance depends on very complex interactions between all components and systems.

Generator advanced monitoring and diagnosis methods provide evaluation and analysis with accurate data to better operate, maintain equipment and identify action plans.

a. Temperature Measurement (Air, Machine, Winding and Bearing)

b. Vibration (generator frame, bearing housing)

c. Noise level

d. Step voltage

e. Waveform analysis and O.C. Oscillogram at rated voltage

GENERATOR ADVANCED MAINTENANCE BEYOND REGULAR MAINTENANCE

ADVANCED CLEANING

- Cleaning of windings and the Interior of the generator
- Cleaning Windings with Solvents

- Washing Windings with Detergent Water
- Cleaning of the Brush Gear and Slip-Rings

ADVANCED TESTING, MONTORING & DIAGNOSIS

In addition to those standard checks, GE Field Service Engineer shall conduct the following additional function tests for those machines installed at least a year ago during maintenance, if required.

- Reliability Centered Maintenance (RCM)
- ViSoR Remote Monitoring System
- Reliability Centered Maintenance (RCM)

RCM is a specific process used to identify the policies which must be implemented to manage the failure modes which could cause the functional failure of any physical asset in a given operating context.

- Comprehensive database
- Maintenance cost effectiveness
- Longer useful life
- Improved operating performance

FAULT FINDING

FAILURE TO START OR ACCELERATE

1. Check all connections against the circuit diagram see that there are no open circuits and that all terminals and contacts are clean and right.

2. Check supply voltage at all the generator terminals to see if any reduction is taking place due to line drop. If on autotransformer start is being used, select a higher tapping.

3. Ensure that the machine is not overloaded – try to start the generator uncoupled from load.

4. Check that any thermal, over current or over-voltage protection devices have not been tripped, and that they have been set correctly.

5. Check that stator line currents and phase resistance is balanced and that the insulation resistance is correct.

6. Inspect the rotor bars and end rings.

7. In case of SR Generators, check the rotor resistance-circuit and control.

8. If generator crawls at low speed, the generator and load torque speed curves are probably

mismatched. (This is only likely to be of concern when starting STAR/DELTA).

9. Load inertia may be too high, thus resulting in a prolonged start-up time – consult GEPC.

VIBRATION

1. Run the machine unexcited. If excessive vibration occurs, then it may be of mechanical origin. Check the alignment. If work has been done on the machine, check for correct re-assembly, tightness of holding down bolts and presence of dowels.

2. If vibration is not present unexcited, excite the machine to rated voltage on open circuit. If vibration appears, check that the machine air-gaps are all within 10% of one another.

3. If the vibration is not present on no-load, add load until it appears. Assuming that the load is balanced, such load-dependent vibration could arise from conditions in the field windings, and GE Energy Power Conversion, Rotating Machines should be consulted.

4. If vibration occurs after a system fault or accidental mal-synchronization, then movement could have occurred or damage could have been done. Consult GE Energy Power Conversion, Rotating Machines.

5. Check the rotor bars, end rings and other rotating parts for damage.

MECHANICAL NOISE

Mechanical noise may occur after work has been carried out on the machine. If this happens, shut down at once and check that no tools, nuts and bolts or debris have been left inside, and that the components have been assembled correctly.

If the noise occurs and no work has been done or if work has been carried out and the above check made, check that:

1. Nothing is rubbing on the shaft (e.g. fan baffles or bearing seals) or coupling.

2. The alignment is correct.

3. The bearing oil supply is working.

4. The air gaps are equal.

5. There is no foreign matter in the air gaps. If there is, establish where it came from

Self-Check -1	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each points (3points)

1. What is Reliability Centered Maintenance (RCM?)
2. How to protect mechanical noise?

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

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1._____

_____

2._____

_____

3._____

_____

4._____

5._____

Information Sheet-2	Performing tests

PERFORMING TEST

Your generator set is a valuable resource that provides a dependable emergency power to your business when power from the utility grid is suddenly lost, or power is not available in your environment. In the event of a power failure you want to have peace of mind that your backup power supply will spring into action seamlessly on a moment's notice. But what happens when the power goes out and your generator fails function as expected? The result can often be costly and sometimes catastrophic depending upon your application.

This is precisely the reason generator load bank testing is an essential piece of a comprehensive preventative generator maintenance plan, which you should ideally have conducted on your generator each year. Load bank testing helps to ensure that your generator will be fully dependable and operational, as well as completely capable of the highest possible load it may be required to handle at any critical point in time. Load testing your emergency standby generator system should be part of a standard planned maintenance program for all systems.

Reasons to Test Your Generator

To make sure the generator will perform as designed, when it is needed most. This is the only true way to check the performance of the generator. A load test will allow verification that the generator system will produce and maintain full load without overheating and shutting down. It also allows testing of all components of the system, to ensure all work together as designed and intended and can help identify any potential weaknesses in controlled conditions. This allows proactive maintenance, as weaknesses are identified during controlled conditions, not during a utility outage when a weakness can cause the system to fail.

The load can come from building load, but that may cause business interruptions when transferring from utility to generator. It also does not allow the load to be applied in steps, where performance can be monitored and recorded. Generally, utilizing a portable load bank is the preferred method of load testing a generator system.

Most generator systems are programmed to exercise on a regular basis. Typically this exercise period is under no (or very little) load. Monitoring the exercise period to ensure the generator starts and runs as programmed is also important, but does not ensure the generator will operate as designed.

Most generator systems are installed and then put into automatic mode. As the generator ages, the possibility of weaknesses in the system will rise. Among other potential enemies, weather, pests and age can negatively affect the efficiency of a generator system. A good planned maintenance program that includes load testing is the best way to spot and minimize potential weaknesses in a generator system.

In addition, because many of the installed generator systems that utilize a diesel engine present another challenge. That challenge is referred to as wet-stacking. If not addressed, wet-stacking will degrade the performance of the system and not allow the system to operate as designed. Many systems are designed with some redundancy on load or for future expansion. This means many systems are not loaded appropriately to eliminate wet-stacking. At a minimum, I recommend all diesel system be load tested with a portable load bank for a minimum of two hours, annually. If a diesel system hasn't been load tested in over a year, longer testing may be required. This annual testing will reduce the impact wet-stacking will have on a generator system.

A good planned maintenance program that includes regular load testing should be a standard component of a generator system. The regular testing of the system will provide the highest comfort level that when the system is required, it will operate as designed.

What is Generator Load Bank Testing?

Generator Load Bank Testing is an Important Aspect of Preventative Maintenance. A generator load bank test involves an examination and assessment of a genset. It verifies that all primary components of the generator set are in proper working condition. The equipment used to conduct a load bank test produces artificial loads on the generator by bringing the engine to an appropriate operating temperature and pressure level. This is especially important for standby and emergency generator sets that do not run very often and/or may not be exposed to carrying heavy loads on a frequent basis. The general rule is – if your generator is not exposed to higher than 30% of its rated kW load then you should be considering a load test.

Load bank testing involves firing up a standby or prime power generator and running it under an artificial load at its maximum capacity for a specified period of time. During load bank testing, data can be recorded that offers a more thorough look into the health of the gen set on the whole. The test verifies that the generator is capable of handling incrementally higher kW loads, that it is still capable of accommodating its maximum specified load, and that it can work for an extended period of time. So, at its simplest, load bank testing is a way of verifying that your standby or prime power generator is still capable of kicking on and operating at its maximum kW output.

A load bank test ensures that your generator will run property when it's needed so that you can fully depend on it during an emergency situation. The key to a proper load bank test is that it tests your generator at its full kilowatt (kW) output rating. Because many generators do not regularly operate at their full kW rating, it's especially important that you verify your generator can actually produce the highest possible horsepower that may be required – while at the same time maintaining adequate temperature and pressure levels that will allow it to run as long as necessary.

The recommended procedure to follow for the load bank test would be to:

- Start and run the generator until the water temperature stabilizes.
- Transfer all manual or automatic transfer switches to the emergency source.

- Step load the generator with the load bank until the desired load is reached.
- Remove the load bank load first, after the test.
- Transfer all transfer switches back to the normal position.
- Allow the generator to cool down according to manufacturers' guidelines.

It will be discussed in detail in the following section.

Care labs can help in designing the proper planned maintenance program for your standby generator system, and our team of factory trained technicians will make sure your planned maintenance will be carried out skillfully and any issues found will be brought to your attention immediately, ensuring you are prepared for the next interruption in utility power.

Load Banks:

Load Banks are electrical devices that are temporarily wired into a generators AC voltage output. Load is applied to the generator through switches that are calibrated to produce specific Kilowatt (Kw) output. This allows the operator to apply specific load steps during the testing process to match the generators rated capacity.

A load bank test ensures that your generator will run property when it's needed so that you can depend on its proper operation during an actual emergency situation. The key to a proper load bank test is that your generator operates and maintains its full kilowatt (kW) output rating. Most generators do not operate at their full kW rating during their routine exercising.

It is especially important that you verify your generator can actually produce the highest possible horsepower that may be called upon to produce. Only through this type of testing can you verify your unit's proper operation of recommended temperature and pressure levels throughout the full range of operational status.

How does a Load Bank Test Work?

When a load bank test is implemented, an artificial load is placed on the generator. The test is timed and gradually increases the kW load in specific increments. Each time the kW load is increased, the test measures and records critical engine parameters, the generator's ability to handle the boost, and its ability to continue functioning at the highest possible level for a sustained period of time. The equipment needed to complete the test includes a load bank (machine with kW rated sizes and battery like cables).

Placing a 100 percent capacity load on a generator and allowing it to run for a while not only brings to light any problems in the generator and in the engine and its cooling system; it also benefits the engine by properly seating the rings and dislodging build-up in the combustion chambers and on the valves. Diesel engines especially need a periodic load test in order to maintain performance and fuel economy.

At Care labs we dispatch a portable load bank to the site, allowing the generator to be load-tested safely in controlled conditions, at a time that suits your business. We test the generator over a range of loads, monitoring and gathering data constantly for two to four hours, depending on your requirements.

Step 1

Check all fluid levels in the generator. Make sure the fuel tank is full, the oil level is correct, and the radiator or coolant tank is full, if it is a water-cooled generator.

Step 2

Start the generator and allow it to reach normal operating temperature. Watch and listen for any potential problems or abnormal noises. If any problems are noted, do not proceed with the test until you take care of them.

Step 3

Begin connecting the loads, beginning with any large 220 volt loads and adding smaller 110 volt loads until each leg carries 50 percent of the maximum continuous rated load of the generator. Do not exceed 50 percent on any one leg. If possible, use 220 volt

resistive loads, such as large space heaters or water heaters. They simplify this step because they apply the load to each leg equally.

Step 4

Check the amperage of each leg with the ammeter, and check the voltage from each leg to neutral with the VOM set to read AC volts. For a 110/220 volt single phase generator, the voltage of each leg should fall between 105 and 125 volts, and the current should be half of the rated watt output divided by the voltage, for each leg. For example, if the voltage from each leg to neutral is 117 volts loaded, and the generator is rated at 10 kilowatts continuous, each leg should be loaded to 5000 divided by 117 or approximately 42 amperes. If one or both legs drops below 105 volts at full load, the generator has failed the test and needs repair.

Step 5

Monitor the generator while maintaining this load for the duration of the test. Watch for overheating, listen for unusual noises, and monitor the output. If a problem develops, shut the generator down

quickly to minimize damage, and repair the generator before returning it to service. How long the test should continue depends upon the type of generator. Light-duty portable generators should not be run at full load for more than three to four hours. Contractor grade generators should be able to run for eight hours. Continuous duty air or water cooled generators should run 24 hours. Larger industrial quality diesel generators should ideally be run under full load for about a week.

Step 6

Remove the loads gradually at the conclusion of the test, and allow the generator to run under light load for one hour. Remove all loads five to ten minutes before shutting the generator down.

The load test results are recorded, reviewed and reported to our customers for further action. We provide our customers with a Load Bank Report that contains thorough, comprehensive test results

Wet-Stacking

When a diesel engine powered generator is not used frequently or only run on light loads, it can be prone to experiencing unburned fuel and soot build-up in the exhaust system. This is called 'wet-stacking.' When wet-stacking occurs, the genset is likely to perform poorly, to endure damage, can become a fire hazard, and can even lead to complete failure. During a load bank test, the generator is allowed to run at full power and full temperature. This will cause any wet-stacking to burn off. Hence, a load bank test actually serves two purposes:

It tests the generator to determine whether it will function properly and efficiently on all levels; and it eliminates any wet-stacking that may have built up within the generator.

Benefits of Load Bank Testing

1. Verifies the gensets capabilities opposed to just routinely starting it up.
2. Problems discovered early can be significantly less expensive and prevents future major issues.
3. Helps to avoid wet-stacking and cleans out carbon deposits.
4. Verifies the engine cooling systems will perform while under load.
5. Provides assurance that the genset should work properly when you need it most.
6. Tests that a gen set is capable of operating at peak specified kW output for a specified amount of time.
7. Eases the effects of light loading by burning off the residue that leads to wet stacking.

Care lab's load bank testing removes the issue of unburned fuel build-up by permitting your generator's engine to reach its maximum operating temperature. As a result, your standby generator operates more efficiently, thereby guaranteeing the unit is working exactly as it was designed to do. Regardless of whether your generator's engine is

fuelled by diesel or natural gas, it can benefit remarkably from our load bank testing service.

Care lab's load testing of generator sets is a wide-ranging service that monitors every critical component of your generator, including the engine temperature as well as the oil pressure. Throughout the testing process, we wisely oversee the entire unit, ensuring that it is run at normal operating pressures and temperatures once optimal levels are achieved. As part of this service, we provide you with a broad report that includes all your generator's output readings % load, kW meter, engine speed, power factor, frequency meter, lube oil pressure, water temp, ambient room temp, oil temp, battery voltage, fuel pressure and fuel level as well as any comments and recommendations. As a plus when Care lab's operates, you will experience no disruption to your facility's operating schedule during the testing process.

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. How does a Load Bank Test Work?
2. Why is Generator Load Bank Testing Done?
3. What is Generator Load Bank Testing?
4. Write the Benefits of Load Bank Testing
5. Write the recommended procedure of load bank test

Note: **Satisfactory rating 6 points** **Unsatisfactory - below 6 points**

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1._____

_____

2._____

_____

3._____

_____

4._____

5._____

Information Sheet-3	Observing system

Introduction

Generator maintenance is the process of sustaining a generator's peak condition through regular inspections, repairs, and monitoring. They are typically performed by in-house engineers and generator dealers to ensure a unit's:

- Reliability – ensure that the battery and engine are in peak working condition at all times
- Efficiency – maintain optimum performance
- Lower operating costs – early detection of defects and damage before they worsen

Why Perform Generator Maintenance Inspections?

Establishments rely on diesel generators when unplanned power outages occur. Depending on the nature of the business, an unexpected power outage could range from a simple inconvenience (a shopping mall) to downright fatalities (intensive care units). It is important that generator maintenance inspections are regularly performed in order to avoid such problems from occurring.

Using Generator Maintenance Checklist

A generator maintenance checklist typically includes:

Physical and visual checks of the diesel generator; Leakage checks of engine, exhaust, cooling, fuel, and DC electrical systems; Oil and lubrication services; Battery testing; Overall condition assessment; and Signature, date, and time of inspection.

DIY Diesel Generator Maintenance Tips

In-house engineers and professionals may not always be available to perform generator maintenance tasks. Here are some easy diesel generator maintenance tips for non-experts:

- Run the generator every 3 to 6 months – Diesel fuel degrades if it sits idle, which is why it's ideal to run the generator for a few minutes every 3 to 6 months to

keep it from corroding. This also gives assurance that the generator is in good working condition.

- Check for signs of damage – Observe the case, fuel system, exhaust system, and engine for holes, cracks, and fuel or oil leaks. It is essential that leaks are spotted immediately before they turn into a fire hazard.
- Clean the generator regularly – Remove visible dirt, mud, dust, and other irregularities from your generator on a regular basis. This can help ensure that external elements do not affect the generator's operation.

1. Basic Diesel Generator Maintenance Checklist

A basic diesel generator maintenance checklist is used to ensure diesel generators provide good power quality. Engineers and operators can follow this template as a guide when performing the following during inspections:

- Perform physical and visual inspection of diesel generator
- Take photo evidence of leakage, damage, and defects
- Check the battery, oil, and fuel condition
- Provide overall condition assessment of diesel generator
- Conclude the inspection with a digital signature and timestamp

Visual Inspection

Overall condition/appearance of equipment (controls, leaks, loose wires)

OK	Needs Action	N/A

Fan belt tension and condition

OK	Needs Action	N/A

Fuel filter or sediment bowl

OK	Needs Action	N/A

Lubricating oil level and viscosity

OK Needs Action N/A

Coolant level and anti-freeze mixture

OK Needs Action N/A

Air filter

OK Needs Action N/A

Battery electrolyte level and specific gravity and load test

OK Needs Action N/A

Battery charging rate (trickle charger).

OK Needs Action N/A

Operating Inspection

Day tank pump and level switches if so equipped

OK Needs Action N/A

Operation of cooling thermostat or louvers

OK Needs Action N/A

Battery charging

OK Needs Action N/A

Alternator and regulator

OK Needs Action N/A

Other Services

Inspect of cooling system for leaks (pressure test), residue and operation. Check engine block heater.

OK Needs Action N/A

Inspect and clean generator brush holders and brushes

OK Needs Action N/A

Clean and inspect exciter

OK Needs Action N/A

Inspect safety shutdown devices. This includes simulated faults on low oil pressure cut-off, high water temperature cut-off, over speed cut-off and failed start.

OK Needs Action N/A

Inspect and clean engine/generator set control

OK Needs Action N/A

Run generator set (under load) to check voltage, check frequency, check instrument system and make adjustments.

OK Needs Action N/A

2. Generator Maintenance and Testing Checklist

Diesel generator maintenance and testing checklist is used to ensure that the generator is in good working condition and that power supply tests are conducted. It is used by engineers to log defects and record electricity tests. Perform the following when completing the form:

- Collect general Information provided by the manufacturer of the diesel generator
- Check the condition of equipment, engine, and control system
- Perform electrical testing

- Record findings and provide recommendations
- Affix engineer/operator digital signature to validate the test

Condition checks

Exterior of equipment

Acceptable Corrected Needs Action N/A

Completeness of assembly

Acceptable Corrected Needs Action N/A

Equipment rotation

Acceptable Corrected Needs Action N/A

Oil level

Acceptable Corrected Needs Action N/A

Vibration

Acceptable Corrected Needs Action N/A

Batteries

Acceptable Corrected Needs Action N/A

Proper system ground

Acceptable Corrected Needs Action N/A

Proper phase connections

Acceptable Corrected Needs Action

N/A

Electrical Test

Voltage Measurement

Enter text

Current Measurement

Enter text

Insulation resistance

Enter text

Completion

Other Notes and Recommendations

Engineer/Operator Signature

3. Generator Inspection Checklist

A generator inspection checklist is used to evaluate engineers/operators performance when conducting generator maintenance. This template can be used by supervisors to ensure maintenance procedures are followed. Perform these steps when completing the form:

- Check the working condition of the diesel generator before and after starting it
- Record recommendations and overall condition assessment
- Capture electronic signature of engineer/operator and countersigned by the supervisor

BEFORE STARTING

Check all fluids (fuel, oil, trans/radiator)

✔ ✖ N/A

Ensure full fuel tank with secured cap

✔ ✖ N/A

Clean fuel filter

✔ ✖ N/A

Check battery charge indicator

✔ ✖ N/A

Check battery fluid level, terminals & leads

✔ ✖ N/A

AFTER STARTING

Check all gauges if undamaged and functional

✔ ✖ N/A

Check for abnormal noises and vibrations

✔ ✖ N/A

Check for any fluid leaks

✔ ✖ N/A

Check if emergency stop switch is functional

✔ ✖ **N/A**

Secure and check compliance with cooling system

✔	✖	N/A

COMPLETION

Recommendations and Overall Condition Assessment

Engineer/Operator Full Name and Signature

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. Why Perform Generator Maintenance Inspections?
2. What is generator maintenance?
3. List down main checks and inspections before generator starting?
4. Write at list three visual Inspections.
5. List down main checks and inspections after generator starting?

Note: **Satisfactory rating 6points** **Unsatisfactory - below 6points**

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1._____

_____

2._____

_____

3._____

_____

4._____

5._____

Information Sheet-4	Taking correct action

Introduction

Troubleshooting a generator is investigating or dealing with the cause of partial or complete failure of it to do the appropriate measures to return to its design purpose in which it is designed for. It includes any breakdown that may be occurred during operation, due to long service age, due to lack of prevention and follow-ups and so on.

To do troubleshooting basically;

- There should be manual which is provided by the manufacturer and understanding of it
- Availability of testing tools & materials.
- Understanding of the operation, construction and function of unit.

Doing a troubleshooting & finding the root cause of malfunctioning takes great part of a maintenance activity and it helps/tells to decide what should be the proper maintenance activity. It starts from identifying existence of unusual operational noises or noisy

operation, investigating the root causes for partial or total failure by following provided troubleshooting techniques and by starting from the working principle.

Before breakdown occurs, the equipment/machine should be prevented & protected from the causes of failure to sustain and secure the service that is needed from it. If failure occurs maintenance activity is performed starting from simple to complex after doing troubleshooting is done.

The following tables show troubleshooting techniques of problems that will occur on generator sets.

Generator problems and remedies

No.	Failure	Possible causes	Corrective action (Remedy)
1	Engine fails to start	Faulty starter key/ Ignition switch	Check Operation of starter key/ Ignition Switch & replace as necessary.
		Loose connections	Clean and tighten connections
		Lack of diesel fuel	Add diesel fuel
		Faulty starter motor assembly	Check motor brushes and replace Check starter relay and replace Check contact points from battery and to the motor field tighten/ change cable Check starter solenoid contacts and hold-in & pull-in coils and replace Check motor armature & field windings rewind/ replace the motor

			Check springs Check pushing rod/arm & plunger
		Faulty/dead battery	Check battery status and change
2	Starter motor spins, but engine does not crank	Faulty over-running clutch	Check over-running clutch, replace starter if necessary
		Damaged or worn starter pinion gear or engine ring gear.	Check gears for damage or wear. Replace starter or ring gear
3	Starter motor does not engage / disengage properly	Damaged or worn starter pinion gear or engine ring gear	Check gears for damage or wear. Replace starter or ring gear
		Faulty starter solenoid,	Test starter & replace if necessary
4	Starter motor does not stop running	Key switch, start switch or starter relay contacts keep closing or stick.	Replace faulty component
		Over-running clutch sticks to shaft	Replace starter
5	Engine Stops After it starts	Oil problem	Check Oil Level/quality and fill/ change
		Run out of fuel	Top up/fill the fuel
		Obstruction in fuel pipe or air filter	Check or clean.
		Air exists in fuel system	Emit the air.

		Sudden increase of load	Lighten the load.
		Coolant problem	Check coolant level. (Be sure to allow the generator set to cool first as hot water/steam can be present when you remove the radiator cap).
		Engine over speed	Check if the speed governing system is flexible and verify the actual engine speed
6	Engine's exhaust is white smoke	Water mixed in diesel fuel	Clean the fuel tank and filter and change the diesel fuel.
7	Engine's exhaust is dark black smoke	Overload	Lighten the load; change the matched machine if it does not comply with the requirements.

8	generator is not generating electricity	Voltmeter connected incorrectly, or faulty multimeter	Check and verify voltage at Generator terminals with a multimeter
		Circuit breaker failure	Check and replace
		Main rectifier failure	Check and replace
		Loss of residual magnetism Residual magnetism is stored in the laminated steel core of the Exciter Stator, and is used on run up to energize self excited AVR systems.	'Flashing' the Exciter Stator:- With Generator running at rated speed, without load,
		Loose broken or corroded connections.	Check all auxiliary terminals. Check the AVR push on terminals for tightness. Repair or renew where necessary
		Faulty/wear out of brushes and/or slip rings (if the generator has brushes and slip rings)	Check and replace
		Fault in AVR	Check and replace
		Stator and/ rotor windings failure	Check winding resistances and rewind/replace

9	generator is generating low voltage	Voltmeter faulty or sticking.	Check and verify voltage across output terminals, with a Multimeter.
		Low engine speed	Increase the engine speed
		The sample voltage has short circuit.	Check inputs of AVR (Adjust the resistance of AVR if available). If the voltage remains, change the stator of the alternator.
		Faulty AVR	Check and replace AVR
10	generator is generating high voltage	Voltmeter faulty or sticking.	Check and verify voltage across output terminals, with a Multimeter.
		Faulty AVR	Check and replace AVR
11	Charge Indicator lamp does not light with key switch ON	Blown fuse	Check charge, Ignition and Engine fuses, replace as needed.
		Indicator lamp burned out	Replace lamp
		Wiring connections loose	Tighten loose connections
		Defective relay	Check relays, if used, for continuity and proper operation
		Defective regulator	Replace regulator or alternator (charging

			generator)
12	Batteries not charging	Insufficient belt tension	Tighten or replace
		Defective battery(s) or battery connections	Check battery and battery terminal connections
		Blown fuse or fusible link	Check fuse and fusible link, replace as needed
		Defective wiring	Check voltage drop
		Faulty alternator	Replace alternator
		Excessive electrical load	Reduce load by turning off all unnecessary accessories
13	Constantly overcharging (battery electrolyte is depleted in a short time)	Battery	Faulty battery; replace
		Poor contact at voltage detection point of alternator	Clean contact area
		Faulty voltage regulator	Replace regulator or alternator (charging generator)
14	Abnormal Noise – in alternator (charging generator) operation	Insufficient belt tension	Tighten or replace
		Faulty bearing	Replace alternator (charging generator)

Self-Check -4	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 3pts

1. If generator is generating low voltage, what should you check and correct?
2. If engine fails to start, what should you check and correct?

3. If Abnormal Noise – in alternator (charging generator) operation, what should you check and correct?

4. Batteries not charging, what should you check and correct?

Note: **Satisfactory rating 6 points** **Unsatisfactory - below 6points**

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1._____

_____

2._____

_____

3._____

_____

4._____

Information Sheet-5	**Returning generator**

INTODUCTION

When utility power is interrupted, the automatic transfer switch immediately senses the problem and signals the generator to start. Once the generator is running at proper speed, the automatic transfer switch safely shuts off the utility line and simultaneously opens the generator power line from the generator

HOW AN AUTOMATIC GENERATOR AND TRANSFER SWITCH SYSTEM WORKS

- The completely automatic transfer switch monitors incoming voltage from the utility line, around the clock.
- When utility power is interrupted, the automatic transfer switch immediately senses the problem and signals the generator to start.
- Once the generator is running at proper speed, the automatic transfer switch safely shuts off the utility line and simultaneously opens the generator power line from the generator.
- Within seconds, your generator system begins supplying electricity to the critical emergency circuits of your home or business. The transfer switch continues to monitor the utility line conditions.
- When the automatic transfer switch senses the utility line voltage has returned at a steady state, it re-transfers the electrical load back to the utility line and resumes monitoring for subsequent utility loss. The generator will continue to run for an engine cool-down period of several minutes while the entire system stands ready for the next power outage.

Self-Check -5	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What do you do when your generator comes back on power? 3(points)
2. How automatic generator and transfer switch system work? 3(points)

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

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1._____

_____

2._____

_____

Instruction Sheet 4	Learning Guide 40: Analyze generator faults

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

- Identifying cause of abnormal generator operating conditions
- Determining actions necessary to rectify fault
- Maintaining generator failure and personnel safety

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 –

- Cause of abnormal generator operating conditions are identified by analysing the technical and operational information in a logical and sequential manner
- Actions necessary to rectify fault are correctly determined
- Generator failure and personnel safety are maintained through consultation with appropriate personnel, and reference to technical and operational documentation

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- 3”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2,3, and in each information sheets on pages 111,118,and 125.
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 126,127 and 129.and do the LAP Test on page 130”. 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 cause of abnormal generator operating conditions**

INTRODUCTION

Generator faults can be considered under the following heads:

1. Stator Winding Faults
2. Field Winding or Rotor Circuit Faults
3. Abnormal operating Conditions.

1. Stator Winding Faults:

Such faults occur mainly due to the insulation failure of the stator coils.

The main types of stator winding faults are

(i) Phase-to-earth faults

(ii) Phase-to-phase faults and

(iii) Inter-turn faults involving turns of the same phase winding.

The stator winding faults are the most dangerous and are likely to cause considerable damage to the expensive machinery. So, automatic protection is absolutely necessary to clear such faults in the shortest possible time in order to minimize the extent of damage.

Phase-to-phase faults and phase inter-turn faults are less common, these usually develop into an earth fault. Inter-turn faults are more difficult to be detected.

The effect of earth fault in the stator is two-fold:

(i) Arcing to core, which welds laminations together, causing eddy current hot spots on subsequent use. Repairs to this condition involve expenditure of considerable money and time.

(ii) Severe heating in the conductors damaging them and the insulation with possible fire breaks.

2. Field Winding or Rotor Circuit Faults:

Faults in the rotor circuit may be either earth faults (conductor-to-earth faults) or inter-turn faults, which are caused by severe mechanical and thermal stresses.

The field system is normally not grounded (i.e., remains isolated from the earth) and, therefore, a single fault between field winding and rotor body due to insulation breakdown does not give rise to any fault current. However, a second earth fault will short circuit some part of the rotor winding and may thereby develop an unsymmetrical field system, giving unbalanced force on the rotor. This can cause severe vibration of the rotor with possible damage to the bearings. Thus a single earth fault can be tolerated for a while but it should not be allowed to continue. Rotor earth fault protection is provided in case of large generators.

Owing to a fault, there may be an unbalance in the three-phase stator currents. According to the theory of symmetrical components, unbalance three-phase currents have a negative sequence component, which rotates at synchronous speed in a direction opposite to the direction of rotation of rotor. So, double frequency currents are induced in the rotor.

This causes overheating of rotor and possible damage to the rotor. Unbalanced currents may also cause severe vibration, but the overheating problem is more acute. Rotor temperature indicators are used with large generators for detecting rotor overheating due to unbalanced loading of generator.

Rotor open-circuit faults, though rare, can cause arcing and thus result on serious conditions.

Reduced excitation may occur due to open circuit or short circuit in the field or exciter circuits or a fault in automatic voltage regulator. When a generator loses its field excitation it speeds up slightly and continues to run as an induction generator deriving excitation from the system and supplying power at a leading power factor.

A fall in voltage will also occur due to loss to excitation which may result in loss of synchronism and system stability. There is also the possibility of overheating of the rotor due to induced currents in the rotor and damper windings. This can be avoided by using a tripping scheme which is so arranged that opening of field circuit breaker causes the tripping of generator unit breaker.

3. Abnormal Operating Conditions:

The abnormal operating conditions that are likely to occur in a generator are:

(i) Failure of prime mover (turbine) resulting in operation of the generator as a synchronous motor.
(ii) Failure of field
(iii) Unbalanced loading and subsequent heating of generator
(iv) Over-speed
(v) Over loading
(vi) Over-voltage at generator terminals
(vii) Current leakage in the body of the generator.

Self-Check -1	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 3pts

1. List the three faults of generator (3points)
2. Write the main types of stator winding faults (3points)

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

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1._____

_____

2._____

_____

3._____

_____

Information Sheet-2	Determining actions necessary to rectify fault

Introduction

Typical generator fault finding procedure

Listed below are typical faults which may occur together with the action required to remedy the fault.

- **ENGINE**

Fault	Possible cause
-Engine will not turn Electrical	a) Battery discharged. Loose or incorrect cable connections.
	fault in starting circuit.
	b) Faulty starter motor.
Action	c) Starter pinion will not engage on flywheel starter ring

a) Check voltage.

- Voltage at battery terminals. If no voltage change or put on charge.

- Voltage at starter motor terminals.

b) If voltage present:

- Check all connections.

- Change starter motor.

c) Turn engine by the tools provided and repeat attempt to start. Replace starter motor if fault remains.

Fault	Possible cause
-Engine will not fire	a) No fuel reaching injectors. Fuel supply line blocked.
	b) Air lock in fuel line.
	c) Fuel filters choked.
	d) Water in fuel.
Action	e) Air cleaners choked.

a) Operate excess fuel device.

b) Check that fuel tap is 'on' and adequate amount/head of fuel is in tank.

c) Bleed fuel system.

d) Change filter elements on engine. Drain contaminated fuel. Empty fuel filter bowls and change elements.

e) Clean air cleaners.

Fault	Possible cause
-Engine fires but fails to pick up speed	a) Fuel supply system faulty.
	b) Air cleaner choked.
	c) Faulty lift pump.
Action	d) Faulty air injectors.

a) Check all pipe joints. Bleed fuel system.

b) Clean air cleaners.

c) Change lift pump.

d) Change injector(s).

Fault	Possible cause
-Engine misfires	a) Air lock in fuel line.
	b) Fractured injector feed pipe. Faulty injector.
	c) Faulty injection pump.
Action	d) Tappet clearances incorrect.

a) Bleed fuel system. Replace pipe.

b) Loosen feed pipe to each injector in turn and note any change in engine response.

c) Change injection pump.

d) Check and readjust tappet clearance accordingly

Fault	Possible cause
-Low power output	a) Inadequate fuel pressure.
	b) Air filters choked.
	c) Fuel injection pump timing incorrect.
Action	d) Faulty injection.

a) Check over complete fuel supply system as previously laid down.

b) Clean air filters.

c) Reset timing.

d) Change injector(s).

Fault	Possible cause
-Low oil pressure (Sudden pressure drop as opposed to	

progressive drop due to worn bearings)

a) Oil level too low.

b) Oil pressure gauge faulty.

c) Oil filters choked.

d) Relief valve faulty.

Action

a) Check for leaks and fill to level indicated on dipstick.

b) Fit an identical replacement gauge.

c) Change filter elements.

d) Examine and clean pressure relief valve.

Fault	Possible cause
Overheating	a) High oil temperature.
	b) No coolant in engine.
	c) Coolant system polluted.
	d) Blocked air passages in radiator matrix.
	e) Fan belt tension incorrect.
	f) Thermostat fault.
Action	g) Fuel injection pump timing out.

a) Check out as detailed in 'overheating' below.

b) Check for leaks and refill (ensure correct percentage of anti-freeze is also added if necessary).

c) Drain, flush out and refill.

d) Carefully clean all air passages.

e) Adjust tension.

f) Fit an identical replacement thermostat.

g) Reset timing.

- **CONTROL EQUIPMENT**

The faults liable to occur in this equipment will depend upon the design of the control scheme supplied. It is only possible to give general recommendations regarding fault findings on this equipment.

Fault	Possible cause
-Circuit fuses blowing	a) incorrect rating of fuse used.
	b) Short circuit between panel wires and/or between wires and frame.

Action

a) Check circuit rating and fit new fuse of the recommended rating.

b) From circuit diagram check wiring of components. Rewire or replace components found faulty

Fault	Possible cause
-Circuit operating satisfactorily Only intermittently	- Faulty or out of adjustment relay or auxiliary contacts.

Action

Replace and/or readjust auxiliary and clean where necessary.

❖ **ALTERNATOR**

In all instances it is recommended that for specific fault finding instructions the manufacturers

handbook be referred to as designs vary in detail from manufacturer to manufacturer. The details

given below are for general guidance only.

Fault	Possible cause
-No output voltage	a) Engine speed too low.
	b) Loose terminals.
	c) No excitation and/or loss of residual magnetism.
Action	d) Open circuit in windings.

a) Check and set up correctly.

b) Check over and tighten all terminals.

c) Re-excite by flashing in accordance with manufacturers handbook.

Fault	Possible cause
-Output voltage unstable	-Incorrect setting of gain control.

Action

-Adjust slowly until a stable voltage is obtained.

Fault	Possible cause
-Output voltage incorrect	-Voltage set up incorrectly on band trimmer or choke tappings.

Action

-Adjust accordingly.

Fault	Possible cause
-Output voltage too high and cannot be reduced on controls	- Automatic voltage regulator faulty.

Action

-Remove AVR and make recommended tests.

-Replace if found necessary.

Self-Check -2	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 3pts

1. Write typical generator fault finding procedure

   A. Engine

   B. Control equipment

   C. Alternator

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

Score = _____
Rating: _____

Name: _____ Date: _____

Answer sheet

1._____

_____

2._____

_____

3._____

_____

4._____

5._____

Information Sheet-3	**Maintaining generator failure and personnel safety**

INTRODUCTION

Maintenance– an activity carried out on an equipment or physical plant in order to ensure that an equipment or physical plant continues to perform its intended functions, or to repair the equipment. Maintenance and repair should be made by the authorized staffs. Note that modifications are not maintenance, even though they may be carried out by maintenance personnel.

Types of Maintenance

Maintenance may be classified into three categories:

1. Corrective or Breakdown maintenance – implies that repairs are made after the equipment is failed and cannot perform its normal function any more.
2. Predictive (Condition-based) maintenance – In predictive maintenance, machinery conditions are periodically monitored and this enables the maintenance crews to take timely actions, such as machine adjustment, repair or overhaul. It makes use of human sense and other sensitive instruments, such as audio gauge, vibration, pressure, temperature and resistance strain gauges etc.
3. Preventive maintenance – provides periodic/scheduled inspections, lubrication, repair and overhaul of equipment's to reduce the danger of unexpected failures

   Advantage of Preventive maintenance

   - Reduces failures and thereby down time
   - Greater safety of workers
   - Lower maintenance and repair costs
   - Better product quality
   - Increases machines life.
   - It used to maximize the productivity of the equipment

Purpose of Maintenance

- to maximize performance of production equipment efficiently and regularly
- to prevent breakdown or failures
- to minimize production loss from failures
- to increase reliability of the operating system

Proper diesel generator maintenance is key to ensuring that your equipment keeps running for years to come and these 8 key points are essential.

1. Diesel Generator Routine General Inspection

During the running of the diesel generator, the exhaust system, fuel system, DC electrical system and engine require close monitoring for any leaks that can cause hazardous occurrences. As with any internal combustion engine, proper maintenance is essential. According to Georgia Scott of Constant Power Solutions one of the leading Generator and Power Equipment Manufacturers in the UK, standard servicing and oil change times are recommended at 500hrs, however some applications may require shorter servicing times which is why after sales services should be top notch.

2. Lubrication Service

The engine oil must be checked while shutting down the generator at regular intervals using a dipstick. Allow the oil in the upper portions of the engine to drain back into the crankcase and follow the engine manufacturer's recommendations for API oil classification and oil viscosity. Keep the oil level as near as possible to the full mark on the dipstick by adding the same quality and brand of oil.

The oil and filter must also be changed at acclaimed time intervals. Check with the engine manufacturer for procedures for draining the oil and replacing the oil filter and their disposal is to be done appropriately to avoid environmental damage or liability.

Nevertheless, it pays to use the most dependable, highest quality oils, lubricants and coolants to keep your engine working. Therefore, according to Jim Girard of Lubriplate from Newark NJ, in the US, it is highly advisable to purchase lubricants that comply with the Original Equipment Manufacturer's (OEM) generic lubricant specifications.

3. Cooling System

Check the coolant level during shutdown periods at the specified interval. Remove the radiator cap after allowing the engine to cool, and, if necessary, add coolant until the level is about 3/4 in. Heavy-duty diesel engines require a balanced coolant mixture of water, antifreeze, and coolant additives. Inspect the exterior of the radiator for obstructions, and remove all dirt or foreign material with a soft brush or cloth with

caution to avoid damaging the fins. If available, use low-pressure compressed air or a stream of water in the opposite direction of normal air flow to clean the radiator.

4. Fuel System

Diesel is subject to contamination and corrosion within a period of one year, and therefore regular generator set exercise is highly recommended to use up stored fuel before it degrades. The fuel filters should be drained at the designated intervals due to the water vapor that accumulates and condenses in the fuel tank.

Regular testing and fuel polishing may be required if the fuel is not used and replaced in three to six months. Preventive maintenance should include a regular general inspection that includes checking the coolant level, oil level, fuel system, and starting system. The charge-air cooler piping and hoses should be inspected regularly for leaks, holes, cracks,dirt and debris that may be blocking the fins or loose connections.

According to Marketing Department of the Italy-based Visa SpA one of the world's leading gensets suppliers, dedicated to design, production, sales and rental of generating sets; some engines used in Stand-by generating set applications have had a few issues concerning diesel fuel.

"While the engine maintains its mechanical properties, it can give rise to problems related to the quality of diesel fuel. The chemical make-up of diesel fuel has changed in recent years; a certain percentage of biodiesel at low or high temperatures releases impurities, while a certain percentage of biodiesel at warm temperatures mixed with water (condensation) can be the cradle of bacterial proliferation. Besides, the reduction of Sulphur reduces lubrication, which eventually blocks the fuel-injection pumps."

“Moreover, by purchasing a genset, it is important to know that a wide range of optional accessories are available that allow to extend maintenance intervals and ensure providing quality power throughout the genset’s life. In the mobile range for example, Visa SpA offers fuel water separator filters, giving the customers the reassurance required when engine failure is not an option, or the fuel tank inspection points.”

Ms. Clarizza Cortez of Adpower one of the leading providers of Diesel and Gas Generators in the Middle East and North Africa also mentions that, since the fuel quality is bad in most countries, they install Water Separator Fuel Filters and additional filtration system to protect the sensitive fuel injection system; and advise the customers to replace the elements on time to avoid such breakdowns.

5. Testing Batteries

Weak or undercharged starting batteries are a common cause of standby power system failures. The battery must be kept fully charged and well-maintained to avoid dwindling by regular testing and inspection to know the current status of the battery and avoid any start-up hitches of the generator. They must also be cleaned; and the specific gravity and electrolyte levels of the battery checked frequently.

• Testing batteries: Merely checking the output voltage of the batteries is not indicative of their ability to deliver adequate starting power. As batteries age, their internal resistance to current flow goes up, and the only accurate measure of terminal voltage must be done under load. On some generators, this indicative test is performed

automatically each time the generator is started. On other generator sets, use a manual battery load tester to attest the condition of each starting battery.

• Cleaning batteries: Keep the batteries clean by wiping them with a damp cloth whenever dirt appears excessive. If corrosion is present around the terminals, remove the battery cables and wash the terminals with a solution of baking soda and water (¼ lb baking soda to 1 quart of water). Be careful to prevent the solution from entering the battery cells, and flush the batteries with clean water when finished. After replacing the connections, coat the terminals with a light application of petroleum jelly.

• Checking specific gravity: In open-cell lead-acid batteries, use a battery hydrometer to check the specific gravity of the electrolyte in each battery cell. A fully charged battery will have a specific gravity of 1.260. Charge the battery if the specific gravity reading is below 1.215.

• Checking electrolyte level: In open-cell lead-acid batteries, verify the level of the electrolyte at least every 200 hr of operation. If low, fill the battery cells to the bottom of the filler neck with distilled water.

6. Routine Engine Exercise

Regular exercising keeps the engine parts lubricated and thwart oxidation of electrical contacts, uses up fuel before it deteriorates, and helps to provide reliable engine starting. Engine exercise is recommended to be executed at least once a month for a minimum of 30 min. loaded to no less than one-third of the nameplate rating.

Most importantly, when it comes to engine maintenance, according to Peter Whitfield of YorPower a leading independent UK diesel generator manufacturer, it is recommended to do inspections regularly because preventative maintenance is better than reactive maintenance. Nevertheless it is of utmost importance to follow the designated service procedure and intervals

7. Keep your Diesel Generator Clean

Oil drips and other issues are easy to spot and take care of when the engine is nice and clean. Visual inspection can guarantee that hoses and belts are in good condition. Frequent checks can keep wasps and other nuisances from nesting in your equipment. The more a generator is used and relied on, the more it needs to be taken care of. However, a generator set that is rarely used might not need a lot of care.

8. Exhaust system inspection

In case there are leaks along the exhaust line which usually occurs at the connection points, the welds and the gaskets; they should be repaired immediately by a qualified technician.

Nevertheless according to Ms. Arlene of Maverick Generators in South Africa, always make sure your units are serviced. Especially 24 hrs before using your generators. “For standby generators for example you need to have your units serviced 150hrs on average. However if the generator is used constantly the hours go up much quicker and in more regular intervals,” she adds.

Furthermore, according to Ryan Mason of Lister Petter a manufacturer of internal combustion engines from the UK, it is quite advantageous when you have maintenance kits for different service intervals

Safety of Personnel

Abnormal operating conditions do not usually involve hazards to plant Personnel unless inspection or maintenance work is performed on operating equipment.

The Operator must always be informed when such work is being done. If an abnormal or emergency condition develops while performing work on the equipment, the Operator must be sure that all personnel are in the clear before taking any action toward restoring the equipment to normal. If correction of the abnormal condition requires work performed by maintenance personnel, the Operator must be sure that the equipment is safe to work on and any necessary clearance issued before beginning. Where abnormal operating conditions involve hazards to personnel, their safety must receive top priority in any remedial action taken by the Operator

Self-Check -3	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 3pts

1. List down types of maintenance and their function
2. Why only authorized personnel should be allowed to do repair or maintenance work?
3. List down the Purpose of Maintenance
4. Write at list three Advantage of Preventive maintenance

Note: **Satisfactory rating 6 points** **Unsatisfactory - below 6 points**

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1._____

_____

2._____

_____

3._____

_____

4._____

5._____

Operation Sheet – 1	**generator maintenance failure**

Problem 1– engine fails to start

Possible causes include - loose connections, Faulty starter key/ Ignition switch, lack of diesel fuel, faulty starter motor assembly and /or flywheel gear, faulty/dead battery.

A. loose connections

- Use a multimeter to test the continuity and your hand to check tightness of lines from the key to the starter relay and then to a starter motor.
- Make tighten loose connections and replace damaged cables.

B. <u>faulty starter key/ ignition switch</u>

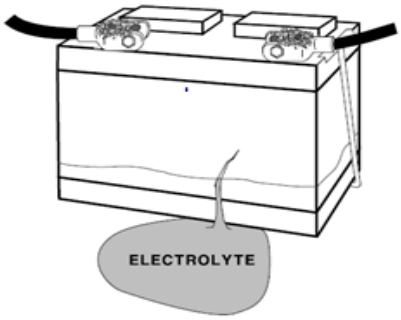
- check that the key is its own key and replace.

C. <u>lack of diesel fuel</u>

- Check and fill the fuel

D. <u>faulty/dead battery</u>

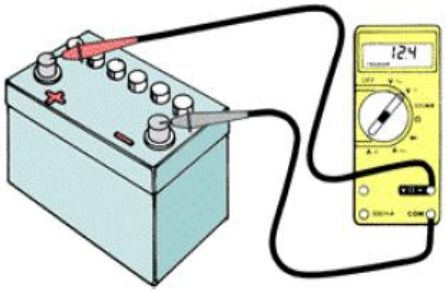
- Visual checks for rusted connections clean & tighten connections and check for the cracked container, if there since it will cause leakage of electrolyte it has to be replaced.



- Check specific gravity of battery electrolyte with a hydrometer

State of Charge Level	Specific Gravity
100%	1.265 or Greater
75%	1.225 - 1.230
50%	1.185 - 1.190
25%	1.140 - 1.175
Discharged	1.125 or Less

- Check open circuit voltage



% of charge

12.6v = 100%

12.4v = 75%

12.2v = 50%

12.0v = 25%

11.9v = 0%

E. faulty starter motor assembly and /or flywheel gear

- controlling and starting circuits testing
- Field coils: Check for opens and shorts
- Armature windings: Check for opens and shorts, there should no continuity between field coil with motor shaft as well as between armature coil with motor shaft
- Armature commutator: check for carbon deposits, Check for shorts & insulation depth from brushes and bar appearance. If necessary, clean up with crocus cloth or fine sand paper.
- testing solenoid terminals, field coil terminals
- Armature condition: Check for shaft straightness and bearing mount surface.
- Solenoid: Check for opens and shorts, energize, and check that it pulls in plunger.
- Drive shift mechanism: Check for positive movement both ways.
- Brushes: measure length.
- Brush holder: Check for brush to base ground, no continuity between positive and negative terminal base.
- Brush springs: Check tension.
- Pinion gear, ring gear

Problem 2 – A generator is not delivering electricity /No output.

Possible causes include - Voltmeter connected incorrectly or faulty multimeter, loose broken or corroded connections, circuit breaker failure, main rectifier failure, faulty/wear out of brushes and/or slip rings (if

the generator has brushes and slip rings), fault in AVR, loss of residual magnetism, stator and/ rotor windings failure.

A. Voltmeter connected incorrectly or faulty multimeter

- Ensure the correct connection of the voltmeter, calibrate the multimeter and measure other parameters, if there is still incorrect reading, change/ replace the multimeter.

B. loose broken or corroded connections

- Use a multimeter to test the continuity and your hand to check tightness of lines coming out from the armature windings, output from the main circuit breaker, inputs and outputs from the AVR.
- Make tighten loose connections and replace damaged cables.

C. Circuit breaker failure

- Check if the handle is positioned at a middle position and reset to its normal position.
- Check the functionality of the breaker

D. main rectifier failure

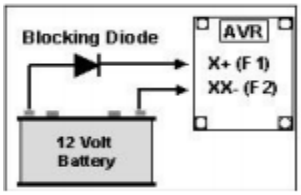
- Check lost connections and tighten if there.
- Check the forward and backward current flow of rectifier diodes and for the normal working the reading should tell that the diode passes the current only in the forward direction.

E. fault in AVR

- Check lost connections and tighten if there.
- Check and compare values of the inputs and outputs of the AVR from the manufacturer's manual by using a multimeter and replace the AVR if there are variations.

F. loss of residual magnetism/ excitation problem

- Temporarily connect a 12 volt D.C. battery supply, (with a blocking diode in one lead), to AVR terminals X+ (F1) and XX- (F2). Maximum connection time 1 second.



NOTE: Loss of residual magnetism can occur after:-

(i) Many years storage without use.
(ii) Reversal of the Exciter Stator magnetic field while 'flashing' with a battery.
(iii) Rewind of the Exciter Stator.
(iv)Mechanical 'shock' to the Exciter Stator laminated core, (where magnetism is stored).

CAUTION! Never connect a battery to the AVR terminals, without a blocking diode. In most cases this will destroy the AVR power devices. Battery polarity MUST be correct!

G. stator and/ rotor windings failure

- measure the insulation resistances of rotor and field windings by an insulation tester/ megger by setting measure range from lower and increasing the range. insulation resistance is more than 1MΩ if there is no damage on insulation.

Connect clip to body ground Connect plug to output terminal Push measure button, and measure

H. <u>faulty/wear out of brushes and/or slip rings (if the generator has brushes and slip rings)</u>

- Inspect brushes for wear out and replace with similar new brush
- Inspect slip rings for the lost connections and wear due to sparks

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Total time allowed to perform the following task: 1 hr for each trainee

Instructions:

2. You are required to perform the following tasks:

- Prepare the necessary tools and safety clothes
- Troubleshoot the generator for a problem “A generator is not giving electrical output” by following the necessary steps and within the specified enterprise standard procedures.
- Provide the maintenance/solution for the identified possible cause.
- Post-check the generator operation.

2. Request your trainer for evaluation and feedback.

Instruction Sheet 5	Learning Guide 41: Complete documentation

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

- Updating documentation and reporting generator problems, movements, abnormalities and status

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 –

- Update documentation and reporting generator problems, movements, abnormalities and status

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”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,information sheets on pages 136.
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, on pages _and do the LAP Test on page _”. 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	Updating documentation and reporting generator problems, movements, abnormalities and status

Introduction

Reporting is an indispensable part of all management functions and provides the key input to performance evaluation.

Technical personnel of the generator operating shall understand the value of the records and keep the forms in their routine operation activity and make the reporting process realized. Such record reports allow management to measure performance and compare actual performance with standards and targets. The results may indicate that corrective action is required to obtain conformity with the plan

Reporting defects

A generator operator should report defects immediately:

If a defect is considered to be a hazard to safety, generator operations should be stopped until the defect is repaired.

The details of reported defects and subsequent action taken should be entered into a log book

Log books and inspection record sheets

Instruction, maintenance and repair manuals should be kept in a safe place at the registered premises, and should include a parts catalogue.

The operator should be familiar with the contents of the instruction manual which should be available at the site of operation.

All log books and inspection record sheets must show complete details of all inspections, tests, repairs, replacements and modifications carried out on equipment,

and be available for inspection by the principal contractor or person in control of the workplace.

Evidence that the generator and other equipment has been inspected and certified to be 'suitable for continued service' (i.e. in a safe working condition), should be made available to the principal contractor or person in control of the workplace for inspection (on request), before the unit is allowed to operate on site.

Record keeping routine operations/maintenance procedures

This section provides a description of the routine operation and maintenance (O&M) procedures designed to maximize operating techniques and preventative maintenance to ensure proper operation of the system.

Daily Operations:

List and describe the daily tasks performed with the frequency and who is responsible for performing that task

Example: check gauges, fuel, oil, visual inspection of generator

Routine Operations:

List and describe the tasks performed other than daily (weekly, monthly, annually, as needed) with the frequency and who is responsible for performing that task

Routine record keeping is accomplished by utilizing the following reports:

- Monthly Operating Report
- Daily Start-up Checklist
- Weekly/Monthly Inspection Report
- Maintenance Activity Report
- Incident/Follow-up Action Report

The Monthly Operating Report is used to maintain daily records of operate generator and routine test results. This report is submitted monthly following the month for which the records contained in the report are compiled,

The Weekly/Monthly Inspection Report can be used to document weekly and/or monthly inspections of mechanical equipment and appurtenances. Weekly/monthly inspections will ensure that the system is operating properly and in compliance with all applicable rules, regulations, and permit conditions. This report is not required to be submitted to the Bureau but should be kept on-site for review upon request.

The Maintenance Activity Report can be used to document preventative maintenance and testing activities, based on the manufacturer's recommendations and specifications for equipment. This report is not required to be submitted to the Bureau but should be kept on-site for review upon request.

The Incident/Follow-up Action Report can be used to record follow-up measures taken to correct any deficiencies noted during daily, weekly or monthly inspections. This report is not required to be submitted to the Bureau but should be kept on-site for review upon request.

Example Daily Start-up Checklist

Inspected by: _____ Date: _____

- performed mechanical inspection of motors
- performed electrical inspection of wires, fuses
- Well generator operational
- performed physical inspection of generator, tubing, injection assembly
- other (describe)

Weekly / Monthly Inspection Report

Inspection of:

	Observations/Initials	**Date / Time**

Maintenance Activity Report

Activity Performed: **Location**

Initials / Date

Incident/Follow-up Action Report

This report documents all breaks, breakdowns, problems, bypasses, generator failures, occurrences, emergencies, complaints and/or intervening factors that result in or necessitate deviation from routine O&M procedures, and any situations that have the potential to affect public health, safety, welfare, or the environment or have the potential to violate any permits, regulations or laws relating to the electrical system. In addition, this report records the remedial or follow-up action taken to correct the circumstance.

Follow Up Action

and/or Incident complaint Corrective Action Taken Initials Date/Time

Self-Check -1	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. Discuss how to report defects occur generator operation. (5 points)
2. What kinds of reports are included routine record keeping (5 points)?

Note: **Satisfactory rating 6 points** **Unsatisfactory - below 6 points**

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1._____

_____

2._____

_____

Reference Materials

- Generator set operator & maintenance instruction manual, FG WILSON 356-5901(GB) V9 06/ 14
- Unified Facilities Criteria (UFC), Operation and maintenance of Generators, Department of Defense USA.
- https://www.dieselserviceandsupply.com/pdf/Operations-Manual-Operating-Procedures-Emergency-Diesel-Generator.pdf
- Bruce G. Miller, in Clean Coal Engineering Technology (Second Edition), 2017
- Amorim, L., Cai J. (2015). Modeling recurrent events: Alion Science and Technology.
- CMMS selection and standby diesel generator maintenance study