RQF LEVEL 5

TRADE: HYDROPOWER

MODULE CODE: HPOHP 501

TEACHER'S GUIDE

Module name: HYDROPOWER PLANT MAINTENANCE

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Acronyms

PPE Personal Protective Equipment

RQF Rwanda Qualification Framework

HPP Hydropower Plant

Introduction

A hydropower plant has an advantage in that it does not need fuels for its operation as compared with oil or thermal power plants. However, there are no differences between both types of plants in that appropriate operation and maintenance (O&M) are essential for their long-term operation. They can be operated for long periods if its facilities are properly operated and maintained. We should effectively utilize hydropower because aside from being an indigenous energy resource, it is also renewable. We have to operate and maintain micro-hydro power plants with strict compliance to the operation and maintenance manuals. In general, operators of micro-hydro power plants should understand the following:

（1）Operators must efficiently conduct operation and maintenance of a plant complying with the work plans, rules and regulations.

（2）Operators must familiarize themselves with all the plant components and their respective performance or corrective and preventive functions. Furthermore, they must also be aware of measures against various accidents for prompt recovery.

（3）Operators must always check conditions of facilities and equipment. When they find some troubles or accidents, they must inform a person in charge and try to remedy the situation.

（4）Operators must try to prevent any accidents. For this purpose, they should repair or improve facilities preventively as necessary. Operation and maintenance manuals should basically be prepared for each plant individually before the beginning of operation. The following are general manuals of operation and maintenance for micro-hydro power

Module Code and Title: HPOHP 501: HYDROPOWER PLANT MAINTENANCE

Learning Units:

1. Prepare for HPP maintenance
2. Execute preventive maintenance
3. Repair faults in HPP systems
4. Clean the workplace

1. **Learning Unit** 1: Prepare for HPP maintenance

Picture/reflecting the Learning unit 1

STRUCTURE OF LEARNING UNIT

Learning outcomes:

1.1 Identify the work to be done

1.2 Prepare tools, equipment and materials

1.3 Identify PPE

Learning outcome 1.1 **Identify the work to be done**

Duration: 2hrs

Learning outcome 1 objectives:

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

- Identify properly the duties and responsibilities of HPP maintenance technician
- Interpret properly drawings and manuals of different HPP components
- Interpret properly HPP operation and maintenance manuals

Resources

Equipment	Tools	Materials
- Voltmeter and Ammeter - Wattmeter - VAR-meter and VA-meter - Phase-meter - Ohmmeter - Thermometer - Tachometer - Multi-meter - Pressure switch - Pressure gauge - Flow sensors - Hydraulic meters - Pneumatic meters - Hygrometer - Overcoat and overall - Gloves - Safety shoes - Helmet - Earmuff and Goggles - Nose protection - mask	- Books - HPP operation and maintenance manuals - Hand-out notes - Internet	✓ Lubricating oil ✓ Fuel ✓ Cleaning equipmen

Advance preparation:

- Drawings and manuals of different HPP components
- Duties and responsibilities of HPP maintenance technician
- HPP operation and maintenance manuals

Indicative content 1.1: **Duties and responsibilities of HPP maintenance Technician**

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

- Duties and responsibilities of HPP maintenance Technician

The following are duties and responsibilities of HPP maintenance Technician

- Monitor and control activities associated with hydropower generation.
- Operate plant equipment, such as turbines, pumps, valves, gates, fans, electric control boards, and battery banks.
- Monitor equipment operation and performance and Make necessary adjustments to ensure optimal performance.
- Perform equipment maintenance and repair as necessary.
- Troubleshoot, adjust, and replace AC and DC electrical equipment such as controls, proximity sensors, fuses, motor starters, relays, switches, and timers.
- Repair and maintain high pressure pasteurization equipment.
- Inspect, troubleshoot, repair and/or replace mechanical components such as motors, drive chains,

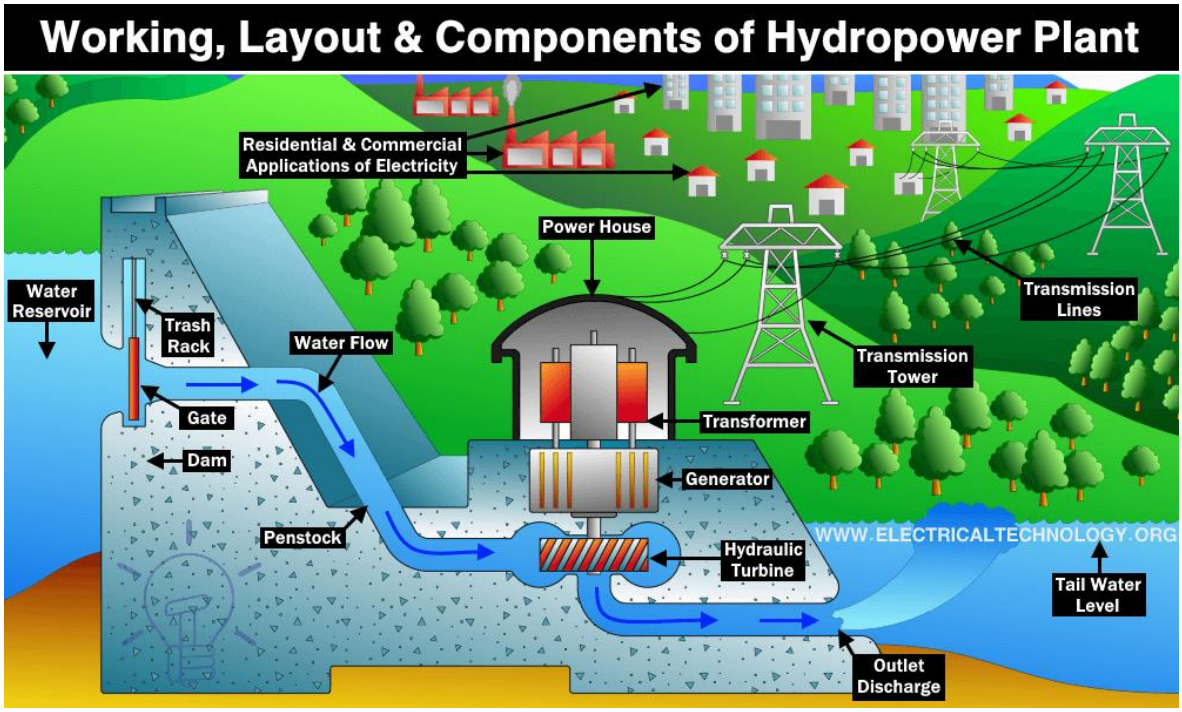
sprockets, sheaves, pulleys, rollers, conveyor belts, bearings, and transfer plates.

- Inspect, troubleshoot, repair and/or replace pneumatic equipment such as hydronic and hydraulic seals, high pressure components, air compressors, pumps, hoses, and cylinders.
- Performs preventative maintenance inspections of plant equipment such as conveyors, water heaters, water pumps, heat exchangers, evaporators, fans and powered industrial equipment.
- Welding of equipment such as frames, conveyors, package handling equipment, carts, and guards.
- Performing routine maintenance around the building such as fixing structural damage and electrical wiring repairs.
- Repairing broken or leaking plumbing to avoid water damage and restore full use of water fixtures
- Understand and use computer software for documenting all daily activity including submitting accurate parts requests.
- Responsible for the overall Safety and cleanliness of equipment and area.
- Adherence to the facility's Document Control Policy following completion of training.
- Electrical, hydraulic trouble shooting and fabrication of light processing equipment lines.
- Assist with trouble shooting and maintenance for electric, propane forklift warehouse equipment.
- Light plumbing and refrigeration skills a plus but not required.

Indicative content 1.2: **Interpretation of drawings and manuals of different HPP components**

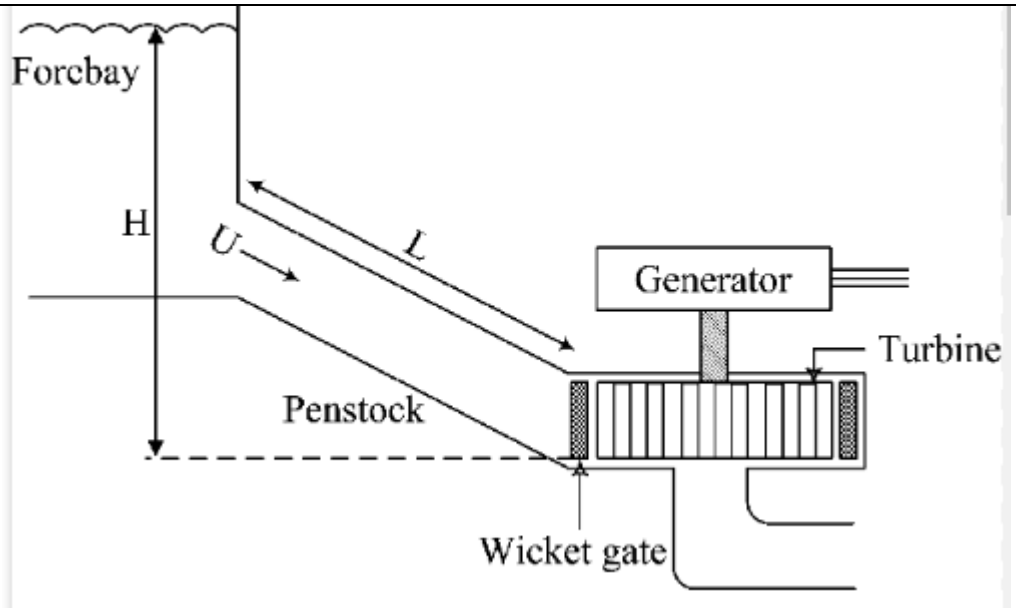
Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

Interpretation of drawings and manuals of different HPP components



The major components of a Hydroelectric Power Plant

- Head race tunnels/channels.
- Surge shaft/surge chambers.
- Pressure shaft/Penstock.
- Underground and surface power house.
- Tailrace channel or tailrace tunnel.



Simplified schematic of Hydropower plant

Indicative content 1.3: **Interpretation of HPP operation and maintenance Manuals**

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

- **Interpretation of HPP operation and maintenance manuals**

Operation and maintenance manuals, instructions and guidelines are all the same. Basically, they are the directives for users, i.e., operators/ maintenance personnel of the structures, equipment, instruments, accessories, etc. However, while the manuals/ instructions are prepared specifically for specific equipment by manufacturers/ suppliers, the guidelines being prepared by the regulatory authority or on its behalf for general reference purpose and for standardization purpose of the operation and maintenance activities, in no way, can be substitute for manuals or instructions for operation and maintenance provided by the concerned manufactures. It should also to be noted that the hydropower station equipment are custom built, which cannot be fully assembled or tested at manufacturer's shop. Hence, they need to be tested after erection at the powerhouse; and records of actual performance of the equipment including their operation characteristics need to be established.

The operation of hydropower plants comprises: (i) operation of hydro-mechanical works such

as gates, stop logs, valves, etc. to regulate the discharge through turbines, (ii) operation of generating equipment such as turbines and generators, and (iii) synchronization into a Grid (Power supply system). A number of checks are to be done particularly before starting the machine. The following are the activities to be carried out for operation of the hydropower plants after the general check-up as mentioned above:

- ✓ For intake gate opening, check intake gate power supply and hoisting system, give raising command and check gate position in raised condition.
- ✓ For Inlet Valve Opening, put oil pumps on 'auto' mode, open bye-pass valve manually or give opening command to by-pass auto valve, check water pressure on spiral side, and then give opening command to inlet valve on equalized pressure.
- ✓ For turbine operation, put oil pumps on 'auto' mode to maintain required pressure in pressure accumulator, check availability of Nitrogen cylinder and check also pressure of the same for systems using compresses nitrogen, check air pressure for maintaining proper oil level in pressure accumulator (if provided), open cooling water for bearings, open shaft seal water, put brake on 'auto' mode, unlock guide vane lock, fix GV (Governor) opening limit, and put machine on 'auto' mode.
- ✓ For generator operation, select AVR Auto/Manual mode as required, keep fire fighting system operative (where provided), switch on DC supply for excitation flashing, at 30% of generator voltage DC supply from battery cuts off, at 90% speed switch on generator excitation (if not on auto), start machine on 'Auto' or 'Manual' mode as required.
- ✓ For synchronization, check grid voltage and frequency, check generator voltage and frequency, reduce or increase generator voltage & frequency to match with line voltage & frequency, put synchroscope in 'ON' position. Needle will start moving and lamps will start glowing. Needle on 12o clock position and lamps on dark position indicate that voltages and frequencies of grid and generator respectively are matching, at equal grid & generator voltage and frequency, close generator breaker, now generator is synchronized with grid, and then take minimum prescribed load immediately.
- ✓ For checks after synchronizing and taking load, unit control board supply is changed to Unit Auxiliary Transformers, Change excitation from "manual" to 'Auto mode, transformer "Motor for cooling water supply" started, all parameters in control room are matching and correct, and general check up for machine and other unit auxiliaries at all floors.

Theoretical learning Activity

- ✓ Conduct Brainstorming on duties and responsibilities of HHP maintenance technician and HPP operation manuals.
- ✓ Have students in their respective groups discussion on duties and responsibilities of HHP maintenance technician and HPP operation manuals.
- ✓ Conduct Physical demonstration of HPP operation and maintenance manuals.

Practical learning Activity

- ✓ Provide students drawings and manuals of different HPP components for interpretation.

Points to Remember (Take home message)

- Duties and responsibilities of HPP maintenance technician
- Interpretation of drawings and manuals of different HPP components
- Interpretation of HPP operation and maintenance manuals

Learning outcome 1.1 formative assessment

Written assessment

1. Answer by True or False

a. The duties and responsibilities of HPP maintenance Technician is to monitor and control activities associated with hydropower generation.

b. The duties and responsibilities of HPP maintenance Technician is to perform equipment maintenance and repair as unnecessary.

c. The duties and responsibilities of HPP maintenance Technician is to operate the plant equipment, such as turbines, pumps, valves, gates, fans, electric control boards, and battery banks.

d. The duties and responsibilities of HPP maintenance Technician is to monitor equipment operation and performance and Make necessary adjustments to ensure optimal performance.

Answer:

a. True
b. False
c. True
d. True

2. List down the five (5) major components of a Hydroelectric Power Plant.

Answer:

The five major components of a Hydroelectric Power Plant are:

- Head race tunnels/channels.
- Surge shaft/surge chambers.
- Pressure shaft/Penstock.
- Underground and surface power house.
- Tailrace channel or tailrace tunnel.

3. Provide any three (3) activities to be carried out for operation of the hydropower plants.

Answer:

The following are the activities to be carried out for operation of the hydropower plants after the general check-up as mentioned above:

- ✓ For intake gate opening, check intake gate power supply and hoisting system, give raising command and check gate position in raised condition.
- ✓ For Inlet Valve Opening, put oil pumps on 'auto' mode, open bye-pass valve manually or give opening command to by-pass auto valve, check water pressure on spiral side, and then give opening command to inlet valve on equalized pressure.
- ✓ For turbine operation, put oil pumps on 'auto' mode to maintain required pressure in pressure accumulator, check availability of Nitrogen cylinder and check also pressure of the same for systems using compresses nitrogen, check air pressure for maintaining proper oil level in pressure accumulator (if provided), open cooling water for

bearings, open shaft seal water, put brake on 'auto' mode, unlock guide vane lock, fix GV (Governor) opening limit, and put machine on 'auto' mode.

Reference

1. GOOD&BAD of Mini Hydro Power by Klaus Jorde with the resources of Entec ACE karthartmann, Heinz Unger

2. Principles of Power systems by V.KMehta

3. A COURSE INPOWERPLANTENGINEERING by DHANPAT RAI &CO.(P)Ltd.,1710,Nai Sarak, Delhi.

4. Harvey, A., Village planning of isolated energy schemes, IMechE,1995.

4. www.worldenergy.org.

Learning outcome 1.2 Prepare tools, equipment and materials

Duration: 2hrs

Learning outcome 2 objectives:

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

- Identify properly tools used at HPP.
- Identify properly the measuring equipment used at HPP.
- Identify clearly consumable and non consumable materials used at HPP.
- Identify properly the lifting cranes used at HPP.

Resources

Equipment	Tools	Materials
- Voltmeter and Ammeter - Wattmeter - VAR-meter and VA-meter - Phase-meter	- Books - HPP operation and maintenance manuals - Hand-out notes - Internet	✓ Lubricating oil ✓ Fuel ✓ Cleaning equipment

- Ohmmeter - Thermometer - Tachometer - Multi-meter - Pressure switch - Pressure gauge - Flow sensors - Hydraulic meters - Pneumatic meters - Hygrometer - Overcoat and overall - Gloves - Safety shoes - Helmet - Earmuff and Goggles - Nose protection - mask		

Advance preparation:

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

Indicative content1.1: Identification of tools

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

An electric An electromechanical device is one that has both electrical and mechanical processes. The device usually involves an electrical signal that creates a mechanical movement, or a mechanical movement that creates signal. This kit includes the most complete selection of fastener tools we offer. Everything from Klein Cushion Grip screwdrivers and fixed handle nut drivers. The most familiar electromechanical component is the electric motor. Though the functional details of motors vary widely, almost all of them have the same fundamental purpose: to convert electrical energy into mechanical energy in the form of rotational motion. The electro

mechanical equipment in a hydro power plant consists of two main components: turbine and electric motor. A turbine works to convert the kinetic energy of moving water into rotational motion and an electric motor converts the rotational motion of the turbine into useful work.

Indicative content1.2: Identification of Measuring equipment

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

The common types of measuring tools include speedometers, measuring tape, thermometers, compasses, digital angle gauges, levels, laser levels, macrometer, measuring squares, odometers, pressure gauges, protractors, rulers, angle locators, bubble inclinometers, and callipers.

Electrical measuring instruments are all the devices used to measure the magnitude of an electric current with different objectives. The values that are usually measured with this equipment are current, voltage, resistance, and power. Each is expressed in different units: amps, volts, ohms, and watts, respectively.

- Voltmeter
- Ammeter
- Wattmeter,
- VAR-meter, VA-meter
- Phase-meter
- Ohmmeter
- Thermometer
- Tachometer
- Multi-meter
- Pressure switch
- Pressure gauge
- Flow sensors
- Hydraulic meters
- Pneumatic meters
- Thermometer
- Hygrometer

The main electrical measuring instrument and their uses

Electrical measuring instruments are all the **devices used to measure the magnitude of an electric current** with different objectives. The values that are usually measured with this equipment are **current, voltage, resistance, and power**. Each is expressed in different units: **amps, volts, ohms, and watts,** respectively.

- **Galvanometer:** indicates the **intensity** of the flow of electric current through a circuit.
- **Voltmeter:** used to measure the **potential difference** between two points of a **closed electrical circuit** or the electromotive force of a battery. This instrument must have high electrical resistance so that, when it's connected to the circuit, it does not generate consumption that alters the result and accuracy of the measurement.
- **Ammeter:** measures the **intensity** (i.e. amps) **of current** circulating through an electrical circuit.
- **Ohmmeter:** records the ohms, or the **electrical resistance,** in a circuit**.**
- **Multimeter:** a meter that **brings together the capabilities of the other meters**: it incorporates the tools necessary to measure voltages, resistances, capacitances, etc.
- **Oscilloscope:** a measuring instrument and **graphical display of electrical signals that vary over time.** This tool makes it possible to visualize transient phenomena and facilitates the diagnosis and analysis of an electrical circuit's operation, as well as its possible failures.
- **Spectrum analyzer:** measuring equipment that displays the components and **spectral ranges of electrical signals** coming from any wave, whether electromagnetic, mechanical, acoustic, or optical.

Indicative content 1.3: **Identification of consumable and non consumable Materials**

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

A non-consumable resource is an item that you have a limited quantity of and something that you reuse such as a projector, electronic equipment, or chairs. A consumable resource is something you keep a quantity of on stock such as information packets, workbooks, or art materials.
The following are materials used at HPP:

✓ Lubricating oil

✓ Fuel

✓ Cleaning equipment

Indicative content 1.4: **Lifting cranes**

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

A crane is a type of machine, generally equipped with a hoist rope, wire ropes or chains, and sheaves, that can be used both to lift and lower materials and to move them horizontally. It is mainly used for lifting heavy objects and transporting them to other places.

7 crane types that are used commonly depending on the project, work objective and environment are

- Telescopic Crane
- Mobile Cranes
- Truck Mounted Crane
- Tower Crane
- Rough Terrain Crane
- Overhead Crane
- Loader Crane

Theoretical learning Activity

- ✓ Conduct Brainstorming on tools, equipment and materials needed.
- ✓ Have students in their respective groups discussion on how to use tools, equipment and materials needed.

Practical learning Activity

- ✓ Conduct Physical demonstration of tools, equipment and materials needed.

Points to Remember (Take home message)

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

Learning outcome 1.2 formative assessment

Written assessment

I. Choose correct answer
1. What is the purpose of a claw hammer?
A) To tighten nuts and bolts
B) To cut wood
C) To drive nails into wood
D) To sand wood

Answer: C) to drive nails into wood

Which tool is best suited for cutting through PVC piping?
A) A hacksaw
B) A pair of scissors

C) A pair of pliers D) A wrench

Answer: A) A hacksaw

II.Answer by true or false

1.Power tools should be operated with safety precautions in mind. True or False?
Answer: True.
2. Power tools can be used without proper training or experience. True or False?
Answer: False.

III. 1. What is the difference between an analog and digital multimeter?
Answer
An analog multimeter uses a needle and a scale, while a digital multimeter displays the measurement on a screen.

2. What is an ammeter used for?

Answer;
An meter is used for Measuring electrical current

IV What are the electro mechanical equipment in a hydro power plant?

Answer:

It consists of two main components: turbine and electric motor. A turbine works to convert the kinetic energy of moving water into rotational motion and an electric motor converts the rotational motion of the turbine into useful work

Learning outcome 1.3 **Identify PPE**

Duration: 1hr
Learning outcome 1 objectives: By the end of the learning outcome, the trainees will be able to: - Identify properly the HPP safety instructions - Identify properly the Personal protective equipment at HPP.
Resources

Equipment	Tools	Materials

- Overcoat - overall - Gloves - Safety shoes - Helmet - Earmuff - Goggles - Nose protection - mask	- Books - HPP operation and maintenance manuals - Hand-out notes - Internet	✓ Lubricating oil ✓ Fuel ✓ Cleaning equipment
Advance preparation: • HPP safety instructions • Identification of Personal protective equipment		

Indicative content 1.1: HPP safety instructions

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

Hydropower stations can pose significant safety risks to those who work in them, but there is no excuse for injury or death in workplaces. Developers, owners and operator s of hydropower plants all need to make a strong commitment to workplace health and safety.

SAFETY AND PRECAUTIONS FOR ELECTRICIAN

a) A great care should be taken against electric shock while doing any work on the main line.

b) Switch off the main switch immediately to release the victim of electric shock. If the main switch is not in easy approach then use dry wood or any other insulating material to release the victim.

c) Don't touch the main line with bare hands.

d) Switch off the main switch before the replacement of a fuse.

e) Always use insulated tools while doing any work on the main line.

f) Use safety belt while working on an electric pole.

g) The ladder should always be firmly help by helper while doing any overhead work, so that it may not slip.

h) Before supplying mains to any equipment, check that the equipment is in perfect working order and it is properly earthed.

i) All metallic parts and the metallic cover of an electric machine should be well earthed.\

j) Before switching – on main-switch, check that nobody is working on the main-line.

k) Before starting a repair work on the main-line, switch off the main switch and pull out the fuses.

l) Before starting a job, be ensured that you are authorized to do the job.

m) The battery charging room should be well airy and lighted.

n) Don't charge the batteries in a dark or in a closed room.

o) The battery charging room should be away from the fire or the flames.

p) A fire caused due to an electric spark should be extinguished with dry sand and carbon dioxide type fire extinguisher

q) To work on a clear and clean place

r) To see (check) if all equipments are on their proper position

s) Persons who intend to or are required to work on high-voltage equipment after switching, isolation, short circuiting and earthing must be appropriately instructed and provided with an access permit issued by an appropriately trained and authorized person (High Voltage Switching Operator).

Indicative content 1.1: HPP safety instructions

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

Personal protective equipment at HPP

PPE is defined as all equipment designed to be worn, or held, to protect against a risk to health and safety for workers from hazard. Workers must wear the following personal protective equipment (PPE) as it is required at the workplace and when by the supervisor instructed:

- **Shoes or strong/rubber boots:** Those are for protection against any sharp object on the floor.
- **gloves**: This is for Hand and Fingers protection from injuries in the work place
- **Helmet:** Those are for Head protection from any dropped materials or tools to the head. This device is needed where heavy machines are suspended. This is a must in all construction companies.
- **Overalls:** Those are work clothes to prevent your everyday clothing from becoming contaminated by oils, grease fluxes or general dust and dirt.
- **Goggle and Eye lids**: This equipment protects the eyes during welding and grinding operations.
- **Earmuff /Nose protection mask**: Those are for ear protection from noise.
- **Security belt**: is used in conjunction with other safety equipment when working on the Utility poles, the reason of this is to avoid fall hazard.

Safety and protective devices shall be used to protect persons and the environment whenever an inherently safe design measure does not reasonably make it possible either to remove hazards or to sufficiently reduce risks.

Theoretical learning Activity

- Conduct brainstorming on PPE at HPP
- Conduct brainstorming on HPP safety instructions at HPP
- Group discussion on the use of PPE

Practical learning Activity

- Physical demonstration of PPE

Points to Remember (Take home message)

- HPP safety instructions
- Identification of Personal protective equipment

Learning outcome 1.3 formative assessment

Written assessment

I. What type of protective equipment should workers wear when working with electricity at a power plant?

A) Hard hat

B) Safety goggles

C) Earplugs

D) Rubber gloves

Answer: D) Rubber gloves

II.What is the purpose of a safety harness at a power plant?

A) To protect workers from falling

B) To protect workers from heat exposure

C) To protect workers from electrical shock

D) To protect workers from chemical exposure

Answer: A) to protect workers from falling

III. What type of respiratory protection might be necessary for workers in a power plant?

Answer: Depending on the specific hazards present in the power plant, workers may need to wear respirators to protect their lungs from dust, fumes, or other airborne contaminants. Respirators should be properly fitted and chosen based on the specific hazards present in the work environment.

Reference

1. GOOD&BAD of Mini Hydro Power by Klaus Jorde with the resources of Entec ACE karthartmann, Heinz Unger

2. Principles of Power systems by V.KMehta

3. A COURSE INPOWERPLANTENGINEERING by DHANPAT RAI &CO.(P)Ltd.,1710,Nai S arak, Delhi.

4. Harvey, A., Village planning of isolated energy schemes, IMechE,1995.

Learning Unit 2: Execute preventive maintenance

Picture/reflecting the Learning unit 2

STRUCTURE OF LEARNING UNIT

Learning outcomes:

2.1 Identify planned activities
2.2 Inspect different parts of hydropower plant

2.3 Complete the maintenance report

Learning outcome 2.1 **Identify planned activities**

Duration: 5 hrs

Learning outcome 2 objectives:

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

1. Recall properly on manufacturer's recommended maintenance activities
2. Maintenance practices for different parts of the hydropower plant

Resources

Equipment	Tools	Materials
Voltmeter ✓ Ammeter ✓ Wattmeter, VAR-meter, VA-meter ✓ Phase-meter ✓ Ohmmeter ✓ Thermometer ✓ Tachymeter ✓ Multi-meter ✓ Pressure switch ✓ Pressure gauge ✓ Flow sensors ✓ Hydraulic meters ✓ Pneumatic meters ✓ Thermometer ✓ Hygrometer	- Books - HPP operation and maintenance manuals - Hand-out notes - Internet	

Advance preparation:

- Recall on manufacturer's recommended maintenance activities
- Maintenance practices for different parts of the hydropower plant

Indicative content2.1: Identify planned activities

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

Recall on manufacturer's recommended maintenance activities

- ✓ Daily activities
- ✓ Weekly activities
- ✓ Monthly activities
- ✓ Annually activities

Indicative content2.2: Maintenance practices for different parts of the Hydropower plant

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

Some of the practices to be adopted at hydropower station for maintenance are broadly given below.

- ✓ **Water Intake, Water Conduit System and Associated Equipment:**

  Water storage (Reservoir) & water conductor system comprising of intake, headrace tunnel, surge shaft, emergency valves & pressure shafts, penstock, main inlet valves are very vital organs of a hydropower plant. Due to negative and positive water hammer during sudden changes in water flow, it is essential to attend to these plants & equipment very carefully. It is very important to regularly test operation of conduit isolation system/equipment, i.e. intake gates, butterfly valves, excess flow device, surge equipment, etc

- ✓ **Turbine & its Auxiliaries:**

  Regular inspection of runners of turbines should be carried out, and record to that effect should be invariably maintained. Many a times it is not possible for Francis Turbine being always immersed in water and needs isolation on either side. For this, it is done as recommended by manufacturer without any compromise. Due to cavitations, there may be huge damages to turbine wheel causing adverse effect on

performance and consequently on efficiency.

- ✓ **Turbine**

  - Periodic ultrasonic,
  - Polishing of the various under water parts of the turbines once in a year to minimize the white pitting,
  - Inspection & testing of the runners from experts to decide residual life so as to initiate action for procurement of runners for replacement,
  - Inspection of labyrinth seals in case of reaction turbines,
  - Painting of runner housing with anticorrosive/tar based paints,
  - Applying anti-erosion coating to the runner, and
  - Checking of brake jet operation in power stations having Pelton turbines once in three months.

- ✓ **Governor**

  - Purification of hydraulic oils by centrifugal as well as electrostatic liquid cleaner,
  - Periodic maintenance of the servo valves and motors after carrying out inspection of the pistons & housings of the servo valves and motors for their worn-out parts.
  -Replacement of the leaking seals, and
  - Survey of the component failure & procurement of the same and maintain minimum inventory.

- ✓ **Generator & its Auxiliaries:**

  Stator & rotor winding, bearings & excitation system are the main parts of a generator. As regards stator and rotor windings, regular recording of IR Values of these winding should be maintained at regular intervals. Tanδ (delta) and DLA (Dielectric Loss Analysis) tests of stator winding indicate the status/ condition of stator winding insulation. Likewise impedance test (voltage drop test across each pole) indicates condition of the rotor winding. Proper cooling system is to be maintained to limit rise in stator winding temperatures and consequently increase the life of stator winding. Inspection of the stator winding is also required to be carried out to verify its firmness in stator core slots and healthiness of overhang portion with firm end winding caps & end spacers, slots wedges checked for healthiness. Windings are re-varnished to enhance their life. Looseness of stator core or inter lamination, core insulation are direct factors affecting winding heating due to eddy current loss. Thus, recommended maintenance as per schedule should be carried out, its records maintained and corrective actions be taken if necessary.

- ✓ **Transformers & Switchyard:**

- Continuous monitoring of oil & winding temperature,
- Periodic oil filtration,
- Oil testing for various tests and Dissolved Gas Analysis,
- Checking of Tan δ (delta) & insulation resistance etc. as per schedule,
- Cleaning and replacement of oil cooler,
- Testing protection system for healthiness,
- Mock Maintenance and inspection for fire fighting system, CO2 & Mulsifyre,
- Tests for operation time of the breaker,
- Operation & testing of isolator opening & closing,
- Checking of control circuit & healthiness of operating system of the breaker,
- Periodic cleaning of transformer bushing & insulator strings,
- Switchyards are to be kept neat & tidy. Minimum area surrounding the yard to be free from growth of scrubs and bushes to avoid any bush fire damaging the equipment

✓ **Emergency Diesel Generator Set:**

- Regular maintenance of the emergency DG set. Checking control & protection system, and
- Running of DG set at regular intervals.

✓ **Other Powerhouse Equipment:**

- Periodic maintenance of unit auxiliary, station auxiliary & station service transformer,
- Checking healthiness of station batteries & battery chargers. The two chargers should be rotated once in a week,
- Regular inspection of cable ducts to ensure proper ventilation / heat dissipation, and
- Checking the healthiness of pressure relief valve, if provided.

Theoretical learning Activity

- Brainstorming on maintenance activities for different parts of hydropower plant
- Group discussion on maintenance activities for different parts of hydropower plant

Practical learning Activity

✓ In group trainees must draw all the parts of hydropower plant.

Points to Remember (Take home message)

- Recall on manufacturer's recommended maintenance activities
- Maintenance practices for different parts of the hydropower plant

Learning outcome 2.1 formative assessment

Written assessment

1. What is the skill required to become maintenance and repair worker.

Answer:

To become maintenance and repair worker you must know

- Basic calculation
- Safety practices and handling tools
- Basic plumbing repair skills
- Basic knowledge of electrical wiring
- Ability to decipher written or oral instructions
- Physical agility
- Able to lift and move heavy objects

2. Mention what are the challenges that maintenance and repair work usually face.

Answer:

- Unusual working condition like bad weather or low temperature
- May have to work in an unusual shift
- May have to work in a messy area

- May sometimes be physically distressing and exhausting
- May have to work in dangerous places like working at height or working with electrical appliances and wires

Reference

1. GOOD&BAD of Mini Hydro Power by Klaus Jorde with the resources of Entec ACE karthartmann, Heinz Unger

2. Principles of Power systems by V.KMehta

3. A COURSE INPOWERPLANTENGINEERING by DHANPAT RAI &CO.(P)Ltd.,1710,Nai S arak, Delhi.

4. Harvey, A., Village planning of isolated energy schemes, IMechE,1995.

Learning outcome 2.2 **Inspect different parts of hydropower plant**

Duration: 5 hrs

Learning outcome 2 objectives:

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

1. Perform correctly Inspection techniques of different parts of hydropower plant

Resources

Equipment	Tools	Materials
Voltmeter ✓ Ammeter ✓ Wattmeter, VAR-meter, VA-meter ✓ Phase-meter ✓ Ohmmeter ✓ Thermometer ✓ Tachymeter ✓ Multi-meter ✓ Pressure switch ✓ Pressure gauge ✓ Flow sensors ✓ Hydraulic meters ✓ Pneumatic meters ✓ Thermometer	- Books - HPP operation and maintenance manuals - Hand-out notes - Internet	

✓ Hygrometer		

Advance preparation:

- Recall on manufacturer's recommended maintenance activities
- Maintenance practices for different parts of the hydropower plant

Theoretical learning Activity

- Brainstorming on the typical fault finding procedures
- Group discussion on the recognition of faulty parts

Practical learning Activity

- Practical exercises on fault finding procedures
- Physical demonstration of faulty parts

Points to Remember (Take home message)

- Typical generator fault finding procedures
- Recognition of faulty parts/system for different HPP Components

Learning outcome 3.1 formative assessment

Written assessment

1. What are the various faults and abnormal operating conditions in generator?

Answer:

Generator protection can be divided into the below categories: Internal Faults - Phase and/or ground faults in the stator and/or the field winding (rotor). Abnormal Operating Conditions -

Issues such as: loss of field, overload, over voltage, under/over frequency, loss of synchronization.

2. What causes generator overload?

Answer:

An overload in a generator generally happens when too many appliances are plugged into the generator. This causes the generator to exceed its designed wattage. Some generators are protected from an overload by circuit breakers to help combat this but if not, you should know the signs.

Practical assessment

Task: Inspect different parts of HPP

Checklist		
	Yes	**No**
Inspection of intake		
Inspection of water conduit		
Inspection of turbine and accessories		
Inspection of generator and accessories		
Inspection of transformer		
Inspection of switch yard		
Observation		

Reference

1. GOOD&BAD of Mini Hydro Power by Klaus Jorde with the resources of Entec ACE karthartmann, Heinz Unger

2. Principles of Power systems by V.KMehta

3. A COURSE INPOWERPLANTENGINEERING by DHANPAT RAI &CO.(P)Ltd.,1710,Nai Sarak, Delhi.

4. Harvey, A., Village planning of isolated energy schemes, IMechE,1995.

Learning Outcome 2.3: Complete the maintenance report

Duration: 5 hrs

Learning outcome 2 objectives:

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

- **Prepare effectively the maintenance report**
- **Filing properly maintenance records**
- **Analyse clearly** the maintenance report

Resources

Equipment	Tools	Materials
Voltmeter ✓ Ammeter ✓ Wattmeter, VAR-meter, VA-meter ✓ Phase-meter ✓ Ohmmeter ✓ Thermometer ✓ Tachymeter ✓ Multi-meter ✓ Pressure switch ✓ Pressure gauge ✓ Flow sensors ✓ Hydraulic meters ✓ Pneumatic meters ✓ Thermometer ✓ Hygrometer	- Books - HPP operation and maintenance manuals - Hand-out notes - Internet	

Advance preparation:

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

Indicative content1.1: Preparation of the maintenance report

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

Maintenance report format
Company/institution name,
technician name,
Date of **maintenance,**
Planned **activities,**
planned date for next maintenance,
Equipment specifications,
Checklist table,
Observation

Repair Report
It is a document that records all the activities that were carried out in a maintenance operation. It includes information such as what was done; when it was done; who did it, and how long it took. This report is then used to improve maintenance operations or as a reference for future maintenance activities.

Things to Include in a Repair Report

Proper organization is crucial when creating a customer maintenance report for your business. While the specific items will depend on the needs of your company, six staples should always be present in every report that you make:

Category
Maintenance managers and engineers should always assign a category to each maintenance activity. This will help keep track of the different types of maintenance tasks being carried out. Categories can include preventative maintenance, emergency maintenance, or corrective maintenance.

Location
Along with the type of maintenance being performed, your report should also allow users to document where the maintenance took place. This information is important for keeping track of maintenance activities in different parts of your facility.

Date and Time
Another essential piece of information to include in your maintenance report is the date and time that the maintenance was carried out. This information will help you keep track of when each maintenance task was completed.

Description
Your maintenance report should also include a description of the maintenance activity carried out. The description should briefly summarize what was done during the maintenance task. However, it should also be detailed at the same time. Elaborate enough so that someone reading the maintenance report will understand what was done, but don't include so much information that it becomes overwhelming.

Pictures

Images can also be a valuable addition to your maintenance report. They can help document the condition of equipment before and after maintenance activities have been carried out. At the same time, pictures also prove that the maintenance task was actually completed.

Signature

The last thing to include in your maintenance report is a signature from the maintenance manager or engineer who completed the task. This will help to ensure that the maintenance report is accurate and complete

Benefits of Using a Maintenance Report

There's a reason why this is an essential tool in every business—it provides a number of benefits that help to improve operations. Here are some of the benefits:

Assists in Maintaining Reliability

A maintenance report can help improve your equipment's reliability by providing a record of all maintenance activities. If there are any issues with your equipment, you can refer back to the maintenance report to see if anything was missed.

Improves Maintenance Planning

Another benefit of a maintenance report is that it can help with maintenance planning. By having a record of all maintenance activities, you can plan future maintenance tasks more easily. This is because you can see what needs to be done and when it needs to be done.

Good Recordkeeping

A maintenance report is also a good way to keep track of all the different maintenance tasks that have been carried out. This can be useful for businesses with a lot of equipment or machinery. By keeping a record of all the maintenance tasks, you can easily track what needs to be done and when.

Prevents Unexpected Breakdowns

One of the most important benefits of a maintenance report is that it can help to prevent unexpected breakdowns. By having a record of all maintenance activities, you can ensure that all tasks are carried out properly and on time. This means that there is less chance of something going wrong and causing a breakdown.

Helps to Achieve Maintenance Goals

A maintenance report can also help you to achieve your maintenance goals faster. It can help you track your progress and identify any areas that need improvement. That way, you can focus your efforts on the areas that need it the most.

Saves Time and Money

Finally, a maintenance report can save both time and money. By having a record of all maintenance activities, you can plan maintenance tasks more efficiently. This means that you can avoid carrying out tasks that are not necessary, which can save both time and money.

Indicative content 1.2: **Filling the maintenance report**

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

Things to Include in a Maintenance Report

- Category
- Location
- Date and Time
- Description
- Pictures
- Signature
- Assists in Maintaining Reliability
- Improves Maintenance Planning

Indicative content 1.3: Analysis of the maintenance report

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

Maintenance reports play a critical role in keeping your equipment, machinery, and business in good health. It should be done regularly and correctly to ensure productivity, safety, and efficiency. Regardless of your industry, proper documentation for routine and emergency maintenance services helps to keep your business running smoothly

The six function of maintenance analysis:

- Predetermined Maintenance,
- Preventive Maintenance,
- Corrective Maintenance,
- Condition-based Maintenance,
- Predictive Maintenance and
- Reactive Maintenance

The right maintenance strategy is crucial because **it reduces risks and improves efficiency while keeping costs in an affordable range**. You also have the opportunity to extend the life of your assets. That process also means reducing the cost of repairs and keeping overall productivity higher

The different types of maintenance strategies include:

- **Preventive maintenance** – includes regular and **periodic (time-based)** schedules.
- **Corrective maintenance** – occurs when an issue is noticed.
- **Predetermined maintenance** – follows a factory schedule.
- **Condition-based maintenance** – occurs when a situation or condition indicates maintenance is needed.
- **Predictive maintenance** – is data-driven and impacted by preset parameters.
- **Reactive maintenance** – occurs when a total breakdown or failure appears

How to Choose the Right Maintenance Strategy?

Choosing the best maintenance methodology is a risk measurement. Start by looking at what you lose when equipment fails. If the cost is higher than the repair cost, then a reactive maintenance method may be ideal for your business. On the other hand, if the costs are higher in the event of a machine failure, then a proactive maintenance method might be more beneficial.

Theoretical learning Activity

- Brainstorming on how to prepare the maintenance report
- Group discussion on taking records
- Group discussion on analysis of the maintenance report

Practical learning Activity

- Practical exercises on filling the maintenance report

Points to Remember (Take home message)

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

Learning outcome 2.1 formative assessment

Written assessment

1. What should be included in maintenance report?

Answer:

A maintenance report should include a place to input the date(s) in which maintenance or repairs were completed. Having this record is crucial to ensure upkeep. It can also be useful to reference in cases of equipment failure, so you can check to see if any missing maintenance issues may have caused the problem

2. How do I write a monthly maintenance report?

Answer:

- Identify the purpose and audience of the report.
- Gather data and information on maintenance activities that were performed during the month.
- Organize the information into an easy-to-read format.
- Include a summary of the key takeaways from the report

3. What is the introduction of 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. You use them to gain visibility on your operations, which you can then leverage into better decision-making

What are the six function of maintenance analysis?

The 6 different types are;

- Predetermined Maintenance,
- Preventive Maintenance,
- Corrective Maintenance,
- Condition-based Maintenance,

- Predictive Maintenance and
- Reactive Maintenance

Reference

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4. Harvey, A., Village planning of isolated energy schemes, IMechE,1995.

Learning Unit 3: Repair faults in HPP systems

Picture/reflecting the Learning unit 1

STRUCTURE OF LEARNING UNIT

Learning outcomes:

3.1 Identify damaged parts of HPP equipment

3.2 Rectify detected faults

3.3 Complete the repair report

Learning outcome **3.1: Identify damaged parts of HPP equipment**

Duration: 2hrs

Learning outcome 1 objectives:

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

- Identify properly typical generator fault finding procedures
- Recognition properly of faulty parts/system for different HPP components

Resources

Equipment	**Tools**	**Materials**
- Voltmeter and Ammeter - Wattmeter - VAR-meter and VA-meter - Phase-meter - Ohmmeter - Thermometer - Tachometer - Multi-meter - Pressure switch - Pressure gauge - Flow sensors - Hydraulic meters - Pneumatic meters - Hygrometer - Overcoat and overall - Gloves - Safety shoes - Helmet - Earmuff and Goggles - Nose protection - mask	- Books - Internet - Service manuals - Spare parts - Handout notes	✓ Lubricating oil ✓ Fuel ✓ Cleaning equipments

Advance preparation:

- Typical generator fault finding procedures
- Recognition of faulty parts/system for different HPP components

Indicative content 1.1: Typical generator fault finding procedures

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

- Typical generator fault finding procedures

Most Common Generator Problems are

- Leaks
- Low Coolant
- No Fuel
- Generator Failure
- Fuel Leaking Into the Tank
- Dead Battery
- Control Malfunction
- Block Heater Wear

Typical generator fault finding procedures

✓ Visual inspection

✓ testing

✓ Assumptions (possible causes)

Indicative content 1.2: **Recognition of faulty parts/system for different HPP**

Components

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

Recognition of faulty parts/system for different HPP components

✓Water intake, water conduit system and associated equipment
✓ Turbine and its auxiliaries
✓ Governor
✓ Generator and its auxiliaries
✓ Transformer and switchyard
✓ Emergency generator set
✓ Other equipment (unit auxiliary, station auxiliary, service transformer, cable ducts, ventilation/heat, pressure relief valve)

- ✓ **Water Intake, Water Conduit System and Associated Equipment:**

  Water storage (Reservoir) & water conductor system comprising of intake, headrace tunnel, surge shaft, emergency valves & pressure shafts, penstock, main inlet valves are very vital organs of a hydropower plant. Due to negative and positive water hammer during sudden changes in water flow, it is essential to attend to these plants & equipment very carefully. It is very important to regularly test operation of conduit isolation system/equipment, i.e. intake gates, butterfly valves, excess flow device, surge equipment, etc

- ✓ **Turbine & its Auxiliaries:**

  Regular inspection of runners of turbines should be carried out, and record to that effect should be invariably maintained. Many a times it is not possible for Francis Turbine being always immersed in water and needs isolation on either side. For this, it is done as recommended by manufacturer without any compromise. Due to cavitations, there may be huge damages to turbine wheel causing adverse effect on performance and consequently on efficiency.

- ✓ **Turbine**

- Periodic ultrasonic,
- Polishing of the various under water parts of the turbines once in a year to minimize the white pitting,
- Inspection & testing of the runners from experts to decide residual life so as to initiate action for procurement of runners for replacement,
- Inspection of labyrinth seals in case of reaction turbines,
- Painting of runner housing with anticorrosive/tar based paints,
- Applying anti-erosion coating to the runner, and
- Checking of brake jet operation in power stations having Pelton turbines once in three months.

✓ **Governor**

- Purification of hydraulic oils by centrifugal as well as electrostatic liquid cleaner,
- Periodic maintenance of the servo valves and motors after carrying out inspection of the pistons & housings of the servo valves and motors for their worn-out parts.
-Replacement of the leaking seals, and
- Survey of the component failure & procurement of the same and maintain minimum inventory.

✓ **Generator & its Auxiliaries:**

Stator & rotor winding, bearings & excitation system are the main parts of a generator. As regards stator and rotor windings, regular recording of IR Values of these winding should be maintained at regular intervals. Tanδ (delta) and DLA (Dielectric Loss Analysis) tests of stator winding indicate the status/ condition of stator winding insulation. Likewise impedance test (voltage drop test across each pole) indicates condition of the rotor winding. Proper cooling system is to be maintained to limit rise in stator winding temperatures and consequently increase the life of stator winding. Inspection of the stator winding is also required to be carried out to verify its firmness in stator core slots and healthiness of overhang portion with firm end winding caps & end spacers, slots wedges checked for healthiness. Windings are re-varnished to enhance their life. Looseness of stator core or inter lamination, core insulation are direct factors affecting winding heating due to eddy current loss. Thus, recommended maintenance as per schedule should be carried out, its records maintained and corrective actions be taken if necessary.

✓ **Transformers & Switchyard:**

- Continuous monitoring of oil & winding temperature,
- Periodic oil filtration,
- Oil testing for various tests and Dissolved Gas Analysis,

- Checking of Tan δ (delta) & insulation resistance etc. as per schedule,
- Cleaning and replacement of oil cooler,
- Testing protection system for healthiness,
- Mock Maintenance and inspection for fire fighting system, CO2 & Mulsifyre,
- Tests for operation time of the breaker,
- Operation & testing of isolator opening & closing,
- Checking of control circuit & healthiness of operating system of the breaker,
- Periodic cleaning of transformer bushing & insulator strings,
- Switchyards are to be kept neat & tidy. Minimum area surrounding the yard to be free from growth of scrubs and bushes to avoid any bush fire damaging the equipment

✓ **Emergency Diesel Generator Set:**

- Regular maintenance of the emergency DG set. Checking control & protection system, and
- Running of DG set at regular intervals.

Other Powerhouse Equipment:

- Periodic maintenance of unit auxiliary, station auxiliary & station service transformer,
- Checking healthiness of station batteries & battery chargers. The two chargers should be rotated once in a week,
- Regular inspection of cable ducts to ensure proper ventilation / heat dissipation, and
- Checking the healthiness of pressure relief valve, if provided.

Theoretical learning Activity

- Brainstorming on the typical fault finding procedures
- Group discussion on the recognition of faulty parts

Practical learning Activity

- Practical exercises on fault finding procedures
- Physical demonstration of faulty parts

 Points to Remember (Take home message)

- Typical generator fault finding procedures
- Recognition of faulty parts/system for different HPP Components

 Learning outcome 3.1 formative assessment

Written assessment

3. What are the various faults and abnormal operating conditions in generator?

Answer:

Generator protection can be divided into the below categories: Internal Faults - Phase and/or ground faults in the stator and/or the field winding (rotor). Abnormal Operating Conditions - Issues such as: loss of field, overload, over voltage, under/over frequency, loss of synchronization.

4. What causes generator overload?

Answer:

An overload in a generator generally happens when too many appliances are plugged into the generator. This causes the generator to exceed its designed wattage. Some generators are protected from an overload by circuit breakers to help combat this but if not, you should know the signs.

Practical assessment

Task: Identification of damaged part of different components of HPP

Checklist		
	Yes	**No**
Fault rectification procedures		
Water intake, water conduit and accessories faults and their remedies		
Turbine and auxiliaries' faults and their remedies		
Generator and auxiliaries' faults and their remedies		
Transformer faults and their remedies		
Switch yard faults and their remedies		
Observation		

Reference

1. GOOD&BAD of Mini Hydro Power by Klaus Jorde with the resources of Entec ACE karthartmann, Heinz Unger

2. Principles of Power systems by V.KMehta

3. A COURSE INPOWERPLANTENGINEERING by DHANPAT RAI &CO.(P)Ltd.,1710,Nai Sarak, Delhi.

4. Harvey, A., Village planning of isolated energy schemes, IMechE,1995.

Learning outcome **3.2: Rectify detected faults**

Duration: 2hrs

Learning outcome 1 objectives:

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

- Identify properly typical generator fault finding procedures
- Recognition properly of faulty parts/system for different HPP components

Resources

Equipment	Tools	Materials
- Voltmeter and Ammeter - Wattmeter - VAR-meter and VA-meter - Phase-meter - Ohmmeter - Thermometer - Tachometer - Multi-meter - Pressure switch - Pressure gauge - Flow sensors - Hydraulic meters - Pneumatic meters - Hygrometer - Overcoat and overall	- Books - Internet - Service manuals - Spare parts - Handout notes	✓ Lubricating oil ✓ Fuel ✓ Cleaning equipments

- Gloves - Safety shoes - Helmet - Earmuff and Goggles - Nose protection - mask		

Advance preparation:

- General engine faults occurring in different parts of HPP and their remedies

Indicative content 1.1: General engine faults occurring in different parts of HPP and their remedies

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

- General engine faults occurring in different parts of HPP and their remedies
  - ✓ Water intake, water conduit system and associated equipment
  - ✓ Turbine and its auxiliaries
  - ✓ Governor
  - ✓ Generator and its auxiliaries
  - ✓ Transformer and switchyard
  - ✓ Emergency generator set
  - ✓ Other equipment (unit auxiliary, station auxiliary, service transformer, cable ducts, ventilation/heat, pressure relief valve)

The most common car engine problems revealed are

- Poor lubrication
- Failing oil pump
- Oil deposits and debris
- Inadequate fuel and air compression

- Leaking engine coolant
- Blocked engine radiators
- Prolonged engine detonation
- Damaged oxygen sensors

#1 Engine does not turn over when starting is attempted

- Discharged battery
- Open starting circuit
- Jammed Bendix drive
- Jammed cranking drive
- Jammed engine
- Also, causes are listed under item 3

#2 Engine turns over slowly but does not start

- Discharged battery
- Defective cranking motor
- Bad connection in starting circuit
- Undersized battery cables
- Also, causes listed under item 3

#3 Engine turns over at normal speed but does not start

- Defective battery system
- Defective or over-chocking fuel system
- Air leakage in the intake manifold or carburetor
- Defective engine

#4 Engine runs but misses one cylinder

- Defective spark plug
- Defective distributor lead or cap
- Stuck valve
- Defective piston or rings
- Defective head gasket

#5 Engine runs but misses different cylinders

- Defective ignition
- Defective fuel system
- Loss of compression
- Defective valve action
- Defective rings
- Overheated engine
- Sticking manifold heat control valve
- Clogged exhaust

#6 Engine lacks power acceleration

- Defective ignition
- Defective fuel system
- Clogged exhaust
- Throttle valve not opening fully
- Loss of compression
- Excessive carbon in the engine
- Defective valve action
- Excessive rolling resistance from low-type pressure, dragging brakes, wheel misalignment, etc.

- Heavy oil
- Wrong or bad fuel

#7 Engine lacks power or high-speed performance, hot only

- Engine overheats
- Defective choke
- Sticking manifold heat control valve
- Vapour lock

#8 Engine lacks power or high-speed performance, cold only

- Stuck automatic choke
- Due to a stuck manifold heat control valve
- Stuck cooling system thermostat
- Stuck engine valves

#9 Engine overheats

- Lack of water
- Late ignition timing
- The loose or broken fan belt
- Defective thermostat
- Clogged water jackets
- Defective radiator hose
- Defective water pump
- Insufficient engine oil
- High-altitude, hot climate operation
- Late valve timing

#10 Rough idle

- Incorrect carburetor idle adjustment
- Malfunctioning crankcase ventilator valve on closed crankcase ventilating system
- Also, causes listed under items 6, 7 and 8

#11 Engine stalls cold or as it warms up

- Closed choke valve
- Fuel not getting to or through the carburetor
- The manifold heat-control valve stuck
- Engine overheats
- Too low setting of idling speed

#12 Engine stalls after idling or speed driving slow

- Defective fuel pump
- Overheating
- High carburetor float level
- Incorrect idling adjustment

#13 Engine stalls after high-speed driving

- Vapor lock
- Defective carburetor ventilating or idle compensator valve
- Engine overheats

#14 Engine backfires

- Ignition timing off
- The spark plug of the wrong heat range
- Excessive rich or lean mixture
- Overheating of the engine
- Carbon in engine
- Valves hot or sticking

#15 Smoky exhaust (Blue smoke & Black smoke)

- Excessive oil consumption

- Excessive rich mixture

#16 Excessive oil consumption

- External leaks
- Burning oil in the combustion chamber

#17 Low oil pressure

- Worn engine bearing
- Engine overheating
- Oil dilution or foaming
- Defective lubrication system

#18 Excessive fuel consumption

- Nervous driver
- High speed
- Short-run operation
- Excessive fuel pump pressure or pump leakage
- Choke partly closed after warn-up
- Clogged air cleaner
- High carburetor float level
- Stuck or dirty float needle value.
- Worn carburetor jet
- Stuck metering rod or full power piston.
- Idle too rich or too fast
- Stuck accelerator-pump check value
- Carburetor leaks
- Faulty ignition
- Loss of engine compression
- Defective value action
- Clutch slippage
- Excessive rolling resistance from low pressure, Dragging brakes, wheel misalignment, etc.

#19 Engine is noisy

- Value and tappet noise
- Spark knock due to low octane fuel carbon advance ignition timing. Also, causes listed under item 14
- Worn connecting rod bearing or crankpin, misaligned rod, lack of oil
- Worn or loose piston pin or lack of oil
- Worn rings, cylinder walls, low ring tension, broken rings
- Piston slap due to worn pistons, walls, collapsed piston skirts, excessive clearance, lack of oil, and misaligned connecting rods.
- Regular noise, worn main bearings, irregular, worn end thrust bearings.
- Rattles, etc., from loosely mounted accessories, generator horn, oil pan,

Theoretical learning Activity

- Brainstorming on general faults occurring in different parts of HPP and their remedies
- Group discussion on general faults occurring in different parts of HPP and their remedies

Practical learning Activity

- Practical exercises on faults correction

Points to Remember (Take home message)

General engine faults occurring in different parts of HPP and their remedies

Learning outcome 3.2 formative assessment

Written assessment

1. What are common engine faults?

Answer:

- Poor lubrication
- Failing oil pump
- Oil deposits and debris
- Inadequate fuel and air compression
- Leaking engine coolant
- Blocked engine radiators
- Prolonged engine detonation
- Damaged oxygen sensors

2. What are five safety steps to take when working on an engine?

Answer:

Safe work with engines

- Remove rings, metal watches, bracelets and any loose clothing before beginning work.
- Tie back long hair.
- Keep hands clear of all moving parts.
- Use extreme caution around engine fans, as these may strike you, fling objects, start unexpectedly, or catch dangling leads or strings

Practical assessment

Task: Correct rectifying of detected fault

Checklist		
	Yes	**No**
Fault rectification procedures		
Water intake, water conduit and accessories faults and their remedies		
Turbine and auxiliaries' faults and their remedies		
Generator and auxiliaries' faults and their remedies		
Transformer faults and their remedies		
Switch yard faults and their remedies		
Observation		

Learning outcome **3.3: Complete the repair report**

Duration: 2hrs

Learning outcome 1 objectives:

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

- Fill properly the repair report
- Keeping correctly records of repair activities
- Analysis of the repair report
- Billing effectively the repair work

Resources

Equipment	Tools	Materials
- Voltmeter and Ammeter - Wattmeter - VAR-meter and VA-meter - Phase-meter - Ohmmeter - Thermometer - Tachometer - Multi-meter - Pressure switch - Pressure gauge - Flow sensors - Hydraulic meters - Pneumatic meters - Hygrometer - Overcoat and overall - Gloves - Safety shoes - Helmet - Earmuff and Goggles - Nose protection	-Books - Internet - Service manuals - Repair report templates - Handout notes	

- mask		

Advance preparation:

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

Indicative content 1.1: Preparation of the repair report

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

Repair report format

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

Repair Report

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Things to Include in a Repair Report

Proper organization is crucial when creating a customer maintenance report for your business. While the specific items will depend on the needs of your company, six staples should always be present in every report that you make:

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Maintenance managers and engineers should always assign a category to each maintenance activity. This will help keep track of the different types of maintenance tasks being carried out. Categories can include preventative maintenance, emergency maintenance, or corrective maintenance.

Location

Along with the type of maintenance being performed, your report should also allow users to document where the maintenance took place. This information is important for keeping track of maintenance activities in different parts of your facility.

Date and Time

Another essential piece of information to include in your maintenance report is the date and time that the maintenance was carried out. This information will help you keep track of when each maintenance task was completed.

Description

Your maintenance report should also include a description of the maintenance activity carried out. The description should briefly summarize what was done during the maintenance task. However, it should also be detailed at the same time. Elaborate enough so that someone reading the maintenance report will understand what was done, but don't include so much information that it becomes overwhelming.

Pictures

Images can also be a valuable addition to your maintenance report. They can help document the condition of equipment before and after maintenance activities have been carried out. At the same time, pictures also prove that the maintenance task was actually completed.

Signature

The last thing to include in your maintenance report is a signature from the maintenance manager or engineer who completed the task. This will help to ensure that the maintenance report is accurate and complete

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Improves Maintenance Planning

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Good Recordkeeping

A maintenance report is also a good way to keep track of all the different maintenance tasks that have been carried out. This can be useful for businesses with a lot of equipment or machinery. By keeping a record of all the maintenance tasks, you can easily track what needs to be done and when.

Prevents Unexpected Breakdowns

One of the most important benefits of a maintenance report is that it can help to prevent unexpected breakdowns. By having a record of all maintenance activities, you can ensure that all tasks are carried out properly and on time. This means that there is less chance of something going wrong and causing a breakdown.

Helps to Achieve Maintenance Goals

A maintenance report can also help you to achieve your maintenance goals faster. It can help you track your progress and identify any areas that need improvement. That way, you can focus your efforts on the areas that need it the most.

Saves Time and Money

Finally, a maintenance report can save both time and money. By having a record of all maintenance activities, you can plan maintenance tasks more efficiently. This means that you can avoid carrying out tasks that are not necessary, which can save both time and money.

Indicative content 1.2: **Keeping records of repair activities**

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

Here we list the benefits of keeping a maintenance record.

- Prevent expensive repair works from happening
- Helps you create specialized maintenance programs
- Prevent problems regarding warranty claims
- It increases the safety of operators
- Helps you track who is accountable for a piece of equipment
- It increases the resale value of the equipment

Indicative content 1.3: **Analysis of the repair report**

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

Improve Maintenance Activities Through the Analysis of Repair Reports

To ensure optimal performance of machinery, systems and components while reducing the time and cost of service interventions, manufacturers, Telcos, Utilities, etc. are looking to use internal knowledge sources to drive efficient maintenance responses. However, one of the main challenges is that this data is siloed in operating and maintenance manuals, technical files, instruction documents, service tickets, operator reports.

What is the main advantage of maintenance and repair?

- Lengthen asset lifespan

- Lower risk of breakdowns
- Increase efficiency
- Decrease unplanned downtime
- Promote health and safety
- Boost customer satisfaction
- Save money

Indicative content 1.4: **Billing the repair work**

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

Repairs Invoice means any invoices, bills, or other documents relating to labour and material expenses incurred by a Claimant in the completion of Approved Repairs. Repairs Invoice shall not include any quotes or bids.

What is billing process?

In simple terms, billing refers to the process of raising and sending invoices to customers and requesting them to settle the dues. Invoices are documents that serve as a source of record-keeping for businesses and as a means of requesting payment from customers

What is the difference between billing and payment?

Billing is more focused on issuing invoices and tracking payments, while payment processing is mainly about taking payments and transferring them into your account. Make sure you understand this distinction when running your business so that you will know what you need and use the right software for the job.

Theoretical learning Activity

- Brainstorming on how to prepare the repair report
- Group discussion on taking records
- Group discussion on analysis of the repair report

Practical learning Activity

- Practical exercises on filling the repair report
- Practical exercises on billing the repair work

Points to Remember (Take home message)

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

Learning outcome 3.1 formative assessment

Written assessment

1. What is the main advantage of maintenance and repair?

Answer:

- Lengthen asset lifespan
- Lower risk of breakdowns
- Increase efficiency
- Decrease unplanned downtime
- Promote health and safety

- Boost customer satisfaction
- Save money

2. What is a Maintenance Report?

Answer:

It is a document that records all the activities that were carried out in a maintenance operation. It includes information such as what was done; when it was done; who did it, and how long it took. This report is then used to improve maintenance operations or as a reference for future maintenance activities.

- What Are the Five Elements of Report Writing?

Answer:

- Executive Summary
- Introduction
- Development
- Conclusion
- Recommendations.

- What does bill mean in payment?

Answer:

A bill is a written statement of money that you owe for goods or services.

Practical assessment

Task: Convenient complete the repair report

Checklist		
	Yes	**No**
Format of repair report		
Reports keeping		
Preparation of bill of repair work		
Observation		

Reference

1. GOOD&BAD of Mini Hydro Power by Klaus Jorde with the resources of Entec ACE karthartmann, Heinz Unger

2. Principles of Power systems by V.KMehta

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4. Harvey, A., Village planning of isolated energy schemes, IMechE,1995.

Learning Unit 4: Clean the workplace

Picture/reflecting the Learning unit 4

STRUCTURE OF LEARNING UNIT

Learning outcomes:

4.1 Arrange tools, equipment and materials activities
4.2 Clean tools and working area

4.3 Manage waste materials

Learning outcome 4.1 Arrange tools, equipment and materials activities

Duration: 5 hrs

Learning outcome 4 objectives:

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

1. Arrangement properly tools and equipment

2.Arrange properly Electrician Toolbox

3.Arrange properly Measuring equipment
4.Arrange Mechanical tool set
5. Store properly of non-used materials
6.Arrange properly fuel, lubricating oil
7. Identify correctly the faulty parts

Resources

Equipment	Tools	Materials
Voltmeter Ammeter Wattmeter, VAR-meter, VA-meter	- Books - HPP operation and maintenance manuals - Hand-out notes	

□□Phase-meter □□Ohmmeter □□Thermometer □□Tachymeter □□Multi-meter □□Pressure switch □□Pressure gauge □□Flow sensors □□Hydraulic meters □□Pneumatic meters □□Thermometer □□Hygrometer	- Internet	

Advance preparation:

- ✓ Arrangement of tools and equipment
- ✓ Electrician Toolbox
- ✓ Measuring equipment
- ✓ Mechanical tool set
- ✓ Storing of non-used materials
- ✓ fuel, lubricating oil

Indicative content4.1: Arrangement of tools and equipment

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

- One of the most common ways to organize power tools is in bins or containers below a workbench or a table top . Buying containers that can seal might be a good idea, because they'll protect your power tools from water or any other hazard that could potentially damage them.

Indicative content 4.2: Electrician Toolbox

⚠ Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

When every tool has its own place, not only is it easy to remember where things are located, but it makes choosing the right tool simpler and faster. And that means less stress, faster finishing, and more time to live your life. That means more time for what we actually want to do—hunt, fish, build, and get our relaxation on. It's time to take care of these babies by organizing them in a toolbox. Pull up your sleeves and let's get started.

HOW TO ORGANIZE YOUR TOOLBOX

1. Audit Your Tools

You can't keep track of your tools unless you know what you have. Take a detailed inventory of your tools and get rid of any broken or damaged equipment. The last thing you want while working on a job is to find out you have a broken tool. What's worse is if it breaks right in the middle of a task. If you find yourself leaving a job to run up to Home Depot often, you might need to replace some tools. Making sure all your tools are up to par is not only important but the professional thing to do.

2. Group Tools by Type and/or Function

Organizing tools by type will make them easier to locate for specific uses. Tool storage cabinets that feature slide-out toolbox drawers typically have areas of different sizes to keep tools within the same family (pliers, ratchets, and files) together.

If you have SAE (a measurement standard) and metric hand tools, separate drawers will help avoid

wasting time grabbing the wrong type of tool.

3. Organize by Size, Shape, and Frequency of Use

Alternate handles to conserve space. If the handles on screwdrivers, pliers, or other larger tools at one end are all facing the same direction, this will take up a lot more space. Alternating the handles will help the tools fit into place better and create more space in your toolbox.

Maximize space with different compartments to keep tools that are roughly the same size together. Many chest-style toolboxes come with drawers that get larger in size so that you can store all the small stuff, like socket sets, drill bits, and small tools in the top drawers. The bottom can hold larger tools (power tools, cords, batteries, and heavier items) that take up more space.

4. Store Extra Tools Elsewhere

Carrying around tools that you don't often use is just unnecessary (not to mention, plain 'ol silly). Most professionals who constantly work with tools end up with multiples of the same piece. Great for back up, but not for transporting around. Storing duplicate tools or those you don't use all the time in a separate, task-specific toolbox will clear up space for the things you need. This will keep your portable toolbox free of unnecessary clutter. Not to mention save your muscle from some serious soreness.

5. Choose Your Type of Storage

In your garage or shop, utilizing one of those rolling tool chests with drawers is a great way to go. Inside the drawers, an inexpensive organizer, like this one from Harbor Freight, is ideal. Harbor Freight has a great toolbox on wheels, too (in the $600 range). Still, it's a lot cheaper than other comparable tool chests such as Snap-on or Craftsman, which have similar features. The heavy-duty rolling tool cart is a convenient height with a workspace on top, drawer liners, and smooth rollers. Inside the drawers, you can organize with foam inserts cut to fit specific tools. Or, you can buy a roll of foam and DIY your own drawer organizer dividers. You know what they say–you want something done right, you gotta DIY!

But let's say you don't need to travel around with your tools. If that's the case, your storage solution can include a pegboard above your workbench. It's a great way to keep your most-used tools handy and easy to find. As a bonus, maintaining tools where you can see them helps remind you to make sure they are clean. But if you frequently go out to other sites, you'll need a more portable toolbox solution. Good options include traditional truck toolboxes that you can access from the sides or from inside the bed for pickup trucks.

6. Label Sections and Tools

Another helpful organization tip is to add labels to the foam inserts and outside of the drawers. Placing a label with each tool's name next to their designated spot in the foam inserts makes it much easier to find a piece of equipment and put it back quickly. Labeling the drawers outside of the toolbox helps you identify what is inside much faster. This will save you time searching through different drawers for a tool–and time is money!

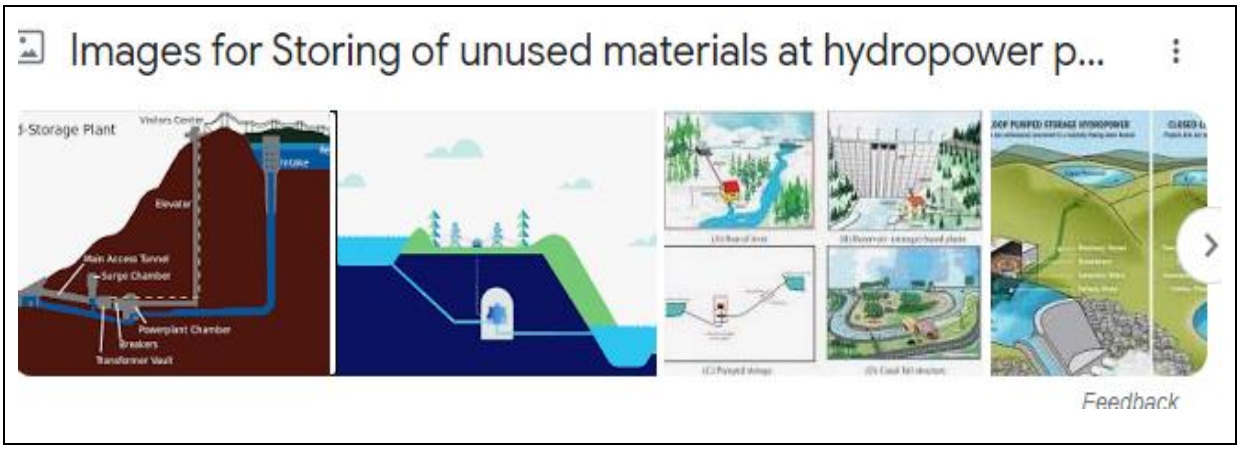
Indicative content 4.3: Measuring equipment

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

The common types of measuring tools include speedometers, measuring tape, thermometers, compasses, digital angle gauges, levels, laser levels, macrometer, measuring squares, odometers, pressure gauges, protractors, rulers, angle locators, bubble inclinometers, and callipers
The different types of electrical and electronic instruments are a voltmeter, ammeter, wattmeter, ohmmeter, LCR meter, and a multimeter. The meter has a pointer which moves over a scale whenever the quantity passes through the meter.

Indicative content 4.5: Storing of non-used materials

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)



Indicative content 4.6: fuel, lubricating oil

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.

- ✓ the functions of lubricating oil that is used in turbine

It reduces varnish, reduces water contamination, lengthens equipment life and extends drain intervals. It is a premium, high-performance turbine oil with excellent water separation characteristics, rust and oxidation inhibitors, and improved wear-reducing properties.

Uses of lubricating oil

It prevents the metal surface corrosion- Lubricating oil prevents the metal surface from any type of corrosion and roughness. ...

It helps in controlling the friction between load-bearing surfaces- ...

Helps in reducing the temperature by carrying away heat from friction and combustion of fuel

Indicative content 4.7 faulty parts

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.

What are the common problems in hydroelectric power plant?

Hydroelectric power is not perfect, though, and does have some disadvantages

- High investment costs.
- Hydrology dependent (precipitation)
- In some cases, inundation of land and wildlife habitat.
- In some cases, loss or modification of fish habitat.
- Fish entrainment or passage restriction.

Theoretical learning Activity

- ✓ Conduct Brainstorming on how to arrange tools and equipment
- ✓ Have students in their respective Group discussion on storing non-used materials

Practical learning Activity

- ✓ Conduct Physical demonstration of tools, equipment and materials needed.

Points to Remember (Take home message)

- Arrangement of tools and equipment
- Electrician Toolbox
- Measuring equipment
- Mechanical tool set
- Storing of non-used materials
- fuel, lubricating oil
- faulty parts

Learning outcome 4.1 formative assessment

Written assessment

I. Choose correct answer
1. What is the purpose of a claw hammer?
A) To tighten nuts and bolts
B) To cut wood
C) To drive nails into wood
D) To sand wood

Answer: C) to drive nails into wood

Which tool is best suited for cutting through PVC piping?
A) A hacksaw
B) A pair of scissors
C) A pair of pliers D) A wrench

Answer: A) A hacksaw

II.Answer by true or false

1.Power tools should be operated with safety precautions in mind. True or False?
Answer: True.
2. Power tools can be used without proper training or experience. True or False?
Answer: False.

III. 1. What are the Uses of lubricating oil

- It prevents the metal surface corrosion- Lubricating oil prevents the metal surface from any type of corrosion and roughness. ...
- It helps in controlling the friction between load-bearing surfaces- ...
- Helps in reducing the temperature by carrying away heat from friction and combustion of fuel

3.What are the common problems in hydroelectric power plant?
Hydroelectric power is not perfect, though, and does have some disadvantages

- High investment costs.
- Hydrology dependent (precipitation)
- In some cases, inundation of land and wildlife habitat.
- In some cases, loss or modification of fish habitat.
- Fish entrainment or passage restriction.

Learning outcome 4.2 Clean tools and working area

 **Duration: 5hr**

 **Learning outcome 4 objectives:**

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

- Identify properly Purpose of cleaning tools and working area
- Identify properly methods of cleaning

 **Resources**

Equipment	Tools	Materials
Voltmeter □□Ammeter □□Wattmeter, VAR-meter, VA-meter □□Phase-meter □□Ohmmeter □□Thermometer □□Tachymeter □□Multi-meter □□Pressure switch □□Pressure gauge	- Books - HPP operation and maintenance manuals - Hand-out notes - Internet	

□□Flow sensors □□Hydraulic meters □□Pneumatic meters □□Thermometer □□Hygrometer		

Advance preparation:

- ✓ Purpose of cleaning tools and working area
- ✓ Methods of cleaning

Indicative content4.2: Purpose of cleaning tools and working area

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

- Cleaning products play an essential role in our daily lives. By safely and effectively removing soils, germs and other contaminants, they help us to stay healthy, care for our homes and possessions, and make our surroundings more pleasant.
- What are the safety measures in hydro power plant?

Sump water level measurement for drainage pump operation

Avoid equipment failure risks linked to humidity and corrosion.

Enhance plant safety with reliable level monitoring.

Implement flood protection schemes to automatically close intake gates or hilltop valves and keep turbines operating.

Indicative content 4.3. Methods of cleaning

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

Cleaning Methods are:

Mechanical Cleaning. Often referred to as clean-in-place (CIP). Requires no disassembly or partial disassembly.

Clean-out-of-Place (COP). Can be partially disassembled and cleaned in specialized COP pressure tanks.

Manual Cleaning. Requires total disassembly for cleaning and inspection.

Also there are many other cleaning methods such as:

- ✓ Blowing
- Sweeping
- Brushing
- Wiping
- Removal of waste materials

Theoretical learning Activity

- ✓ Conduct Brainstorming on the purpose of cleaning tools and working area
- ✓ Have students in their respective Group discussion on methods of cleaning
- ✓ Have students in their respective Group discussion on the removal of waste materials

Practical learning Activity

Conduct Physical demonstration on cleaning generators parts

✓

 Points to Remember (Take home message)

- ✓ Purpose of cleaning tools and working area
- ✓ Methods of cleaning

Learning outcome 4.2 formative assessment

Written assessment

I. Answer by true or false
   a. Mechanical Cleaning. Often referred to as clean-in-place (CIP). Requires no disassembly or partial disassembly.
   b. Clean-out-of-Place (COP). Can be partially disassembled and cleaned in specialized COP pressure tanks.
   c. Manual Cleaning. Requires total disassembly for cleaning and inspection
   a.true, b.true c. true

II. What is the Purpose of cleaning tools and working area?

The purpose of cleaning tools are:

- ✓ Avoid equipment failure risks linked to humidity and corrosion.
- ✓ Enhance plant safety with reliable level monitoring.

Implement flood protection schemes to automatically close intake gates or hilltop valves and keep turbines operating

Learning outcome 4.3. Manage waste materials

Duration: 5hr

Learning outcome 4 objectives:

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

- Identify properly Selection of area for storing waste materials
- Identify properly Storing and treatment of waste materials
- Identify properly Biodegradable
- Identify properly Non-biodegradable
- Identify properly Recyclable

Resources

Equipment	Tools	Materials
Voltmeter Ammeter Wattmeter, VAR-meter, VA-meter Phase-meter Ohmmeter Thermometer Tachymeter Multi-meter Pressure switch Pressure gauge Flow sensors Hydraulic meters Pneumatic meters Thermometer Hygrometer	- Books - HPP operation and maintenance manuals - Hand-out notes - Internet	

Advance preparation:

Selection of area for storing waste materials

- ✓ Storing and treatment of waste materials

- ✓ Biodegradable
- ✓ Non-biodegradable
- ✓ Recyclable

Indicative content 4.3: Selection of area for storing waste materials

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

- ✓ Store waste in areas that can contain a leak or spill and are isolated from surface water drainage systems. Label containment areas or bins for different materials and activities. Consider using colour coding for quick identification, eg red for hazardous waste and green for glass.
- ✓ Landfills. Landfills are excavated or engineered sites where non-liquid hazardous waste is deposited for final disposal and covered. These units are selected and designed to minimize the chance of release of hazardous waste into the environment
- ✓ There are four factors that should be considered in the onsite storage of solid waste. These are the type of container to be used, the location where the containers are to be kept, public health, and the collection method and time

.

Indicative content 4.4. Storing and treatment of waste materials

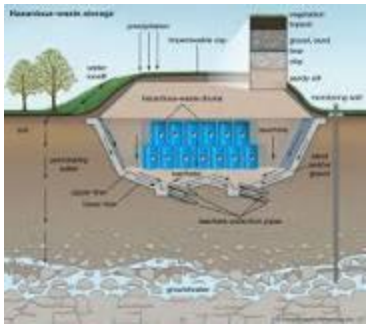
Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

- ✓ Waste disposal methods

Recycling. Incineration. ...
Other thermal treatment plants. Chemical-physical and biological treatment. ...
Chemical-physical and biological treatment. Landfills. ...
Landfills. Collection and logistic

- ✓ You should store your waste securely in sealed, labelled containers ready for recycling or disposal.

What is the treatment of waste?



- ✓ Hazardous waste can be treated by chemical, thermal, biological, and physical methods. Chemical methods include ion exchange, precipitation, oxidation and reduction, and neutralization. Among thermal methods is high-temperature incineration, which not only can detoxify certain organic wastes but also can destroy them

Indicative content 4.5: Biodegradable

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

What is the meaning of biodegradable materials?

- "Biodegradable" refers to the ability of things to get disintegrated (decomposed) by the action of micro-organisms such as bacteria or fungi biological (with or without oxygen) while getting assimilated into the natural environment. There's no ecological harm during the process.

✓ Biodegradeable material generally includes wood, wool, cotton, animal waste or any other organic material which can be broken down into carbondioxide, methane or any other simple organic molecules with the help of micro-organisms. They are often referred to as 'Bio-waste'.

Indicative content 4.6: Non-biodegradable

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

✓ Non-biodegradable wastes are those that cannot be decomposed or dissolved by natural agents. They remain on earth for thousands of years without any degradation. Hence, the threat caused by them is also more critical. A notable example is plastics which are a

commonly used material in almost every field.

- ✓ What are the 3 types of non-biodegradable?

Solution: Glass, metal, and battery are examples of non-biodegradable materials which cannot be decomposed by microorganisms

- ✓ Glass, metals, electronic devices, computer parts, batteries, medical waste, plastic bags, plastic bottles, tetra packs, and carbon paper are a few examples of non- biodegradable materials.

Indicative content 4.7: Recyclable

Summary for the trainer related to the indicative content (key notes using bullets such as ticks etc.)

- ✓ Recyclable materials include many kinds of glass, paper, cardboard, metal, plastic, tires, textiles, batteries, and electronics. The composting and other reuse of biodegradable waste—such as food and garden waste—is also a form of recycling
- ✓ below are some of the recyclable materials - aggregates, electronic equipment, glass, metals, organic waste, paper, plastic, textiles, tyres, wood - found in businesses, and the options for reusing them.

Theoretical learning Activity

- ✓ Conduct Brainstorming on selection of waste material storing area
- ✓ Have students in their respective Group discussion on methods of waste treatment

Practical learning Activity

- ✓ Conduct Physical identification of waste materials

 Points to Remember (Take home message)

- ✓ Selection of area for storing waste materials
- ✓ Storing and treatment of waste materials
- ✓ Biodegradable
- ✓ Non-biodegradable
- ✓ Recyclable

 **Learning outcome 4.3 formative assessment**

Written assessment

II. Answer by true or false

a. Store waste in areas that can contain a leak or spill and are isolated from surface water drainage systems. Label containment areas or bins for different materials and activities. Consider using colour coding for quick identification, eg red for hazardous waste and green for glass. TRUE

b. Landfills. Landfills are excavated or engineered sites where non-liquid hazardous waste is deposited for final disposal and covered. These units are selected and designed to minimize the chance of release of hazardous waste into the environment TRUE

c. There are four factors that should be considered in the onsite storage of solid waste. These are the type of container to be used, the location where the containers are to be kept, public health, and the collection method and time TRUE

II . What are the 3 types of non-biodegradable?

Solution: Glass, metal, and battery are examples of non-biodegradable materials which cannot be decomposed by microorganisms

III. Biodegradeable material generally includes the following except: a.wood, b.wool, c.cotton, d.animal waste e.pvc

Reference books:

1. Principles of power system, V.K MEHTA , ROHIT MEHTA, S.CHAND &COMPANY, NEW DELHI 2004