RQF LEVEL FIVE

TRADE: HYDROPOWER ENERGY

MODULE CODE: HPOGM401

TEACHER'S GUIDE

Module name: ELECTRICAL GENERATOR MAINTENANCE

Table of Contents

Acronyms

AC: Alternating Current

DC: Direct current

EMF: electromotive force

R: Resistance

I: Current

V: Voltage

W: Watt

KWh: Kilo Watt-hour

Hz: Hertz

KVAR: Kilo Volt-Ampere Reactive

KVA: Kilo Volt-Ampere

PPE: Personal protective equipment

LORA: Level of repair analysis

IC: Indicative content

API: Application programming Interface

%: percentage

K: Kilo

p.d: potential difference

Hrs: hours

RRA: Rotating Rectifier Assembly

AVR: Automatic Voltage Control system

RQF: Rwanda Qualification Framework

Introduction

An electric generator is a device which is used to produce electric energy, which can be stored in batteries or can be directly supplied to the homes, shops, offices, etc. Electric generators work on the principle of electromagnetic induction. A conductor coil (a copper coil tightly wound onto a metal core) is rotated rapidly between the poles of a horseshoe type magnet. The conductor coil along with its core is known as an armature. The armature is connected to a shaft of a mechanical energy source such as a motor and rotated. The mechanical energy required can be provided by engines operating on fuels such as diesel, petrol, natural gas, etc. or via renewable energy sources such as a wind turbine, water turbine, solar-powered turbine, etc. When the coil rotates, it cuts the magnetic field which lies between the two poles of the magnet. The magnetic field will interfere with the electrons in the conductor to induce a flow of electric current inside it.

This module describes the skills, knowledge and attitude required to maintain an electrical generator. The learner will be able to select and arrange different materials, equipment and tools used when maintaining an electrical generator. He/she will be able to plan and execute maintenance of different types of DC and AC generator. He/she will also be able to detect faults and faulty parts of generators and then, perform their repair.

Module Code and Title :(HPOGM401) ELECTRICAL GENERATOR MAINTENANCE

Learning Units:

1. Prepare preliminary activities
2. Execute preventive maintenance
3. Repair electrical generators
4. Clean the workplace

Learning Unit 1: Prepare preliminary activities

STRUCTURE OF LEARNING UNIT

Learning outcomes:
1.1 Plan preventive maintenance of electrical generators
1.2 Interpret electrical drawings
1.3 Prepare tools, equipment and materials
1.4 Identify PPE

Learning outcome 1.1 Plan preventive maintenance of electrical generators

Duration: 2 hrs
Learning outcome 1.1 objectives: By the end of the learning outcome, the trainees will be able to: 1. identify properly generator nameplate elements

2.Interpret correctly the generators nameplate indication

3.Read properly manuals specifications

4.Recommend effectively Practice for Maintaining AC/DC Generator Sets

5.Elaborate convenient maintenance schedule/plan


Resources

Equipment	Tools	Materials
✓ Generator ✓ PPE	✓ Screwdriver set ✓ Plier set ✓ Generators tool set	✓ Name plates ✓ Manual Books ✓ internet


Advance preparation:

- Recall on generator nameplate elements
- Interpretation of the generators nameplate indication
- Reading of manuals specifications
- Recommended Practice for Maintaining AC/DC Generator Sets
- Elaboration of convenient maintenance schedule/plan

- **Recall on generator nameplate elements**

✓ kW ratings: kw is the amount of actual power an electrical system has. This shows you how much power is being converted into useful, working output.

✓ kVA ratings: kVA is the measure of apparent power

✓ Power factor: Generator power factor, or generator power rating, measures how efficiently a machine uses its energy. Typically expressed as a decimal or percentage, this value indicates the total current your generator can use to perform a certain job.

✓ Operating voltage : The range of rated voltages is approximately as follows: small generators, 4000–14,000 V; medium generators, 12,000–20,000 V; and large generators, 14,000–28,000 V

✓ Number of phases: generator can have two different types based on the number of phase. Single-phase generators produce and rely upon one AC flow with one up-and-down cycle, while 3-phase produce and cycle three simultaneously

- ✓ Current ratings: the value of a current used for specification purposes, established for a specified set of operating conditions of a generator
- ✓ Number of cycles : the US generators maintain a frequency of 60 cycles per second. However, European ones maintain a frequency of 50.
- ✓ Excitation voltage and current: refers to the DC supply given to the rotor to produce the required magnetic flux
- ✓ Operating temperature : the allowable temperature range of the local ambient environment at which a generator operates

- **interpretation of the generators nameplate indication**

Alternator means alternating generator; Which converts mechanical energy into electrical energy. Core of the power plant is alternator and turbine. In this, we are going to see, how to read alternator nameplate details easily

Common Nameplate Information, Abbreviations, and Units

Description	Abbreviation	Common Units and notes
Rated Flow	Q	Gallons per minute (GPM) Liters per minute (lpm)
Air Flow		Cubic feet per minute (CFM)
Pressure	P	Inches of water (in.) Feet of water (feet, ft.) Pounds per square inch (psi) Pascals (pa)
Power		Horsepower (HP) Watts (W)
Rated Rotational Speed		Revolutions per minute (RPM)
Head pressure at rated flow	H, TDH	See *Pressure*
Maximum pressure	Pmax	See *Pressure*
Maximum fluid temperature	Tmax	Degrees Fahrenheit (°F) Degrees Celsius (°C)
Fuel Type		Natural gas Propane (LPG) #2 Oil
Minimum input		British Thermal Units per hour (Btu/hr, BTUh)
Thermal Output		British Thermal Units per hour (Btu/hr, BTUh)
Efficiency		Percent (%)
Gas Supply Pressure		inches of water (in., in-wc) Pounds per square inch (psi) Pascals (pa)
Rated voltage(s)	V	Volts (V)
Rated full-load amperage	A	Amperes (A) – *listed for each voltage*
Frequency		
Phase	ϕ	*Single* or *three*
Speed		Revolutions per minute (RPM, R.P.M.)
Full Load Efficiency		Percent (%)
Power Factor	PF	

Alternator Name Plate Details Explanation:

Output Voltage: The rated output voltage of an alternator

Output Current: The rated output current of an alternator.

Output Frequency: The output frequency of alternator is derived from number of poles and Synchronous speed.

Speed: The unit rpm means revolutions per minutes.

Limit speed of alternator:That's the maximum speed that the alternator's rotor can without winding collaboration.

Type of connection:This is winding connection of the alternator. The winding connection can be either star or delta. But 98% of the alternator is preferred to winding in star connection.

Excitation current: The output of the Rotating Rectifier assembly(RRA) to the rotor coil.

Excitation voltage: The input DC voltage to the rotor coil from RRA.

Note: These voltage is controlled by the Automatic voltage Control System (AVR) and the control has done through excitation generator.

Enclosure & Cooling System:

The type of enclosure used to protect the alternator from physical substances. And the type of cooling system used in alternator such as Water cooling, self-air cooling, forced air cooling.

Coolant temperature:

If your alternator is air cooled, then it means the air inlet temperature. If you use water instead of air, it means water inlet temperature of the cooling tubes.

Stater maximum temperature:

The maximum temperature that the stator insulation can withstand. It is purely depending upon the insulation used in the winding coil.

Duty: The percentage of time that a device is operating over a specified period

- **Reading of manuals specifications**

  - **<u>Safety</u>**

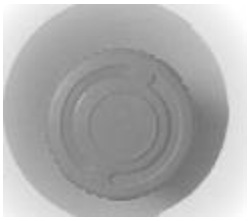
The generator set is designed to be safe when used in the correct manner. Responsibility for safety, however, rests with the personnel who use the set. Before performing any procedure or operating technique, it is the user's responsibility to ensure that it is safe to do so.

  - **Warning:**

1. Read and understand all safety precautions and warnings before operating the generator set. Failure to follow the instructions, procedures and safety precautions in this manual may increase the possibility of accidents and injuries.
2. Never start the generator set unless it is safe to do so.

3. 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.
4. Ensure the generator set is protected from any unauthorised use, use signs were appropriate.
5. Disconnect the battery negative (–) lead prior to attempting installation, repairs or cleaning on the generator set.
6. Install and operate this generator set only in full compliance with relevant National, Local, or Federal Codes, Standards or other requirements.

- **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.

NOTE:

- Familiarise 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.

- **Fire and Explosion**

All fuels, most lubricants, and some coolant mixtures are flammable. Flammable fluids that are leaking or spilled onto hot surfaces or onto electrical components can cause a fire. Fire may cause personal injury and property damage.

Do not allow any flammable materials to accumulate on the engine. Store fuels and lubricants in properly marked containers away from unauthorized persons. Store oily rags and any flammable materials in protective containers. Do not smoke in areas that are used for storing flammable materials.

NOTE:

- Do not charge a frozen battery, this may cause an explosion.
- Ensure the generator set room is properly ventilated.

- Keep the room, the floor and the generator set clean. When spills of fuel, oil, battery electrolyte or coolant occur, they should be cleaned up immediately.
- Never store flammable liquids near the engine.
- Store oily rags in covered metal containers.
- Do not smoke or allow sparks, flames or other sources of ignition around fuel or batteries. Fuel vapours are explosive. Hydrogen gas generated by charging batteries is also explosive.
- Avoid refilling the fuel tank while the engine is running.
- Do not attempt to operate the generator set with any known leaks in the fuel system.
- Do not use aerosol types of starting aids such as ether. Using these types of items could result in an explosion and personal injury.

In case of fire happen , must use fire extinguisher. Personnel must be familiar with the operation of the fire extinguisher. Inspect the fire extinguisher and service the fire extinguisher regularly. Obey the recommendations on the instruction plate

- **First Aid for Electric Shock**

NOTE:

- Do not touch the victim's skin with bare hands until the source of electricity has been turned off.
- Switch off the power, if possible.
- Otherwise pull the plug or pull the cable away from the victim.
- If this is not possible, stand on dry insulating material and pull the victim clear of the conductor, preferably using insulated material such as dry wood.
- If victim is breathing, turn the victim into the recovery position
- If victim is unconscious, perform resuscitation as required: OPEN THE AIRWAY

- **Recommended Practice for Maintaining AC/DC Generator Sets**

One way to ensure a long, reliable operating life is to implement a preventive maintenance (PM) program. Preventive maintenance and service are typically done on a schedule based upon engine hours and/or time periods.

Preventive maintenance is predetermined work performed to a schedule (agenda ,time table,…) with the aim of preventing the wear and tear or sudden failure of equipment components. Prevention is better than cure.

Depending on the application of the generator set, requirement for preventative maintenance will vary.

- ✓ **Daily or at Each Startup**:

(For standby generator sets these procedures may be performed weekly.) A walk around inspection should be performed on a daily basis and prior to starting the engine. The Pre-Start checks should be performed during this walk around.

The following checks should be performed prior to starting the generator set:

1. Ensure the Control Switch / Key Switch is Off.

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. Look for items such as:

- Loose fastenings / fixings, worn (damaged) belts or loose connections. Repair as necessary.
- The fan and exhaust guards must be at the correct positions and securely fixed. Repair damaged / loose guards or renew missing guards.
- Wipe clean all filler caps before the engine is serviced or fluids are topped up to reduce the chance of any system contamination.
- 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.
- Accumulated grease and/or oil on an engine is a fire hazard. Remove it by steam cleaning or by the use of a high pressure water jet. Avoid high–pressure water on the electronic / electrical components, provide suitable protection were possible.
- Ensure that the coolant pipes are fitted correctly and that they are secure. Check for leaks. Check the condition of all pipes for splits or signs of rubbing.

2. Fluid levels

- Check the engine oil and coolant levels – replenish (refill, fill, stock up…) as necessary (see engine handbook for locations).
- Ensure fluids used are as recommended within the engine handbook.

Warning**:** Do not remove the radiator cap or any component of the cooling system while the engine is running and while the coolant is under pressure, because dangerous hot coolant can be discharged, posing a risk of personal injury.

Do not add large amounts of cold coolant to a hot system as serious engine damage could result.

Note**:**

- ➢ Diesel engines normally consume lube oil at a rate of 0.25% to 1% of the fuel consumption at full load.
- ➢ When adding coolant to the radiator system, always pour slowly to help prevent air from becoming trapped in the engine. Always top up when engine is cold.

- When filling the fuel tank, do not smoke or use an open flame in the vicinity (surrounding area, neighborhood, environs…).

3. Check the fuel level – fill as necessary.

Before tightening (reduction) the fan belts, disconnect the battery negative (–) lead to ensure the engine cannot be accidentally started.

4. Check the condition and tension of the fan and engine alternator belts – tighten as necessary.

5. Check all hoses for loose connections or deterioration – tighten or replace as necessary.

6. Check the battery terminals for corrosion – clean as necessary.

When working with the batteries do not smoke or use an open flame in the vicinity. Hydrogen gas from batteries is explosive.

Do not short the positive and negative terminals together.

7. Check the battery electrolyte level – fill with distilled water as necessary.

8. Check the control panel and the generator set for heavy accumulation of dust and dirt – clean as necessary. These can pose an electrical hazard or give rise to cooling problems.

9. Check the air filter restriction indicator, if fitted – replace the filter as necessary.

10. Clear the area around the generator set of any insecure items that could inhibit (slow down, reduce,…)operation or cause injury. Ensure cooling air ventilation screens are clear.

11. Visually check the entire generator set for signs of leaks from the fuel system, cooling system or lubrication seals.

12. Periodically drain exhaust system condensate traps, if equipped.

13. Ensure the alternator output circuit breaker is in the "OFF" (handle down) position.

✓ **Weekly Maintenance actvities**

- Run the generator (typically no-load, automatic transfer switch exercise cycle).
- Verify that the unit ran and has no alarms or warnings.
- Ensure adequate fuel levels.
- Ensure that the generator is in "Auto" mode, for automatic startup.
- Check that the circuit breaker is closed.
- Make sure there are no fluid leaks.

✓ **Monthly Maintenance**

- Check engine coolant level.
- Check engine oil level.
- Check the battery charger.

✓ **Annual Maintenance** *(Schedule maintenance with a certified technician.)*

- Change oil and filter.
- Change the fuel filter.

- Change the air filter.
- Clean the crankcase breathing space.
- Change spark plugs.
- Check coolant concentration.
- Flush the cooling system (as needed).
- Perform load bank testing.
- Fuel testing & reconditioning (diesel-fueled units only).
- Remove water from fuel tank (diesel-fueled units only).

 **Theoretical learning Activity**

- ✓ Brainstorm on generator's nameplate
- ✓ In pair Group discuss on the interpretation of the generators nameplate data

 **Practical learning Activity**

- ✓ With picture, Trainees in pair, demonstrate the elements of generator's nameplate provided by trainer

 Points to Remember (Take home message)

- ✓ kW ratings: kw is the amount of actual power an electrical system has
- ✓ The generator set is designed to be safe when used in the correct manner
- ✓ Avoid refilling the fuel tank while the engine is running.

 Learning outcome 1 .1formative assessment

- List clearly four elements of nameplates
  Answer: rated current, rated voltage, frequency, number of phase, speed, power factor…
- What are the four activities can be done in annual maintenance activities
  Answer:
  - Change oil and filter.
  - Change the fuel filter.
  - Change the air filter.
  - Clean the crankcase breathing space.
  - Change spark plugs.

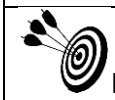
- Check coolant concentration

(rogerA.CAMACHO, may 2017)

(mobley, 2002)

Learning outcome 1.2 Interpret electrical drawings

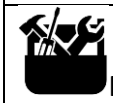

Duration: 1hrs


Learning outcome 1 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Identify clearly electrical symbols

2.Identify correctly electrical drawings


Resources

Equipment	Tools	Materials
✓ Rulers ✓ Eraser ✓ Pen and pencils	- screw driver - pliers - electrical knife - razor	✓ Books ✓ Books ✓ Internet ✓ papers

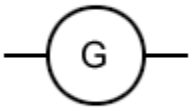
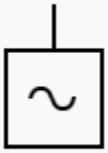

advanced preparation

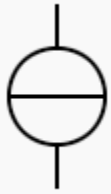
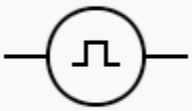
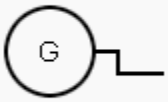
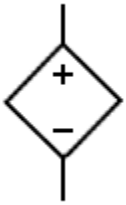
- Review on electrical symbols
- Review on electrical drawings

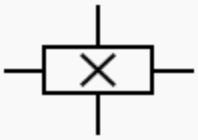
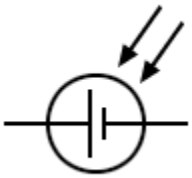
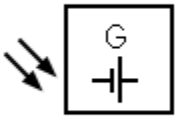
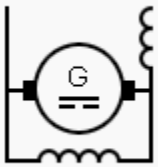
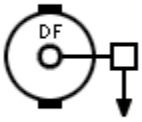
- **electrical symbols**

Electric Generator Symbols

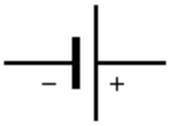
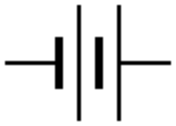
Electrical symbols are **a graphical representation of basic electrical and electronic devices or components**. These Symbols are used in circuits and electrical diagrams to recognize a component.

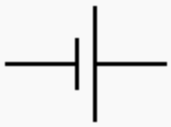
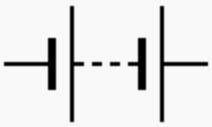
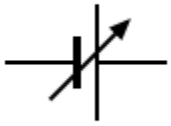
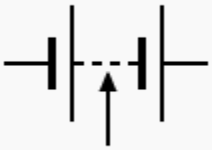
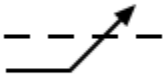
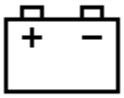
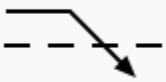
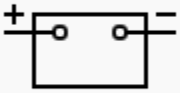
Symbol of Electric Generator			
Symbol	Description	Symbol	Description
	Electric generator Generic symbol + info		Alternator / Sinusoidal generator AC, alternating current Generic symbol + info
	Electric generator AC generator low frequency + info		AC generator non rotating
	AC generator middle frequencies		Dynamo DC generator + info
	AC generator high frequencies		Homopolar generator DC generator + info

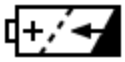
	Generic generator		Magnetohydrodynamic generator MHD generator Generic symbol + info
	Ideal current generator		Pulse generator + info
	Ideal voltage generator		Waveform generator + info
	Generator voltage		Magneto Hand generator + info
	Controlled voltage generator		Controlled current generator

	Motor–generator + info		Resonance generator
	Photovoltaic cell Solar cell + info		Photovoltaic generator Solar cell + info
	DC generator compound excitation with short		Tachometer generator
	Dynamo with built-in brake + info		

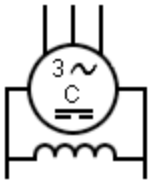
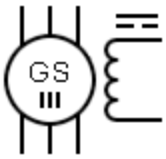
Symbols of Batteries and related / DC Power Supplies

	Cell - Electric battery Generic symbol + info		Battery pack + info

	Cell - Battery		Connected batteries
	Electric cell with voltage adjustable		Multi-battery adjustable in three steps
	Multi-adjustable battery		Battery with connection of mobile voltage
	Indication Overvoltage + info		Representation battery
	Indication of undervoltage		Representation battery

	Charge level of the battery + info		Battery charging indication
	Overload indication		

Symbols Three-Phase Generator

	Three phase synchronous generator with permanent magnet + info		Three phase synchronous generator wye connection + info
	Three phase converter + info		Three phase synchronous generator with access to each winding

- **Electrical drawings**

An electrical drawing is a type of technical drawing that shows information about power, lighting, and communication for an engineering or architectural project. they are three basic circuit diagram

✓ **Control circuit diagram**: is a special type of circuit used to control the operation of a completely separate power circuit

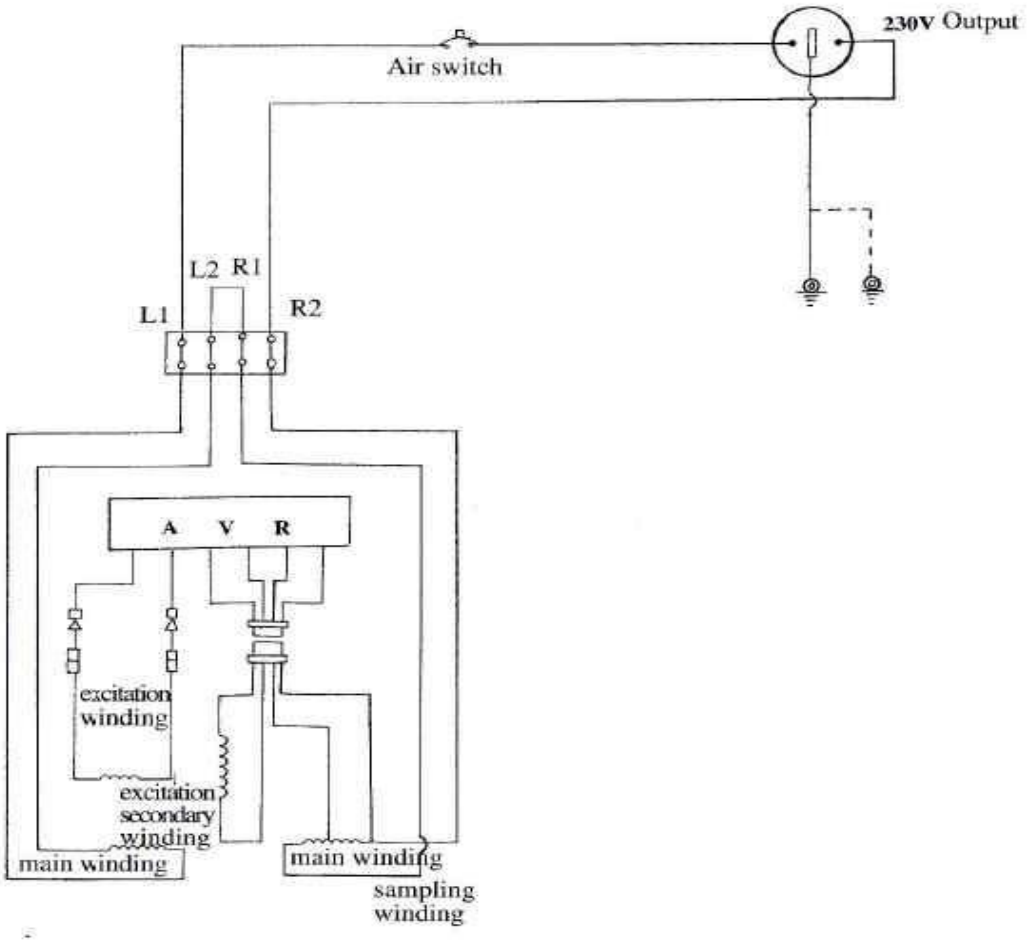
✓ **Power circuit diagram:** A power circuit is defined as any circuit used to carry electricity that operates a load. This may seem like a simplistic definition but it is important to distinguish power circuits from control circuits since they serve different purposes

✓ **Schematic diagram from the manufacturer manual:** A schematic diagram is a fundamental two-

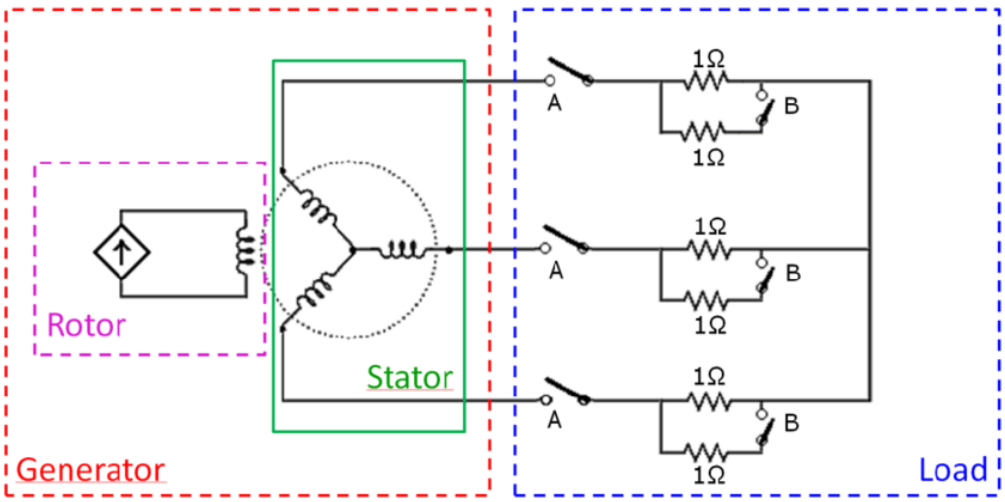
dimensional circuit representation showing the functionality and connectivity between different electrical components

Examples:

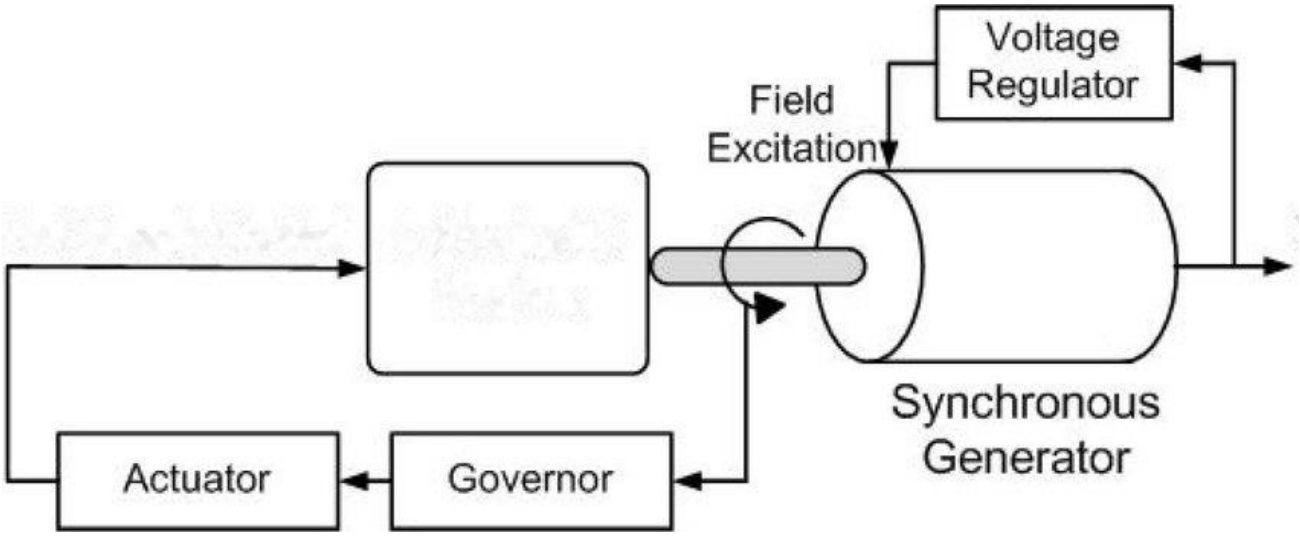
1.control circuit



2.power circuit for generator



3.Schematic diagram from the manufacturer manual



(scaddan, 2002)

(Bird, 2003)

Theoretical learning Activity

- ✓ Trainees In pair group form, brainstorm on electrical drawing and symbols

Practical learning Activity

- ✓ In foursome, draw the 10 symbols of different electrical generator

Points to Remember (Take home message)

- ✓ Electrical symbols are **a graphical representation of basic electrical and electronic devices or components**. These Symbols are used in circuits and electrical diagrams to recognize a component.
- ✓ An **electrical drawing** is a type of technical drawing that shows information about power, lighting, and communication for an engineering or architectural project. Basic classification of electrical drawing are; Control circuit diagram, Power circuit diagram, Schematic diagram from the manufacturer manual.


Learning outcome 1. 2 formative assessments (Written assessment)

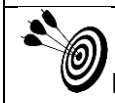
Choose right element and complete the following phrases (control circuit, power circuit and schematic)

I. ……..diagram is a special type of circuit used to control the operation of a power circuit
Answer: Control circuit

II. ……diagram is a fundamental two-dimensional circuit representation showing the functionality and connectivity between different electrical components
Answer: schematic

Learning outcome 1.3 Prepare tools, equipment and materials


Duration: 1hrs


Learning outcome 1.3 : objectives:

By the end of the learning outcome, the trainees will be able to:

1. Identify clearly tools used in electrical maintenance

2. Identify correctively Measuring equipment

3. differentiate effectively consumable and non-consumable materials


Resources

Equipment	Tools	Materials
- Voltmeter - Ammeter - Wattmeter - VAR-meter - VA-meter - Phase-meter - Ohmmeter - Thermometer - Tachymeter	- Screwdrivers set - Pliers set - Generators tool set	-Books -Internet

Advance preparation:

- Identification of tools
- Identification of Measuring equipment
- Identification of consumable and non-consumable materials

- Identification of Tools

Tools: isa physical item that is used to achieve a goal but is not consumed during this process. i.e. is any instrument or simple piece of equipment that you hold in your hands and use to do a particular kind of work.

Tools are followed

✓ **Screwdrivers set:** a tool with a flattened, cross-shaped tip or that fits into the head of a screw to turn it

- **Flat-blade screwdriver:** Installing and removing slot-head screws

- **Phillips screwdriver:** Installing and removing Phillips-head screws

- **Rotating speed screwdrivers:** Used for trim work, installing switch and receptacles

✓ **Pliers set**: Pliers are a tool with two handles at one end and two hard, flat, metal parts at the other. Pliers are used for holding or pulling out things such as nails, or for bending or cutting wire. pliers are classified as follows; Combination pliers, Side cutter pliers, Long nose flat pliers, Wire gripping, pliers Long nose round pliers

✓ Generators tool set

Those tools are:

1. Wrenches
2. Hammer
3. Tape measure
4. Pliers
5. Screw drivers
6. Wire strippers

- **Identification of Measuring equipment**
  - ✓ **Watt meter:** A *wattmeter* is an electrical instrument which is used to measure the electric power (in watts) of any electrical circuit. It consists of two coils i.e. pressure coil (parallel) and current coil (series). As the current coil is connected in series to the load, it measures the current flowing through the load and whereas the pressure coil which is connected across the load is used to measure the voltage across the load

- ✓ **Voltmeter:** A voltmete*r*, also known as a voltage meter, is an instrument used for measuring the potential difference, or voltage, between two points in an electrical or electronic circuit. Some *voltmeters* are intended for use in direct current (DC) circuits; others are designed for alternating current (AC) circuits. voltmeter must be connected in parallel with the part of circuit whose p.d is required.to avoid a significant current flowing through it a voltmeter must have a very high resistance.

- ✓ **Ammeter:** Ammeter is an instrument for measuring electric current especially in amperes.it must be connected in series with the circuit. Since all current in the circuit passes through the ammeter, it must have a very low resistance

- ✓ **Tachometer:** Tachometer is an instrument (sensor device) used to measure the rotation speed of any object such as the engine shaft in a car, and is usually restricted to mechanical or electrical instrument.

- ✓ **Multi-meter**: to measure voltage, current and resistance.

- ✓ **Thermometer:** Thermometer is an instrument for measuring and indicating temperature, typically one consisting of a narrow, hermetically sealed glass tube marked with graduations and having to one end a bulb containing mercury or alcohol which extends along the tube as it expands.

.

- **identification of consumable and non-consumable materials**
  - ✓ **Lubricating oil**: Lubricating oil is a class of refined products used to reduce friction and wear between bearing metallic surfaces.it is consumable materials

    Basic function of lubricating oil are:

    - ➢ Lubrication – Provide a film between moving parts.
    - ➢ Cooling – Heat transfer media.
    - ➢ Sealing – Filling in uneven surfaces.
    - ➢ Cleaning – Holding contaminants in suspension
  - ✓ **Fuel:** Any substance which upon combustion produces a usable amount of energy is known as fuel. Examples: petrol, diesel etc.it is consumable in electrical generator.

  - ✓ **Cleaning equipment**: Any of a large class of implements used for cleaning.

There are many different types of equipment used in cleaning, like pressure cleaners, sweepers and polishers, but also vacuum cleaners. It is important to choose the right equipment for a certain cleaning job.it is non consumable materials

Theoretical learning Activity

- ✓ In quartet, Brainstorm on tools, equipment and materials can be used in generator maintenance

- ✓ In quartet, demonstrate clearly tools, equipment and materials used at the workplace

Practical learning Activity

- ✓ Trainees in pair use pliers for cutting wires and pliers for stripping wires provided by trainer
- ✓ Ask trainee to measure the output voltage of generator by using multimeter

Points to Remember (Take home message)

- ✓ **A wattmeter** is an electrical instrument which is used to measure the electric power (in watts) of any electrical circuit.
- ✓ **Pliers** are used for holding or pulling out things such as nails, or for bending or cutting wire
- ✓ **Lubricating oil** is a class of refined products used to reduce friction and wear between bearing metallic surfaces

Learning outcome 1.3formative assessment

True and false question

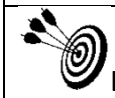
A. Ohmmeter is electrical instrument used for measuring current. Answer: false
B. Multimeter is an instrument used for measuring current. Answer: true
C. Lubricating oil is a consumable material required in electrical maintenance: Answer: true
D. Tool with a flattened, cross-shaped tip or that fits into the head of a screw to turn it is called pliers. Answer: false

(Bird, 2003)

(McGraw, decembe,2011)

Learning outcome 1.4: Identify PPE


Duration: 1hrs


Learning outcome 1.4 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Identify correctly Personal protective equipment

2. Recall clearly on how to use safety equipment


Resources

Equipment	Tools	Materials
- Overcoat and overall - Gloves - Safety shoes - Helmet - Earmuff - Goggles - Nose protection mask	- screw driver - pliers - electrical knife - saws	-Books -internet


Advance preparation:

- ✓ Identification of Personal protective equipment
- ✓ Recall on how to use safety equipment

- Identification of Personal protective equipment

✓ Overcoat and overall
✓ Gloves
✓ Safety shoes
✓ Helmet
✓ Earmuff
✓ Goggles
✓ Nose protection mask

- **Recall on how to use safety equipment**

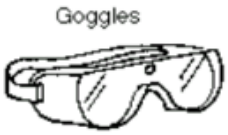
PPE(Personal Protective Equipment):PPE is a clothing or equipment designed to protect works from physical hazards when on the site. PPE should only be considered as a last line of defence between workers and hazard. PPE is a clothing or equipment designed to be worn by someone to protect them from the risk of injury or illness. That personal protective equipment are:

- Head protection:

PPE include head hats(helmet)should be required for tasks that can cause any force or object falling to the head. wearing helmet offers protection and can prevent head injuries

- Face and eyes protection

PPE include googles and face shield should be required for tasks that can cause loss of vision and an eye. examples (burns, splashes, sprays of toxic liquids etc)



- Hearing protection

PPE include earmuff and earplugs should be required for tasks that can cause hearing problem or loss of hearing

- Resipiratory protection

PPE include respiratory or nose protection masks should be required for tasks that can inhalation of harmful material to enter the body. masks offers protection against fine dust and other dangerous particles such as smoke, powder, etc .if the materials are truly toxic use full masks to protect nose and mouth against harmful pollution

- Hands protection

PPE include safety gloves should be required for tasks that can cause hands and skin burns, absorption of harmful substances, cuts or fractures.

- Foot protection

Even your feet need protection by using safety shoes and boots. Safety shoes should be required for tasks that can cause serious feet and legs injuries from falling or rolling objects, hot substances, electrical hazard and slippery surfaces

- Body protection

PPE include safety vests, suits, overalls, overcoat should be required for tasks that can cause body injuries from extreme temperatures, flames and sparks, toxic chemicals, insect bites and radiation. always get a good fit to ensure full body protection

Theoretical learning Activity

- ✓ Ask trainees to brainstorm about the use of PPE

Practical learning Activity

- ✓ Trainees in pair form demonstrate PPE accordingly

Points to Remember (Take home message)

PPE is a clothing or equipment designed to protect works from physical hazards when on the site. PPE should only be considered as a last line of defence between workers and hazard

Learning outcome 1.4 formative assessment

Match column A with column B. Use each letter only once and write it in the blank space provided the PPE with its function/6marks

answers	Function(column A)	PPE(COLUMN B)
	1. Eye protection	A. Earmuffs
	2. Hand protection	B. Goggles
	3. Skin protection	C. Safety shoes
	4. Hearing protection	D. Overalls
	5. Protection against impact, heat, puncture wound and/or oil slipping.	E. Hand gloves
	6. Head protection	F. Helmet

Answer:

answers	Function(column A)	PPE(COLUMN B)
B	1.Eye protection	a.Earmuffs
E	2.Hand protection	b.Goggles
D	3.Skin protection	c.Safety shoes
A	4.Hearing protection	d.Overalls
C	5.Protection against impact, heat, puncture wound and/or oil slipping.	e.Hand gloves
F	6.Head protection	f.Helmet

(Jones, 2007)

(P, 2014)

Learning Unit 2: Execute preventive maintenance

STRUCTURE OF LEARNING UNIT

Learning outcomes:

2.1 Identify planned activities

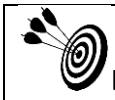
2.2 Test electrical generators

2.3 Clean, replace, lubricate, adjust required devices

2.4 Complete the maintenance report

Learning outcome 2 .1 Identify planned activities

Duration: 2hrs



Learning outcome 2.1 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Recall on manufacturer's recommended maintenance activities

2. Interpret correctly the maintenance records history

3.Follow effectively Maintenance steps of the different parts of the generators

Resources

Equipment	Tools	Materials
✓ GENERATOR	✓ PEN ✓ PENCILS	✓ Manual Books ✓ Internet ✓ Checklist ✓ Maintenance records

Advance preparation:

- Recall on manufacturer's recommended maintenance activities
- Interpret the maintenance records history
- Maintenance steps of the different parts of the generators

- **Recall on manufacturer's recommended maintenance activities**

➢ Daily activities:

For home standby generators, regular maintenance includes changing air filters, oil and oil filters, spark plugs, checking battery charge, sediment traps, valve clearance, and cleaning the generator from dirt and debris inside the enclosure and outside around the unit.

➢ Weekly activities:

A weekly schedule is a way to keep track of your activities and tasks for the week.

Generator Weekly Maintenance Checklist:

- Run the generator (typically no-load, automatic transfer switch exercise cycle).
- Check fuel levels and refuel as necessary.

- Put the generator in “Auto” mode, for automatic start-up
- Check that the circuit breaker is closed.
- Check for fluid leaks.

➢ Monthly activities

Monthly Generator Maintenance Checklist:

- Clean generator.
- Clean surrounding area.
- Check engine coolant levels.
- Check battery charger.
- Check engine oil levels

➢ Annually activities

Annual generator maintenance checklist:

- Change engine sump oil.
- Change full flow oil filter.
- Empty, flush and refill radiator.
- Change bypass oil filter.
- Flush daily service fuel tank.
- Change fuel filter.
- Change air filter
- Check and clear crankcase breathers

- **Interpret the maintenance records history**

For the Interpretation of the maintenance records history you must use Checklist data interpretation to see and understand the maintenance record history:

Maintenance items	Service time				
	Daily	Weekly	Monthly	6 months	Yearly
Inspection	X				
Check coolant heater	X				
Check coolant level	X				
Check oil level	X				
Check fuel level	X				
Check charge-air piping	X				
Check/clean air cleaner		X			
Check battery charger		X			
Drain fuel filter		X			
Drain water from fuel tank		X			
Check coolant concentration			X		
Check drive belt tension			X		
Drain exhaust condensate			X		
Check starting batteries			X		
Change oil and filter				X	
Change coolant filter				X	
Clean crankcase breather				X	
Change air cleaner element				X	
Check radiator hoses				X	
Change fuel filters				X	
Clean cooling systems					X

- **Maintenance steps of the different parts of the generators**

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.

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.

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.

4. Testing Batteries

Weak or undercharged starting batteries are a common cause of standby power system failures.

- 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.
- 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 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

Theoretical learning Activity

- ✓ Ask trainees to brainstorm about the interpretation of the maintenance records within groups
- ✓ Discuss in group on maintenance steps of the different parts of the generator

Practical learning Activity

- ✓ Trainees in pair discuss on how to fill checklist data interpretation
- ✓ Trainees in pair differentiate annual to weekly activities

Points to Remember (Take home message)

- ✓ Weak or undercharged starting batteries are a common cause of standby power system failures
- ✓ There are four maintenance activities:
  - ➢ Daily activities
  - ➢ Weekly activities
  - ➢ Monthly activities
  - ➢ Annually activities

Learning outcome 2. 1. Formative assessment

1) What activities can be done in monthly generator maintenance checklist?

Monthly Generator Maintenance Checklist:

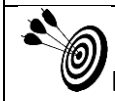
- Clean generator.
- Clean surrounding area.
- Check engine coolant levels.
- Check battery charger.
- Check engine oil levels

(HUBERT, 1969)

(Ware, 2006)

Learning outcome 2.2: Test electrical generators

 Duration:3hrs

 Learning outcome 2.2 objectives:

By the end of the learning outcome, the trainees will be able to:

1. identify general faults in generators

2.Check general condition of prime mover/generator

3. Check the Battery/excitation system:

4.Check the condition of Exhaust system

5.Check the condition of Fuel system:

 Resources

Equipment	Tools	Materials
✓ Generator ✓ Multimeter ✓ Protection device	✓ Screw drivers ✓ Pliers	✓ Books ✓ Internet ✓ Service manuals ✓ Maintenance records

 Advance preparation:

- **General faults in generators**

  - Engine faults

    Engine will not turn**:** Possible causes:

    a) Battery discharged. Loose or incorrect cable connections or Electrical fault in starting circuit.

    b) Faulty starter motor.

    c) Starter pinion will not engage on flywheel starter ring.

    - **Engine will not fire:** Possible causes:

a. No fuel reaching injectors. Fuel supply line blocked.
b. Air lock in fuel line.
c. Fuel filters choked.
d. Water in fuel.
e. Air cleaners choked.
f. Fuel pump timing out.
g. Lift pump faulty.

- **Engine fires but fails to pick up speed:** Possible cause:

a) Fuel supply system faulty.
b) Air cleaner choked.
c) Faulty lift pump.
d) Faulty air injectors

- **Engine misfires:** Possible causes:

a) Air lock in fuel line.

b) Fractured injector feed pipe or Faulty injector.

c) Faulty injection pump.

d) Tappet clearances incorrect

- **Low power output:** Possible causes:

a) Inadequate fuel pressure.

b) Air filters choked.

c) Fuel injection pump timing incorrect.

d) Faulty injection.

e) Tappet clearance inadequate.

f) Faulty turbocharger.

g) Inlet manifold and/or cylinder head joints leaking

- **Low oil pressure (Sudden pressure drop as opposed to progressive drop due to worn bearings:** Possible causes:

  a) Oil level too low.

  b) Oil pressure gauge faulty.

  c) Oil filters choked.

  d) Relief valve faulty.

- **Overheating:** possible causes:

  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.

  g) Fuel injection pump timing out.

  h) Low oil level.

- **Inadequate fuel:** possible causes:

  a) Fuel supply system faulty.

  b) Faulty fuel lift pump.

  c) Fuel relief valve faulty.

  d) Choked fuel filters.

- **Exhaust emits black smoke**: possible cause:

  Excess fuel being used

- Control equipment faults

Circuit fuses blowing: possible cause

a) Incorrect rating of fuse used.

b) Short circuit between panel wires and/or between wires and frame.

Circuit operating satisfactorily only intermittently: possible cause:

Faulty or out of adjustment relay or auxiliary contacts

Excessive 50 Hz buzz or hum: possible cause

Dirty, rusty or badly aligned pole faces

Overheating cable ends and terminations: possible cause

Loose connections

- Alternators and DC generators faults

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

No output voltage: possible causes:

a) Engine speed too low.

b) Loose terminals.

c) No excitation and/or loss of residual magnetism.

d) Open circuit in windings.

e) Faulty automatic voltage regulator (AVR).

f) Faulty diode in main rectifier assembly on the rotor.

g) Open circuit of the gain and/or range control on the AVR.

h) Hand operated voltage trimmer open circuit (if fitted).

f) Remove and test with ohmmeter; the forward resistance should be less than 1000 ohms and the reverse resistance greater than 100K ohms. Replace if necessary.

g) Check for continuity

Output voltage unstable: possible cause:

Incorrect setting of gain control

Output voltage incorrect: possible cause:

Voltage set up incorrectly on band trimmer or choke tapings.

Output voltage too high and cannot be reduced on controls: possible cause

Automatic voltage regulator faulty

- Protection system faults

- **Check general condition of prime mover/generator**
  - ✓ Condition of belts & hoses
  - ✓ Engine oil level

- ✓ Lube oil heater
- ✓ Coolant level
- ✓ Water pump
- ✓ Jacket water heater
- ✓ Radiator
- ✓ Electrical/Generator breaker state

- **Checking the Battery/excitation system:**

Unit will not start due to battery - 80% of generators' failures to start are due to faults in the set's battery. Weak or low charged batteries are a common occurrence. Even a well-charged, well-maintained lead-acid battery will deteriorate over time. Batteries must be replaced when they no longer hold a proper charge. Battery charger systems and alternators should be checked weekly on sets used for standby and emergency applications, and at least monthly on other applications the main thing checked on battery are Electrolyte level and charger

- **Checking of the condition of Exhaust system**

Exhaust system: With the generator set operating, inspect the entire exhaust system including the exhaust manifold, muffler and exhaust pipe. Check for leaks at all connections, welds, gaskets and joints, and make sure that the exhaust pipes are not heating surrounding areas excessively. Repair any leaks immediately**.**

- **Checking of the condition of Fuel system:**

Unit will not start due to fuel - Lack of fuel or low quality fuel are often reasons generator-set engines fail to start or to give rated power. Fuel quality should be checked as part of any planned maintenance visit. Technicians working on diesel-fuelled units will check if water or other contaminants are in the fuel or in the unit's filtration or delivery systems. Having no fuel in diesel and gaseous units could be due to a lack of storage capacity or poor delivery from the on-site storage or tank vents**.** Also **Filters leading to reduced performance -** The air, oil and fuel filter elements must be changed per manufacturer's recommendations or whenever necessary due to site or operating conditions. Any blockage will restrict flow and result in reduced performance. Air and oil filter blockages also contribute to excessive engine wear.

 **Theoretical learning Activity**

- ✓ Ask trainees to brainstorm about cause of generator failure within groups
- ✓ Ask trainees to brainstorm about battery/ excitation.

Practical learning Activity

- ✓ Trainees in pair perform the causes of the generator failure provided by the trainer

Points to Remember (Take home message)

- ✓ Keep generator away from the oil, vapour, acidic/alkaline gas, saline brume and do not let any other solid matter fall into the generator
- ✓ Make sure all the firming components are tight and the rotor is easy to turn by hand without impacting, scrubbing and any abnormal noise. Do not let the rain or other liquid drop into the alternator.

Learning outcome 2. 2. Formative assessment

Answer by true or false

1. Excessive 50 Hz buzz or hum in generator is caused by:

a) Dirty,

b) Rusty

c) Overload

d) Badly aligned pole faces

e) Three phase system

Answer:

a) T
b) T
c) F
d) T
e) F

2. Overheating in generator is caused by:

a. High oil temperature.

b. Coolant in engine.

c. Coolant system polluted.

d. Easy air passages in radiator matrix.

e. Fan belt tension incorrect.

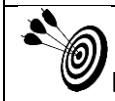
Answer:

a) T
b) F
c) T
d) F
e) T

(willey, 2021)

Learning outcome 2.3: Clean, replace, lubricate, adjust required devices


Duration: 3hrs


Learning outcome objectives:

By the end of the learning outcome, the trainees will be able to:

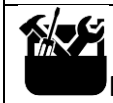
1. Recall on generators parts

2. Use Cleaning techniques of the generator parts

3. Assemble and disassemble correctly parts of generators

4.Lubricate effectively generator parts

5.Adjust/replace correctly defective parts


Resources

Equipment	Tools	Materials
✓ PPE ✓ Switching devices ✓ Protection devices ✓ Generators	✓ Electrician toolbox	✓ Books ✓ Internet ✓ Journals ✓ wires

Advance preparation:

- Recall on generators parts
- Cleaning techniques of the generator parts
- Assembling and disassembling parts of generators
- Lubricating of generator parts
- Adjustment/replacement of defective parts

- Recall on generators parts

A generator is a backup power source used during power outages caused by emergencies, inclement weather, routine maintenance and other factors affecting primary energy sources Similar to residential generators and their ability to power homes during a blackout, commercial generators have the same functionality on a larger scale. Generators has two main parts: Electrical parts and Mechanical parts. Those parts are followed

As an essential item for emergency situations and power outages, generators have many parts that contribute to their functioning. Each part of a generator has a unique purpose that allows the machine to operate properly and supply energy where you need it.

1. FUEL SYSTEM

One vital part of a commercial generator is the fuel system. Before a generator can output mechanical energy, you must supply it with a fuel source so that it can convert that source either natural gas or diesel fuel into chemical energy that converts into mechanical energy and eventually electric outputs.

2.ENGINE

The engine is another key operator within the parts of a commercial generator. Like natural gas or diesel engines in automobiles, generator engines are where chemical energy, or your fuel source, converts into mechanical energy.

3. ALTERNATOR

Also called the generator end, the alternator turns mechanical energy into electricity. This process begins as the engine burns fuel and transmits it to the alternator. The alternator houses two major components that allow the generator to effectively and efficiently produce energy: the stator and rotor.

4.VOLTAGE REGULATORS

Automatic voltage regulators (AVRs) are automatic devices in generators that help keep voltage levels constant. As an essential component of generators, they work to stabilize the output voltage by preventing fluctuating voltage levels and sustaining the alternating current within the right voltage level range.

5. COOLING AND EXHAUST SYSTEMS

Constant generator use causes working parts to heat up. A cooling system is a fixed part of any generator to regulate its temperature and prevent overheating. Most generators have either an air- or liquid-cooled system to regulate their internal heat

6.LUBRICATION SYSTEM

Similar to any other machine with moving parts, generators rely on gears and levers, and these moving parts often generate friction. To ensure these parts can move with ease, generators require lubricant. Lubricant is a fluid or oil formulated to separate a generator's internal components.

7. BATTERY

Batteries are a crucial part of a generator because they provide the power the machine needs to start during a power outage. When the power is out and you need a generator, there is no other energy source the machine can use except the battery. Specifically, the batteries power the engine starter and control panels. Some generators even have a secondary battery in case the primary one fails

8. SKID

The main frame or skid is the main base that a generator and its components are mounted to. In an indoor generator room, the skid is often mounted to the floor to ensure that it is held securely in place. This skid acts as a main base of a generator set and offers a lot of flexibility aside from holding generator parts and components.

9. CONTROL PANEL

The generator control panel is a collection of components displaying details and parameters, including current, voltage and frequency. Presented on either built-in displays, gauges or meters, control panels generally have switches or buttons to ensure the generator's operation.

10. ENCLOSURE

The major purposes of generator enclosures are to protect and quiet the machine. Before deciding on an enclosure for your generator, consider your priorities. Two types of generator enclosures you can choose between are weather proof.

- Cleaning techniques of the generator parts

What is the Need for Cleaning a Generator?

Cleaning generator is important to maintain its performance, prolong its lifespan, and prevent potential problems that can arise due to a dirty generator. Here are some of the reasons why cleaning your generator is important:

A dirty generator can decrease its efficiency and reduce its output power. By cleaning your generator, you can ensure that it is operating at its maximum efficiency and providing the power that you need.

Dirt and debris can accumulate on the components of your generator, causing them to wear down faster and potentially leading to premature failure. Regular cleaning and maintenance can help prolong the lifespan of your generator and prevent the need for costly repairs or replacements.

Cleaning generator allows you to inspect it for signs of wear and tear, potential problems, and other issues that may need attention. By catching these problems early, you can address them before they become major issues that could cause damage to your generator or other equipment.

Dirt and debris can create a fire hazard or cause other safety issues if you don't remove them from your generator. Regular cleaning and maintenance can help ensure that your generator is operating safely and is not at risk of causing harm to you or others.

Overall, regular cleaning and maintenance of your generator is essential to ensure its proper operation, prolong its lifespan, and prevent potential problems.

It is important to follow the manufacturer's recommendations for cleaning and maintenance, as they can vary depending on the specific make and model of your generator.

You Can use the following techniques for cleaning generator

✓ By air blower

Air blower machine is a simple and effective electrical device used in homes and industries to blow away dust from every nook and corner. For gadgets and electronics have delicate parts that cannot be cleaned with a cloth. This is when you need air blowers to remove dust with its continuous air pressure.

✓ By brush

Use a soft-bristled brush or to remove dirt and debris from the exterior of the generator. Pay special attention to the air intake and exhaust areas as they tend to collect the most debris

✓ By oil

Generators need oil to properly lubricate parts of the engine. With oil, you reduce friction and keep the generator running smoothly

- Assembling and disassembling parts of generators

- ✓ Step of assembling generator

- Connecting the diesel engine and the engine

Process: Dismantle the connection plate, bolts and steel plate-clean joints between diesel engine and the engine-disassemble the cooling fan housing-examine the connection plate-mount the fan housing and flywheel housing-connect the diesel engine and alternator-mount the cooling fan housing-dismantle the parts which requires no painting.

- Connecting the diesel engine air end and base frame

Process: Clean the base frame-mount the anti-vibration pad-mount the water tank cross beam and alternator cross beam-install the fuel tank indicator, fuel tank cap and fuel-conduit on the base frame-connect the air end and base-mount the air filter, water tank and fan housing.

- Spray painting

Process: Clean the diesel engine-spray painting

- Mounting of fuel system and accessories

Process: Assemble the water temperature sensor, oil-pressure sensor and oil meter-the oil-conveying pipe, scavenge pipe-fuel tank on the base and blow down valve, liquid level apparatus, and sealing parts-fill in the engine oil-fill the water tank with cold water and cover the water tank

- Preparation for noise reduction device assembly

Process: Be familiar with specific technical conditions and standards-examine reliability of equipment-placement and classification of the accessories and relevant tools-taking the spare parts and accessories

- Mounting for noise reduction device

Process: Cutting the soundproof cotton-platinum parts assembly-paste the soundproof cotton-mount the water tank plate-generator set housing assembly

- Preparation for silencer assembly

Process: Be familiar with the specific technical conditions and standards-inspect reliability of the equipment-placing and classification of accessories and tools-taking spare parts and accessories

- Manufacturing for silencer

Process: Cutting the steel tube and mesh plate-giving rolling and welding to the mesh plate- pipe wall drilling-steel tube welding-glass fiber filling-welding the silencer according to the drawing-polishing-paint spraying and drying

- Mounting of the silencer

Mounting: Welding for connecting exhaust pipe-mount the exhaust pipe and silencer to the silent engine room-giving a well connection to the exhaust pipe and silencer-cover with asbestos cloth

- Electrical assembly of control cabinet and air switch box

Assembly: Knowing the specific technical conditions and standards-inspect the reliability of the equipment-getting the spare parts and accessories-placing and classification of spare parts and tools

- Assembly of terminal blocks and splice connectors of control cabinet

Electrical control
Connect the mutual inductor-alternator output terminal enwinds the mutual inductor-mount the solenoid valve-diesel engine (solenoid valve, water temperature sensor, oil pressure sensor) wiring

- Installation of electrical components of control cabinet and sir switch box

Assembly: Assemble the control panel-wiring-mount the control panel onto the control cabinet-mount the control cabinet into the acoustic enclosure-wiring

- Quality testing on the pre-operation of diesel engine

Process: Welding quality testing-wiring testing-water, oil and air leakage testing-spare parts quality testing-overall quality testing

- Various testing before start of the diesel engine
- Sticking on labels and nameplates

Process: Clean the machine-stick on the label, nameplate-put accessories, specification and purchased accessories inside.

- Pre-package inspection

Process: Attached documents-tools and standby accessories-logo inspection

- Package

Process: Cover the acoustic cabinet with paper-made enclosure-cover the acoustic cabinet with wrapping film-perforation of acoustic cabinet

- ✓ Correct Steps to Dismantle Diesel Generator Parts

The diesel generator should be disassembled when it is repaired and maintained. Here is how to disassemble the diesel engine or alternator.

- The disassembly of diesel engine or alternator shall follow the following steps:

1. Disconnect a circuit that supplies power to an auxiliary device, such as hearing jacket.

2. Disconnect the battery charging line, remove the Generator set battery connection (when the negative electrode is removed first) and remove the battery if necessary.

3. If the generator has a hood, unscrew the bolts on each side of the same cover, remove the exhaust pipe, and then remove the lid.

4. When removing the control screen, remove all wires and support together, fully ensuring that all edges can be reconnected.

5. If the diesel engine and AC motor are to be removed, the rings of the diesel engine and alternator can be hoisted independently, but the bolts that hold them on the underframe must be removed first.

- Remove diesel engine only

1. If we only dismantle the diesel engine, remove the line hose from the diesel engine first.

2. If the alternator has only one foot on the base, the front end of the alternator is first supported when the diesel engine is removed.

3. Bolt off the top of the diesel engine on the base. Loosening the fixed bolts of the alternator may facilitate the removal of the diesel engine.

4. Remove the alternator fan protection cover.

5. Hang on with hooks or wooden supports and be careful not to damage the fan.

6. Remove joint bolts for diesel engine and alternator.

7. Use an overheat hoist or similar device to hold the rail of the diesel engine.

8. Now move the engine forward until it is completely detached from the alternator and can be lifted off the base.

- Dismantle alternator only

1. If the generator is only ready to be removed, then the diesel generator can be lifted from the base.

2. Remove the line hose.

3. Remove the bolts of the generator that are fastened to the base.

4. Remove the AC generator fan protective cover, the socket and the front part of the generator, fix it with a stem at the bottom center line, so as to limit the movement to the air gap, so that the bearing and the magnetic coil do not love the damage.

5. Use a machine or similar device to support the AC motor, and half the AC motor slid back to the chassis before lifting.

- ✓ **Lubricating of generator parts**

The function of the lubricating system is to send the lubricating oil to the friction surface of each moving parts of the diesel engine, which plays the role of friction reduction, cooling, purification, sealing and rust prevention, so as to reduce friction resistance and wear, and take away the heat generated by friction, thus ensuring the normal operation of the diesel engine. Lubrication system is mainly composed of oil pump, oil filter, oil radiator, various valves and lubricating oil passages.

Oil in your diesel generators engine is essential. It lubricates all the moving parts when running, reducing wear and prevents the diesel engine from seizing. It also helps to cool down some parts and it may help to inhibit corrosion when unused for short periods.

- Types of lubricating oils

There are two basic categories of lubricating oil: **mineral** and **synthetic**.

- ☞ Mineral oils are lubricating oils refined from naturally occurring crude oil.
- ☞ Synthetic oils are lubricating oils that are manufactured.
  - Parts needing lubrication

~ The rotor generates a moving magnetic field around the stator, which induces a voltage difference between the windings of the stator. This produces the alternating current (AC) output of the generator

~ Turbocharger: A turbocharger increases the engine's efficiency and power output by forcing extra air into the combustion chamber. ...

~ Piston and liners: The engine block consists of the cylinder liners, pistons and rings, Crankcase.

Theoretical learning Activity

- ✓ Ask trainees to brainstorm about the generator's cleaning techniques within groups

Practical learning Activity

- ✓ Trainees in pair troubleshoot the generator and identify the problem and cause) the generator when you press on starting button is not run.

Points to Remember (Take home message)

Main Parts of generator

Learning outcome 2.3 Formative assessment

1. Choose the correct answer :
   a) The lubricating oils of generator are divided into three main parts
   b) The lubricating oils of generator are divided into two main parts
   c) The lubricating oils of generator are divided into four main parts
   d) The lubricating oils of generator are of one type
   e) No answer in all above

Answer: b)

2. What are the mains parts of electrical generators ?

Answer :

- ✓ Electrical parts

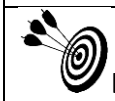
- ✓ Mechanical parts

(M.J.NEALE, 2001)

(Bird, 2003)

Learning outcome 2.4 : Complete the maintenance report

 Duration: 2hrs

 Learning outcome 2.4 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Prepare the maintenance report effectively
2. Fill the maintenance records correctly
3. Analyse the maintenance report effectively

 Resources

Equipment	Tools	Materials
✓ generator	✓ Pen ✓ Hammer ✓ Electrical knife	✓ Books ✓ Internet ✓ Manual reports templates

 Advance preparation:

- Preparation of the maintenance report
- Filing of maintenance records
- Analysis of the maintenance report

- Preparation of the maintenance report

A maintenance report is a document that holds specific data about inspections and tasks as well as their effects on overall maintenance operations. You use them to gain visibility on your operations, which you can then leverage into better decision-making.

There are three major elements that make up a maintenance system; risk assessment, maintenance strategy selection and maintenance task interval determination. These elements must be performed optimally in the maintenance management of a plant system in order to have a safe and reliable system at reasonable cost.

- ✓ The key elements of a report
  - ➢ Title page.
  - ➢ Table of contents.
  - ➢ Executive summary.
  - ➢ Introduction.
  - ➢ Discussion.
  - ➢ Conclusion.
  - ➢ Recommendations.
  - ➢ References.

❖ Maintenance report format contain the following content: Company/institution name, technician name, Date of maintenance, planned activities, planned date for next maintenance, Equipment specifications, Checklist table, and observation.

- Filing of maintenance records

A maintenance record includes the information of the asset, maintenance type, address of the location, date, description of the maintenance, parts replaced, etc. It is useful to keep track of the maintenance records of your assets for easy tracking of the performance of the assets.

Maintenance items	Service time				
	Daily	Weekly	Monthly	6 months	Yearly
Inspection	X				
Check coolant heater	X				
Check coolant level	X				
Check oil level	X				
Check fuel level	X				
Check charge-air piping	X				
Check/clean air cleaner		X			
Check battery charger		X			
Drain fuel filter		X			
Drain water from fuel tank		X			
Check coolant concentration			X		
Check drive belt tension			X		
Drain exhaust condensate			X		
Check starting batteries			X		
Change oil and filter				X	
Change coolant filter				X	
Clean crankcase breather				X	
Change air cleaner element				X	
Check radiator hoses				X	
Change fuel filters				X	
Clean cooling systems					X

- **Analysis of the maintenance report**

Maintenance metrics for better maintenance analysis

- **Time spent supporting production**

What is it?: The total time that the maintenance team spends on production-focused activities. Usually measured weekly, monthly, or quarterly.

How can you use it?: Everyone has to pitch in to complete a big order once in a while.

Follow-up work created after inspections

What is it?: The number of corrective work orders created from routine inspections. Usually measured monthly, quarterly, or annually.

How can you use it?: There are many different ways you can use this metric for maintenance analysis. You can sort it by machine, shift, or site to get insights into how your assets or team are performing. But the most useful is by task

- **Cost of follow-up maintenance vs expected cost of total failure**

What is it?: A comparison between the cost of corrective maintenance (i.e. labor and parts) and the cost of asset failure if maintenance is not done (i.e. lost production, labor, and parts).

How can you use it?: Use this type of maintenance analysis to plan your maintenance strategy. For example, if regular inspections cost you more than failure, you can likely go with a run-to-failure approach for an asset over a preventive one.

- **Cost by maintenance type**

What is it?: The total cost of maintenance (i.e. labor and parts) by maintenance type (ie. preventive, emergency, follow-up). Usually measured monthly, quarterly, and/or annually.

How can you use it?: Higher costs are usually the result of broken processes. This view allows you to find out which processes need work so you can increase efficiency.

- **Clean start-ups after maintenance**

What is it?: The number of times a production line starts without stoppages or waste after completed maintenance. This is measured monthly, quarterly, and annually.

How can you use it?: Include this metric in your maintenance analysis to draw a direct line between your team's work and increased output.

- **Size of backlog**

What is it?: The total number of hours of overdue and scheduled maintenance tasks. Track this metric weekly and monthly.

How can you use it?: This metric can be a godsend when it comes to getting your team some much-needed relief. Quantify the gap between available labor hours and your total backlog hours

- **Assets by downtime**

What is it? This is your heavy hitters list—the equipment that breaks down most often or takes the longest to repair. Keep tabs on these assets weekly, monthly, and quarterly.

How can you use it? This metric keeps your biggest problems visible. You might raise an eyebrow at that, but highly visible problems get solved the fastest. This kind of maintenance analysis can help you prioritize your problem-solving efforts, make decisions quickly, and measure their impact.

- **Planned maintenance percentage (last 90 days)**

What is it?: The ratio of planned maintenance to all other types of maintenance over the last 90 days.

How can you use it? This is a measure of progress, Going from reactive to planned maintenance doesn't happen overnight. The time frame allows you to make a clear connection between action and results. You can draw a line between what happened and its impact on your end goals.

- **Wrench time (last 90 days)**

What is it?: The amount of time technicians spend working on a piece of equipment as part of the total time it takes to complete a job. This is usually measured by job or as a weekly, monthly, and quarterly average.

- **Health and safety work orders completed**

What is it?: The number of work orders completed for health and safety or compliance purposes. This is usually tracked monthly, quarterly, and annually.

 **Theoretical learning Activity**

- ✓ Ask trainees to brainstorm about preparation of the maintenance report within groups)

 **Practical learning Activity**

- ✓ Trainees in pair perform a maintenance report
- ✓ Trainees in group of two or three fill the maintenance records

 Points to Remember (Take home message)

- ✓ The key elements of a report are:
  - ➢ Title page.
  - ➢ Table of contents.
  - ➢ Executive summary.
  - ➢ Introduction.
  - ➢ Discussion.
  - ➢ Conclusion.
  - ➢ Recommendations.
  - ➢ References.

 Learning outcome 2.4 Formative assessment

1. What is a maintenance report?

Answer: A maintenance report is a document that holds specific data about inspections and tasks as well as their effects on overall maintenance operations.

2. What are the elements of maintenance report format?

Company/institution name, technician name, Date of maintenance, planned activities, planned date for next maintenance, Equipment specifications, Checklist table, observation
(Mike, 2006)

Learning Unit 3: Repair electrical generators

Picture/s reflecting the Learning unit 3

STRUCTURE OF LEARNING UNIT

Learning outcomes:

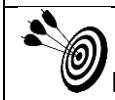
3.1 Identify damaged parts of electrical generators

3.2 Rectify detected faults

3.3 Complete the repair report

Learning outcome 3.1 Identify damaged parts of electrical generators


Duration: 10hrs


Learning outcome 1 objectives:

By the end of the learning outcome, the trainees will be able to:

1. To apply typical generator fault finding procedures

2. Recognize faulty parts/system


Resources

Equipment	Tools	Materials
✓ Generators ✓ Multimeter ✓ Generators spare parts	✓ Electrician tools	✓ Books ✓ Internet ✓ Service manuals


Advance preparation:

- Typical generator fault finding procedures
- Recognition of faulty parts/system

- **Typical generator fault finding procedures**

- **Typical generator fault finding procedures**
  - ❖ Visual inspection
  - ❖ testing
  - ❖ Assumptions (possible cause)
- **Recognition of faulty parts/system**
  - ❖ Engine (Spark plug, Starter motor, battery, injectors, air lock, fuel filter, air cleaners, fuel pumps, lift pump, turbocharger, cylinder, valves, rotor bearing, thermostat, fan belt)

- ❖ Control equipment (Fuses, wiring, relay contacts, connections)
- ❖ Alternator (windings, automatic voltage regulator AVR, diodes, connections, excitation, choke)

- Recognition of faulty parts/system

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

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. e) Air cleaners choked. f) Fuel pump timing out. g) Lift pump faulty.

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

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

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

Fault	Possible cause
Low power output	a) Inadequate fuel pressure. b) Air filters choked. c) Fuel injection pump timing incorrect. d) Faulty injection. e) Tappet clearance inadequate. f) Faulty turbocharger. g) Inlet manifold and/or cylinder head joints leaking

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.

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. g) Fuel injection pump timing out. h) Low oil level.

Fault	Possible cause
Inadequate fuel	a) Fuel supply system faulty. b) Faulty fuel lift pump. c) Fuel relief valve faulty. d) Choked fuel filters.

Fault	Possible cause
Exhaust emits black smoke	Excess fuel being used.

Fault	Possible cause
Machine becomes over-heated	a) Cooling air inlet blocked or obstructed. b) Cooling air discharge blocked or obstructed. c) Rotor bearings running hot. d) Machine overloaded. e) Short circuit between windings and/or windings to frame.

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 satisfac-torily only intermittently	Faulty or out of adjustment relay or auxiliary contacts.
Action	
Replace and/or readjust auxiliary and clean where necessary.	

Fault	Possible cause
Excessive 50 Hz buzz or hum	Dirty, rusty or badly aligned pole faces

Action

Clean, de-rust with fine emery paper and readjust.
Leave a minute film of oil on the parts concerned to retard formation of rust.

Fault	Possible cause
Overheating cable ends and terminations	Loose connections.

Action

Tighten all connections, making sure all dangerous voltages have first been switched off and cannot be switched on again whilst work is in progress.
Ensure all terminations subject to heat/load cycling i.e. the main cabling terminations are suitably lock nutted.

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. d) Open circuit in windings. e) Faulty automatic voltage regulator (AVR). f) Faulty diode in main rectifier assembly on the rotor. g) Open circuit of the gain and/or range control on the AVR. h) Hand operated voltage trimmer open circuit (if fitted).

Action

a) Check and set up correctly.
b) Check over and tighten all terminals.
c) Re-excite by flashing in accordance with manufacturers handbook.
d) Check for continuity in accordance with manufacturers handbook: renew if required.
e) Remove leads at voltage control unit terminal block, run set up to speed and flash excitor in accordance with the manufacturer's handbook. If the voltage appears then the AVR is faulty and should be tested out in accordance with the instructions given for testing A.V.R.'s.

f) Remove and test with ohmmeter; the forward resistance should be less than 1000 ohms and the reverse resistance greater than 100K ohms. Replace if necessary. N.B. When this fault occurs it is likely that more than one and possibly all the diodes may need replacing.

g) Check for continuity.

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.	

Theoretical learning Activity

- ✓ Ask trainees to brainstorm about the typical generators fault finding procedures within groups

Practical learning Activity

- ✓ Trainees in pair perform the demonstration of faulty parts physically

Points to Remember (Take home message)

Typical generator fault finding procedures
✓ Visual inspection
✓ testing
✓ Assumptions (possible cause)

Learning outcome 3.1 Formative assessment

1. Answer by true or false:

Typical generator fault finding procedures are

a) Visual inspection
b) Magnetic attraction
c) Testing
d) Turbine weight
e) Assumption (possible cause)

Answer:

a) T
b) F
c) T
d) F
e) T

2. Enumerates any three alternator faults

Answer:

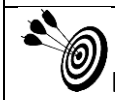
No output voltage
Unstable output voltage
Incorrect voltage output
Output voltage too high and cannot be reduced on controls

(ELSEVIER, 1971)

(Bird, 2003)

Learning outcome 3.2: Rectify detected faults


Duration: 10hrs


Learning outcome 3.2 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Identify correctly general engine faults

2. Identify correctly Control equipment faults

3. Identify correctly Alternator faults

4. Rectification of mentioned faults

5. After-repair testing of electrical generators

Resources

Equipment	Tools	Materials
✓ Multimeter ✓ Generator ✓ PPE	✓ Electrician tools	✓ Books ✓ Internet ✓ Service manuals

Advance preparation:

- General engine faults
- Control equipment faults
- Alternator faults
- Rectification of the mentioned faults
- After-repair testing of electrical generators

- **Rectify general** engine faults

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

Action

a) Check voltage.

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

- Voltage at starter motor terminals.

b) If voltage presents:

- 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. e) Air cleaners choked. f) Fuel pump timing out. g) Lift pump faulty.
Action	

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.

f) Reset timing.

g) Change lift pump.

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

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. d) Tappet clearances incorrect.
Action	

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. d) Faulty injection. e) Tappet clearance inadequate. f) Faulty turbocharger. g) Inlet manifold and/or cylinder head joints leaking
Action	

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

b) Clean air filters.

c) Reset timing.

d) Change injector(s).

e) Adjust tappets.

f) Replace turbocharger.

g) Renew gasket or joint packings as necessary.

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. g) Fuel injection pump timing out. h) Low oil level.
Action	

Check out as detailed in 'overheating' below:

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

b) Drain, flush out and refill.

c) Carefully clean all air passages.

d) Adjust tension.

e) Fit an identical replacement thermostat.

f) Reset timing.

g) Check for leaks &fill to level indicated on dipstick.

Fault	Possible cause
Inadequate fuel	a) Fuel supply system faulty. b) Faulty fuel lift pump. c) Fuel relief valve faulty. d) Choked fuel filters.
Action	
a) Check all pipe joints for leaks. b) Replace with identical unit. c) Examine and clean valve. d) Change filter elements.	

Fault	Possible cause
Exhaust emits black smoke	Excess fuel being used.

Action

Change pump if maximum fuel stop seal has been broken.

Fault	Possible cause
Machine becomes over-heated	a) Cooling air inlet blocked or obstructed. b) Cooling air discharge blocked or obstructed. c) Rotor bearings running hot. d) Machine overloaded. e) Short circuit between windings and/or windings to frame.

Action

a) Clean screen protection and remove any obstruction preventing air entering the air inlet.
b) Proceed as for air inlet above.
c) Too much or too little grease. Remove bearing from machine and check conditions. Repack with correct grade and quantity of grease before reassembling.
d) Check that the electrical overload equipment and circuit breaker are working satisfactorily.
e) Replace windings.

- CONTROL EQUIPMENT

The faults liable to occur in this equipment will depend upon the design of the control scheme supplied.

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 satisfac-torily only intermittently	Faulty or out of adjustment relay or auxiliary contacts.

Action

Replace and/or readjust auxiliary and clean where necessary.

Fault	Possible cause
Excessive 50 Hz buzz or hum	Dirty, rusty or badly aligned pole faces
Action	
Clean, de-rust with fine emery paper and readjust. Leave a minute film of oil on the parts concerned to retard formation of rust.	

Fault	Possible cause
Overheating cable ends and terminations	Loose connections.
Action	
Tighten all connections, making sure all dangerous voltages have first been switched off and cannot be switched on again whilst work is in progress. Ensure all terminations subject to heat/load cycling i.e. the main cabling terminations are suitably lock nutted.	

- 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. d) Open circuit in windings. e) Faulty automatic voltage regulator (AVR). f) Faulty diode in main rectifier assembly on the rotor. g) Open circuit of the gain and/or range control on the AVR. h) Hand operated voltage trimmer open circuit (if fitted).
Action	
a) Check and set up correctly. b) Check over and tighten all terminals. c) Re-excite by flashing in accordance with manufacturers handbook. d) Check for continuity in accordance with manufacturers handbook: renew if required. e) Remove leads at voltage control unit terminal block, run set up to speed and flash excitor in accordance with the manufacturer's handbook. If the voltage appears then the AVR is faulty and should be tested out in accordance with the instructions given for testing A.V.R.'s.	

f) Remove and test with ohmmeter; the forward resistance should be less than 1000 ohms and the reverse resistance greater than 100K ohms. Replace if necessary. N.B. When this fault occurs it is likely that more than one and possibly all the diodes may need replacing.

g) Check for continuity.

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.	

Theoretical learning Activity

- ✓ Ask trainees to brainstorm about alternator faults within groups
- ✓ Ask trainees to brainstorm about engine faults within groups

Practical learning Activity

- ✓ Trainees in pair perform Rectification of the generator faults

Points to Remember (Take home message)

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

a) Check all pipe joints. Bleed fuel system.
b) Clean air cleaners.
c) Change lift pump.
d) Change injector(s).


Learning outcome 3.2 Formative assessment

1. When engine suffer overheating fault; what actions you can take to remove it?

Answer: Check out as detailed in 'overheating' below:

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

b) Drain, flush out and refill.

c) Carefully clean all air passages.

d) Adjust tension.

e) Fit an identical replacement thermostat.

f) Reset timing.

g) Check for leaks &fill to level indicated on dipstick.

2. When the engine fails to fire; the following actions can be taken. Which is not true?

a) Operate excess fuel device.

b) Bleed fuel system.

c) Clean air cleaners.

d) Switch off the engine

e) Change lift pump.

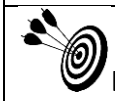
Answer: d)

(ELSEVIER, 1971)

(Mike, 2006)

Learning Outcome 3.3: Complete the repair report


Duration: 10hrs


Learning outcome 3.3 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Preparation of the repair report
2. Keeping records of repair activities
3. Analysis of the repair report
4. Billing the repair work


Resources

Equipment	Tools	Materials
✓ PPE	✓ Books ✓ Internet ✓ Service manuals ✓ Repair report templates	✓ Papers ✓ Books ✓ Internet ✓ Service manuals ✓ Repair report templates


Advance preparation:

- Preparation of the repair report
- Keeping records of repair activities
- Analysis of the repair report
- Billing the repair work

- **Preparation of the repair report**

Repair report format (Company/institution name, technician name, Date of repair, Equipment specifications, Fault description) also repair report are in form of table for simplification of analysis after recording of it.

Company/institution name	technician name	Date of repair	Equipment specifications	Fault description

- Keeping records of repair activities

Documenting every repair or maintenance work done on your equipment will help you process warranty claims much easier. Keep a record of the type of maintenance work done to your equipment as well as the exact time and date repairs were done as this information will help determine your rights for the warranty claims.

What is the role of record keeping?

Their purpose is to provide reliable evidence of, and information about, 'who, what, when, and why' something happened. In some cases, the requirement to keep certain records is clearly defined by law, regulation, or professional practice.

Here we list the benefits of keeping a maintenance record.

a) Prevent expensive repair works from happening
b) Helps you create specialised maintenance programs
c) Prevent problems regarding warranty claims
d) It increases the safety of operators
e) Helps you track who is accountable for a piece of equipment
f) It increases the resale value of the equipment

- **Repair report analysis**

A repair report is a document that contains specific information about your past repair actions and their effect on cost, assets, and business performance.

Level of repair analysis (LORA) is a process used to determine when and where an asset should be repaired. LORA is intended to optimize repair decisions in order to minimize the overall life cycle costs of assets.

Repair is categorized into four classes based on who has initiated the repair and who has taken steps to resolve it: self-initiated self-repair (SISR), other-initiated self-repair (OISR), self-initiated other-repair (SIOR) and other- initiated other-repair (OIOR)
Analysis of the repair report

In whatever situation, you need to identify problem equipment regularly using a maintenance or work order template. This can help you determine what needs fixing and what still works.

Here are the steps you need when analyzing the report:

 The repair costs of each piece of equipment You can use the report to get an estimation of the total repair costs. Look at the planned and unplanned repair costs for the previous year. Don't look at short periods as the cost values could get skewed if some equipment requires heavy repair only during specific times of the year. Find out which piece of machinery is the most expensive to repair. Review the cost and look for anything that seems to be out of place. Filter out such equipment on your list.

 The duration of equipment downtime Review the downtime of equipments for the previous year. There might be unavailability of parts or some of the repair personnel got promoted to other jobs. For such reasons, downtime for some equipment may seem higher because it took a long time to repair them. Filter out these pieces of equipment from the list.

 The history of repair work requests and complaints Review the reported work requests and complaints for the previous year. Look for the assets that registered many requests or complaints associated with repair work.

 Equipment statistics Often, you can use equipment statistics for specific purposes. But such might not be that useful if you have many types of equipment as you can't compare their statistics. However, in the case of having similar equipment that you use in similar ways, this is when a comparison of statistics can happen. Investigate any oddities in your equipment statistics.

- **Billing the repair work**

Role of billing the repair work

1. Prevent expensive repair works from happening

With constant use, your equipment is prone to wear and tear. Performing routine inspections allow you to see and repair small damages before they become a big problem. Documenting these inspections and small repairs help you keep track of all the maintenance work that your equipment has undertaken, ensuring that each machine is in tip-top shape before putting them to work.

2. Helps you create specialised maintenance programs

Each equipment go under different working conditions and they have different limitations as well. With the help of routine check-ups, you will be able to determine and record the differences of each individual equipment with regards to maintenance works. In turn, this information will help you in creating maintenance programs specifically catering to each individual equipment on your fleet.

3. Prevent problems regarding warranty claims

Documenting every repair or maintenance work done on your equipment will help you process warranty claims much easier. Keep a record of the type of maintenance work done to your equipment as well as the exact time and date repairs were done as this information will help determine your rights for the warranty claims.

4. It increases the safety of operators

If a piece of plant or equipment is well maintained, the risk of accidents occurring due to malfunctioning machinery is reduced. When incidents involving faulty machinery occur, there's a big chance that the operator is the first one to be affected. Having an equipment's maintenance history documented will help you keep track of your machinery's health. This enables you to

schedule an inspection when needed, at the same time it ensures that your equipment are safe to work with.

5. Helps you track who is accountable for a piece of equipment

One machine might have multiple operators. Performing a routine inspection and documenting the findings after every project will help you track down who is accountable for any damage inflicted on your machinery. Keeping these types of records will also encourage operators to take better care of the equipment.

6. It increases the resale value of the equipment

Keeping a detailed record of all the repairs that a piece of equipment went through will help increase its resale value. Buyers thoroughly assess a piece of equipment before purchasing it, most especially if the machines have already been used. Presenting potential buyers a documentation of your equipment's maintenance history lets them know that the equipment they are planning to buy have been well taken care of.

 **Theoretical learning Activity**

- ✓ Brainstorm on repair report
- ✓ In pair Group discuss on the keeping records of repair activities

 **Practical learning Activity**

- ✓ Trainees in pair provide billing the report work

 Points to Remember (Take home message)

Repair report analysis
A repair report is a document that contains specific information about your past repair actions and their effect on cost, assets, and business performance.

 Learning outcome 3 .3formative assessment

1. What is the role of record keeping?

Answer: Their purpose is to provide reliable evidence of, and information about, 'who, what, when, and why' something happened. In some cases, the requirement to keep certain records is clearly defined by law, regulation, or professional practice.

2. What is Repair report analysis?

Answer: A repair report is a document that contains specific information about your past repair actions and their effect on cost, assets, and business performance.

(Mike, 2006)

(HUBERT, 1969)

Learning Unit 4 : Clean the workplace

Picture/s reflecting the Learning unit 4

STRUCTURE OF LEARNING UNIT

Learning outcomes:

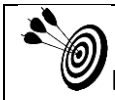
1.1 Arrange tools, equipment and materials

1.2 Clean tools and working area

1.3 Manage waste materials

Learning out come 4.1 Arrange Tools, Equipment and materials

Duration: 2hrs



Learning outcome 1 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Arrange properly tools and equipment at the workplace
2. Store properly non-used materials**,** fuel, lubricating oil and faulty parts

Resources

Equipment	Tools	Materials
✓ Personal protective equipment ✓ Wheelbarrow ✓ generator	✓ pliers ✓ screwdrivers ✓ electrical knife	✓ Internet ✓ Service manuals

Advance preparation:

- Arrangement of tools and equipment
- Storing of non-used materials **,** fuel, lubricating oil**,** faulty parts

- **Arrangement of tools and equipment**

The benefits to organizing and arranging tools and equipment at the workplace

- Proper Maintenance. By storing your tools, you'll increase their durability.
- Improved Accessibility. By properly storing your tools, you'll be able to find the tools that you need promptly.
- Maximize Your Space.

The rules and steps followed for arrangement of tools and equipment

- Keep similar items together. It is best to organize tools by function

here are a few simple steps that will leave your workshop the envy of your neighbours.

- Lay everything in a single row. (This makes it easy to see what you have, and how it should be organized.
- Choose a place where they could be organized
- Hang them to a flat panel board mounted on the wall
- If you have a tool chest organize tools in categories ex.metal work one drawer or bin and woodworking tools in another.

- If you live in a small space (like an apartment), opt for a flat toolbox or designate a spare drawer to your tools.
- If the above suggestions are not available, hang them on a bar mounted on the wall.

- Clean the workplace. Nothing feels more organized than a clean workshop. Polishing the windows is not necessary but sweep the floor and the bench. Don't forget to remove cobwebs from the top corners
- Throw away unwanted items. These include small pieces of wood and thorn nails
- Don't leave duplicate or spare tools. For example, if you have 3 identical screwdrivers, keep one in the workplace and put the others elsewhere
- Categorize the tools. For example, put cutting tools near other cutting tools. Put tools you use more often nearer to your workplace and less used tools further

 Theoretical learning Activity

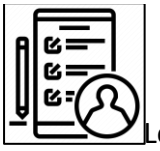
In pair group, discuss the step used for workplace arrangement

 Practical learning Activity

After completing the task provided by trainer, trainee in pair, arrange the workplace

 Points to Remember (Take home message)

- ✓ Keep similar items together. It is best to organize tools by function
- ✓ Categorize the tools. For example, put cutting tools near other cutting tools. Put tools you use more often nearer to your workplace and less used tools further
- ✓ Don't leave duplicate or spare tools. For example, if you have 3 identical screwdrivers, keep one in the workplace and put the others elsewhere

 Learning outcome 4.1 formative assessment

Written assessment

1. What are the three benefits of arranging workplace?

   Answer:
   - Proper Maintenance.
   - Improved Accessibility.
   - Maximize Your Space
2. True and false question, after completing the work at the workplace

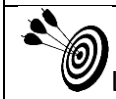
a) Keep similar items together before leaving (true)
b) Do not Clean the workplace (false)

(Theraja)

(Bird, 2003)

Learning outcome 4.2 Clean tools and working area


Duration: 2hrs


Learning outcome 4.2 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Identify correctly the Purpose of cleaning tools and working area
2. Identify clearly the Methods of cleaning


Resources

Equipment	Tools	Materials
✓ Personal protective equipment ✓ Surface cleaner ✓ Grease cleaning machine	✓ Brush ✓ Cleaning cloth, Air blower, ✓ Broom ✓ Pliers ✓ Screw driver ✓ hammer	✓ Oil stain ✓ Degreaser Cleaner ✓ Water ✓ soap


Advance preparation:

Purpose of cleaning tools and working area

Methods of cleaning

○ Purpose of cleaning tools and working area

There are several benefits of cleaning tools:

1. Increased efficiency: Proper cleaning tools are designed to be efficient and effective, which means they can help you clean more quickly and thoroughly than if you were using improvised tools or techniques.

2. Better cleaning results: Quality cleaning tools are designed to remove dirt, grime, and other contaminants more effectively than low-quality or improvised tools. This means you can achieve better cleaning results with less effort.
3. Longer tool lifespan: Investing in quality cleaning tools can help you save money in the long run by reducing the need for frequent replacements. High-quality tools are typically more durable and long-lasting than low-quality or improvised tools.
4. Safer cleaning: Proper cleaning tools are designed to be safe and easy to use, which can help reduce the risk of accidents or injuries during the cleaning process.
5. Healthier environment: By using proper cleaning tools, you can help remove harmful contaminants and bacteria from your home or workplace, which can lead to a healthier and more hygienic environment.

They are several Benefits of cleaning workspace

- Create an effective use of space
- Establishes better control tools and materials
- Creates opportunity for discussion
- Reduces injuries
- Increases productivity
- Reduces fire hazards
- Improves
- Creates morale
- Creates strong first impressions
- Easily identify missing items
- Removes harmful materials

- **Methods of cleaning**

✓ Blowing:

Blowing is to remove loose scale and debris prior to start up using compressed air as the cleaning medium.

Example : air blower

✓ Sweeping:

Sweeping is to clean a surface with or as if with a broom. : to move swiftly, forcefully, or devastatingly.

Example: broom

- ✓ Brushing:

brush, device composed of natural or synthetic fibres set into a handle that is used for cleaning tools and workplace
examples: rubber brush

- ✓ Wiping:

Wiping IS to remove everything from (something) usually used as (be) wiped clean
Example of wiping tools: cleaning cloths

- ✓ Removal of waste materials

Removal of waste materials is the collection, processing, and recycling or deposition of the waste materials.

Theoretical learning Activity

trainees brainstorm about the methods of cleaning within pair groups)


Practical learning Activity

Trainees in group clean the workplace after completing the maintenance.


Points to Remember (Take home message)

- ✓ **Methods of cleaning are:** Blowing, Sweeping, Brushing, Wiping
- ✓ Benefits of cleaning workspace:
  - Create an effective use of space
  - Establishes better control tools and materials
  - Creates opportunity for discussion
  - Reduces injuries


Learning outcome 4.2 formative assessment

1.List the four benefit of cleaning workspace

Answer:

- Create an effective use of space
- Establishes better control tools and materials
- Creates opportunity for discussion
- Reduces injuries

2. what are the two methods of cleaning workplaces

Answer:

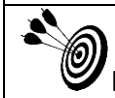
- Brushing
- Blowing
- Sweeping
- Brushing
- Wiping

(Bird, 2003)

(Albert, 2010)

Learning outcome 4.3 :Manage waste materials

 **Duration: 1hrs**

 Learning outcome 4.3 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Select the area properly for storing waste material
2. Store and treat clearly waste materials

 **Resources**

Equipment	Tools	Materials
✓ Personal protective equipment ✓ wheelbarrow	✓ Brush ✓ Air blower, ✓ Broom ✓ Pliers ✓ Screw driver ✓ hammer	✓ Books ✓ Internet ✓ Service manuals

 Advance preparation:

- Selection of area for storing waste materials
- Storing and treatment of waste materials

- Selection of area for storing waste materials

  - Storage Area and Containment Requirements

- Materials will be stored on impervious surfaces, if possible, on plastic groundcovers, or with secondary containment to prevent .spills or leaks from infiltrating the ground.
- Only necessary quantities of materials will be stored, and materials will not be overstocked.

- Incompatible materials will be stored in segregated areas. Materials that are incompatible will not be placed in the same container or in an unwashed container that previously held such material
- Hazardous waste containers will remain closed during transfer and storage, except when it is necessary to add or remove waste.
- Only personnel trained to accept, unload, package, label, load, prepare shipping papers, and transport hazardous materials will be allowed to perform these tasks.

  - Waste-Specific Management and Disposal Requirements regulations.

- Waste generated as part of operation procedures, such as water-laden dredged materials and drilling mud, will be contained and not allowed to flow into drainage channels or receiving waters
- Deposited solids will be removed from containment areas and from containment systems as needed and at the completion of the Project.
- All broken asphalt and concrete will be collected, recycled when feasible, and disposed of in accordance with local, state, and federal requirements.
- Absorbent materials and rags that have been used to clean any spilled fuel will be secured in appropriate storage containers and disposed of at a proper waste-handling facility.
- If concrete or paint residue remains after drying, the area will be swept and the residue will be removed to avoid contact with storm water.
- All temporary construction materials such as markings, barriers, or fencing will be removed following completion of construction activities in that area.
- The recyclable materials identified will be transported to an appropriate local recycling center. Hazardous waste generated at work areas will be transported at the end of each workday to a consolidation site. Consolidation sites may include the ECO Substation, Boulevard Substation, and contractor staging areas.

- **Storing and treatment of waste materials**

You should separate waste materials into different types (paper and cardboard, plastics, metals, etc) for storage, transport and recycling. You should store your waste securely in sealed, labelled containers ready for recycling or disposal.

The standard waste disposal methods are defined and described below:

- Recycling: Recycling refers to both the direct reuse of used products
- Incineration: Combustible waste from workplace and waste wood that is not suitable for recycling undergo thermal treatment in waste incineration plants or waste wood furnaces. The heat released in the process is used to generate electricity and heat buildings
- Landfills: Residues from waste incineration or waste that is not suitable for material recycling or thermal treatment are deposited in landfills that are compliant with the legal requirements

Storing and treatment of waste materials can be done by according:

- Biodegradable

Biodegradation is the breakdown of organic matter by microorganisms, such as bacteria and fungi. Biodegradable waste is a form of waste, originating naturally from plant or animal sources, which may be degraded by other living organisms.

Examples of Biodegradable material are:

- ❖ Human and animal waste. (Such as Fecal matter)
- ❖ Plant products such as wood, paper, food material etc.
- ❖ Remains of dead organisms.
- ❖ Egg shell

- Non-biodegradable

A Non-Biodegradable material can be defined as a type of material that cannot be broken down by natural organisms and serve as a source of pollution.

examples of non-biodegradable wastes are:

- ❖ Plastic
- ❖ glass,
- ❖ metals, etc.

S.No	Biodegradable	Non-Biodegradable
1	The degradation process in Biodegradable waste is fast	The degradation process in Non-Biodegradable waste is slower than in biodegradable
2	Biodegradable waste is decomposed and degraded by microbes or microorganism	Non-Biodegradable waste cannot be decomposed by microbes or naturally
3	Biodegradable waste is not collected but is used up in a short time	Non-Biodegradable waste is often collected
4	Biodegradable waste has become part of biogeochemical cycles and give back quick turnover	Most of the Non-Biodegradable waste can never enter biogeochemical cycles, very slow and more harmful for the earth

- **Recyclable**

"Recycling is the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products. Recycling can benefit your community and the environment.

Benefits of Recycling

- Decrease waste that goes into landfills and incinerators
- Conserves natural resources such as timber, water, and minerals
- Increases economic security
- Prevents pollution
- Saves energy
- Supports American manufacturing and conserves valuable resources
- Helps create jobs

 Theoretical learning Activity

- ✓ Ask trainees to brainstorm about the benefit of recycling within groups
- ✓ In Group discuss on methods of waste treatment

 Practical learning Activity

Trainees in pair perform, after arranging the workplace incinerate the combustible material

 Points to Remember (Take home message)

- ✓ **Recycling** is the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products. Recycling can benefit your community and the environment.
- ✓ **Methods of waste treatment**
  - Recycling
  - Incineration
  - Landfills

 Learning outcome 4.3 formative assessment

Written assessment

1. Define clearly the following term
   Recycling:

Answer:

recycling: the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products

2. Numerate the three method used in waste treatment?
   Answer:
   - Recycling
   - Incineration
   - Landfills
3. Multiple choice questions

Recycling reduces

(A) energy usage
(B) air pollution
(C) water pollution
(D) all of the above

Answer: **Recycling reduces**

(A) all of the above

(Bird, 2003) (Jones, 2007)

Practical assessment

Summative Assessment

Integrated situation

MASAKA FARM Ltd is proposing maintenance of one of two standby generators in KICUKIRO District, Masaka Sector. The generator of 1500 rpm 50Hz 360kVA 230/400V, 0.8 lagging consists of an engine and a generator mounted on a common base frame, whose excitation is controlled by an automatic voltage regulator (AVR) and control system are PLC based systems. According to the information from generator's operator, generating set is running but gives no output. As generator maintenance technician, you are asked to identify possible causes, rectify them and fill the maintenance record within four hours.

Resources

- Combination pliers
- Hammer
- Screw drivers
- Electrician knife
- Insulating tape
- Bolts
- Screws
- Ground wire
- Power cable
- Digital multimeter
- Mechanical keys
- Thermometer
- Maintenance records
- Oil filters
- Fuel filters
- Megger
- Mechanical keys
- PPE

- Air blowers
- Brush
- Cleaning cloth
- Tachometer

Assessment Criterion 1: Quality of Process

Checklist	Score	
	Yes	No
Indicator: Tools, materials and equipment are selected		
Type of tools		
Type of materials		
Type of equipment		
Indicator: The workplace is prepared		
Cleanness		
Proper arrangement of tools		
Proper arrangement of materials		
Proper arrangement of equipment		
Indicator: Generator drawing is interpreted		
Description of electrical drawing		
Indicator: The contactor of plug is checked		
continuity of excitation coil		
excitation coil produces appropriate flux		
Contacts open/close properly		
Indicator: The wires inside control panel are checked		
Proper connection		
Test of continuity		
Indicator: The exciter is checked		
Type of battery		
Depth of discharge		
Indicator: The stator of alternator is checked		
Insulation test		
Test of continuity		
Indicator: The rotor of alternator is checked		
Insulation test		
Test of continuity		
Indicator: The Carbon brush is checked		
cleanness		
Appropriate length of brush		
Indicator: Detected fault is rectified		
Output voltage		
Indicator: Generator is tested		
Functionality testing		
Open circuit test		
Short circuit test		
Ground fault test		
Indicator: Tools, materials and equipment are cleaned		
Proper arrangement techniques of tools		
Proper arrangement techniques of materials		
Proper arrangement techniques of equipment		
Indicator: The waste materials are managed		

Types waste materials		
Waste materials disposal		
Indicator: Maintenance report is done		
Filled report format		
Observation		

Assesment Criterion 2: Quality of product

Checklist	Score	
	Yes	No
Indicator: Bolts are tighten		
Types of bolts		
Tightness of bolts		
Standardised bolts		
Indicator: Generator's spare parts are fixed		
Frame is fixed and cleaned		
Steadiness		
Fitness		
Indicator: Generator is maintained		
Output generation check		
Observation		

Assesment Criterion 3: Relevance

Checklist	Score	
	Yes	No
Indicator: Materials are well used		
No wasted materials		
Indicator: Output voltage is delivered		
Type of voltage		
Level of voltage		
Frequency of voltage		
Indicator: Time is respected		
Given required(4hours)		
Observation		

Safety

Checklist	Score	
	Yes	No
Indicator: PPE are used		
Gloves		
Over-coat/overall		
Safety shoes		
Helmet		
Nose protection mask		
goggles		
Proper use of each PPE		
Indicator: The generator is protected		
Proper grounding		
Observation		

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