CHAPTER 3
Operation

Correct operation and maintenance of an MHP plant is beneficial in many ways. Managers and operators must be fully familiar with the equipment, its functions, and the operational procedures. The technical specifications must also be known and recorded properly in the Operation and Maintenance Manual provided by the installer and in the log book. Table 3.1 shows a typical example of specifications.

3.1 General Operating Procedure

The following checks should be made during starting, stopping, and running of the plant. If a problem is noticed at any stage, for example, an unusual sound, the plant should be stopped and the problem rectified before starting or running the plant again.

3.1.1 The Start-up Procedure

For Water and Turbine

- Follow the specified procedure for cleaning up the civil works as applicable.
- Visually inspect all equipment (e.g., turbine, generator, control panel, isolating switch).
- Check oil levels in any equipment using oil reservoirs.
- Ensure that the penstock and turbine valves are closed.
- Turn on the water at the intake.

For Electricity

- Check that all switches on the load side are in the 'OFF' position (if an electronic load controller (ELC) is installed) alternatively check that all switches on the load side are in the 'ON' position (if there is no ELC).
- Inform users that the plant will be starting (some system for this needs to be developed and put into operation, since it is difficult to inform all consumers separately).
- If belts have been removed, put them on the pulleys. Check belt tension.
- Gradually open the penstock valve (if fitted) to the fully open position.
- Gradually let water into the turbine by opening the turbine valve, while checking the pressure gauge to maintain a smooth rise in pressure.
- If there are any push button switches for exciting the generator, press them until the voltage rises to 200V.

- Increase the water flow by opening the turbine valves until the speed, voltage, and power come up to the desirable/rated level.
- For plants with an ELC, gradually divert power to the load by switching the load switches to 'ON'.
- If there is no load controller, increase the water flow until the voltage rises to 220 V while the load is connected.
- The allowable voltage fluctuation for plants below 25kW is +10 per cent and -14 per cent; for larger plants it should be within ±10 per cent.

For Agro-processing

- Check all nuts, bolts, and similar on the agro-processing machinery; move everything away from the drive system.
- Engage the belt from the turbine to the line shaft and then to the machine.
- If there is no line shaft, place the belt directly from the turbine to the machine; for example a rice huller.
- Admit grains to the huller, oil seed to the expeller, etc.
- Let water into the turbine, gradually opening the turbine valve until the required speed is reached.
- Check the pressure gauge to ensure that pressure is not fluctuating rapidly.
- Listen for any abnormal noise or vibration when the unit is running. Stop the turbine if this happens and look for the fault.
- Check drive systems (e.g., belt or coupling).
- Only connect units simultaneously when power is sufficient.
- If the turbine is powering a generator and agro-processing equipment simultaneously; the electricity generation has priority. Only connect the agro-processing unit if sufficient additional power (i.e., flow) is available.

3.1.2 Continuous Checks during Running

The following checks must be made during the running of the plant. If at any stage an abnormal condition arises, the plant should be shut down and the problem diagnosed and rectified.

- Check the voltage, frequency, and power output every hour and record in the log book once a day. Abnormal readings must be recorded whenever noticed, together with the corrective action taken.
- If the voltage or frequency decreases as a result of overload, remove some loads.
- Compute the power consumed from the panel meter (current and voltage) if no wattmeter is installed.
- If the power consumption is more than design capacity, disconnect some loads from the distribution box.

- Check for abnormal noises and water leaks.
- Check bearing and generator temperatures by touching the housings.
- Periodically check the penstock pressure.
- If overload occurs, it could be that some consumers are using a higher load than permitted (for example a heater) so checks should be made regularly at the premises of such users.

3.1.3 The Shutting Down Procedure

The following procedure should be followed prior to and during shutting down of the MHP plant.

- If time permits, inform users that the plant will be shut down (unless they already know, as in the case of regular shutdowns).
- Switch all connected loads to 'OFF'.
- Close the turbine control valve gradually to prevent a rapid rise in penstock pressure.
- Close the penstock valve.
- Stop water from the forebay tank and intake if necessary.
- Ensure that the powerhouse and equipment are clean and tidy.

If the shutdown is the result of an emergency, action should be quick and emergency devices such as jet deflectors (for Pelton turbines) should be actuated.

3.2 Safety and First Aid

Working with electricity can be very dangerous if adequate care is not taken. Thus it is important to be aware of, remember, and comply with safety precautions; and it is essential to know how to perform first aid and primary treatment when an accident happens.

3.2.1 Workplace Safety Precautions

The following precautions should be taken when operating an MHP scheme or working in a powerhouse while it is in operation.

- If possible, shoes should be rubber soled; they must not be damp or wet.
- While working, hands should not be wet.
- If possible the electricity supply to the work area should be turned off before starting work.
- The location of the switch to turn off the whole electricity supply should always be known beforehand to workers.
- Only essential fuses should be left in place while working on an electrical circuit; others should be removed.

- Make sure that metal covered items, such as the main switch and panel box, are properly earthed.
- If a fire or electrical accident occurs, the electric power should be turned off immediately.
- Tools and materials should be kept in their proper place when not in use; and only proper tools and materials should be used for particular work.
- After finishing work, everything should be cleaned and returned to its proper place; this practice should become a habit.
- Work in a systematic way. If any work is unfamiliar, an experienced person should be asked to assist or advise; especially in the case of electrical machines.
- Oil should not be put in a machine that is running.
- Glasses and gloves should be used when working in front of a machine (grinding, drilling, welding, and similar work).
- Keep a straight back and bend your knees when lifting any machine or heavy material.
- Necessary primary treatment (first aid) should be given immediately to an injured person if an accident occurs.
- Repaired machinery should only be operated after it has been carefully tested.
- The worktable should be well insulated (should be wooden).

3.2.2 *First Aid for Electrical Shock*

If any person suffers an injury from an electrical accident he should be taken to a doctor as quickly as possible. If this is difficult or not possible (the road may be blocked, transport facilities may be limited, or the distance may be long) the sick person may have to remain in place for some time. In this case, the injured person should be kept calm and first aid should be provided. It would be very beneficial if personnel were properly trained in a suitable place to administer first aid (for example at a civil defence centre or hospital). The following procedure should be adopted for providing first aid to an injured person.

- The electricity line should be disconnected immediately, the main switch turned to 'OFF', and the shocked person separated from the source of the shock. Don't forget clothing which may also be in contact with the electrical supply.
- If the switch cannot be reached quickly, the live wire should be removed from the person with the help of a non-conductor such as wood, plastic, or rubber.
- If the person is unconscious and not breathing, artificial respiration should be administered, as described below, or else the person may die.
- After giving artificial respiration, the area affected by the shock should be massaged because an electric shock causes the blood circulation to stop. The arms, feet, etc should be rotated at the joints.
- Feed the person in shock some warm milk or tea.

- The person in shock should be encouraged to talk and move if possible to give him confidence and help him remain conscious. Don't let him lose consciousness.
- Every effort should be made to make the person in shock as comfortable as possible.
- If the condition of the injured is still serious (say, the breathing is irregular or he is sweating), he should be taken to a hospital or to a good doctor. In all cases the injured person should see a qualified doctor as soon as possible for a check-up and treatment.

3.2.3 *Artificial Respiration Techniques*

Anyone who receives a high voltage electric shock may become unconscious, and even stop breathing. If the injured person stops breathing he must be given artificial respiration immediately, until he begins to breathe by himself. The following two techniques are those used most commonly to revive breathing artificially.

The Face-down Method

This method is simple and easy to learn and is thus more commonly used. The basic positions are shown in Figure 3.1. The person giving first aid kneels in front of the sick person and lays the sick person face down on the floor between his knees. The two hands of the injured person are folded in front of his head and the forehead rested on them. In this way, the nose air passage remains open. Then the person giving first aid places his two hands with the fingers spread wide on the back of the sick person below the shoulders and, placing his two thumbs equally on the ribs of the sick person, slowly presses downward with his hands, watching carefully to see how much pressure is needed. The pressure should be such that air emerges from the lungs and they are emptied. The hands should then be released slowly. The sick person is then grasped by the upper arms just above the elbows with both hands, and the arms are pulled upwards towards the person giving first aid. In this way, the chest expands and air enters the lungs. The person giving treatment should repeat this cycle at a rate of about 12 times per minute until such time that the sick person begins to breathe naturally by himself.

Mouth-to-Mouth Resuscitation

This method is illustrated in Figure 3.2. The sick person should be made to lie flat on his back. First check that the jaws of the injured person can be opened easily; if not, open them by hand. Place one hand under the back of the sick person's neck to raise it a little and use the other hand to hold his nose shut. The person giving treatment should place his mouth over the sick person's mouth and blow into it, whilst holding the nose closed to prevent air escaping, to fill the patient's lungs with air. After that, the nose is released so it can open and the air in the lungs can come out. The nose is then held closed again

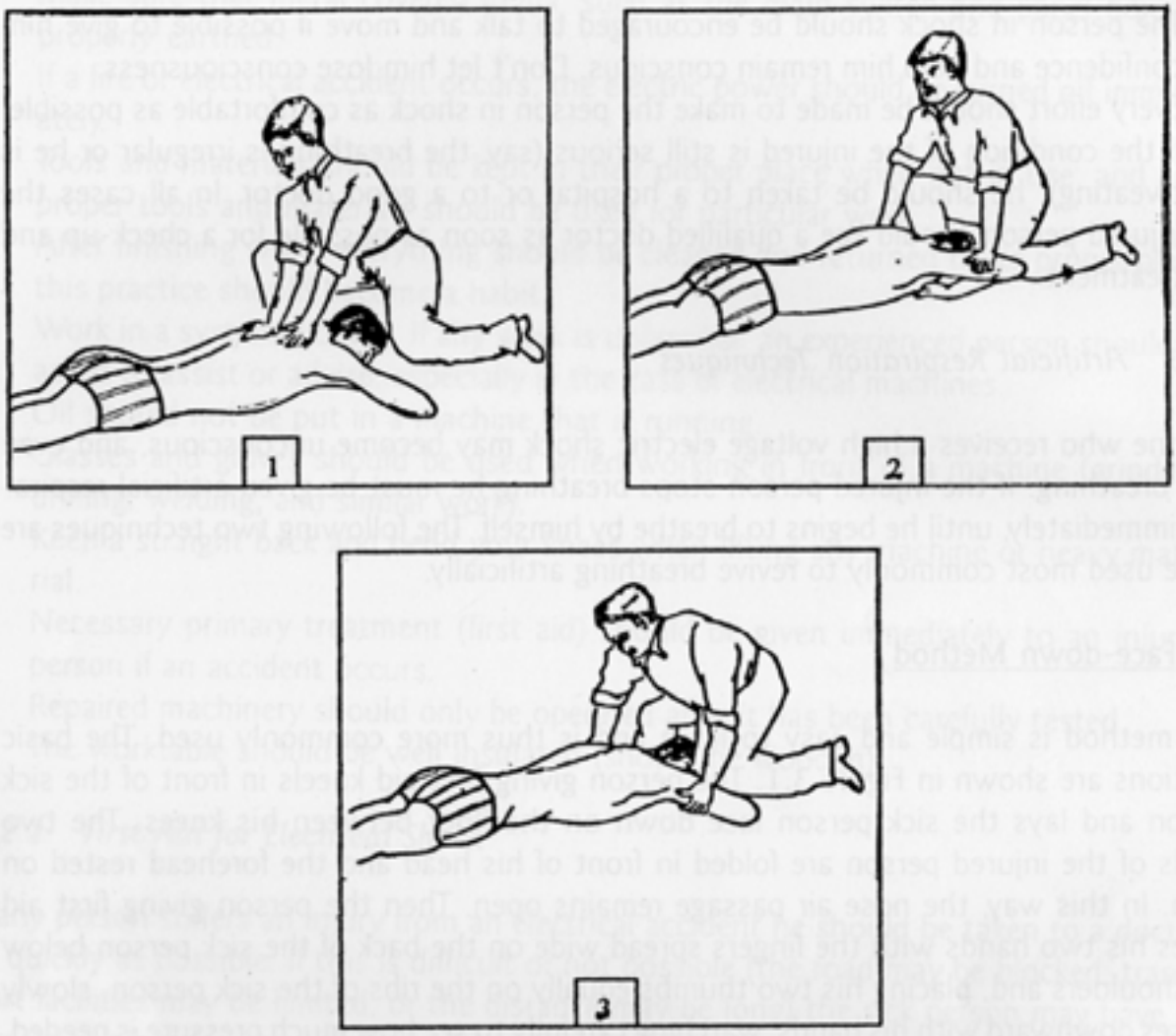

Figure 3.1: The Face-down Method of Artificial Respiration

and the cycle repeated at a rate of 10-15 times a minute until the person giving first aid notices that the pressure needed to blow in is becoming less than in the initial stages.

3.3 Extended Shutdowns

If a major repair has to be carried out on an MHP plant, the powerhouse will have to be shut down for a long period. If an extended shutdown becomes necessary, the operator/manager should notify the villagers about the situation and about the tentative duration of the shutdown. The equipment remaining within the powerhouse must be protected from corrosion, rain, landslides, pilferage, and other such eventualities. Some items located outside the powerhouse (e.g., trash rack, canal gate) may also be dismantled and stored within the powerhouse or some other safe place.

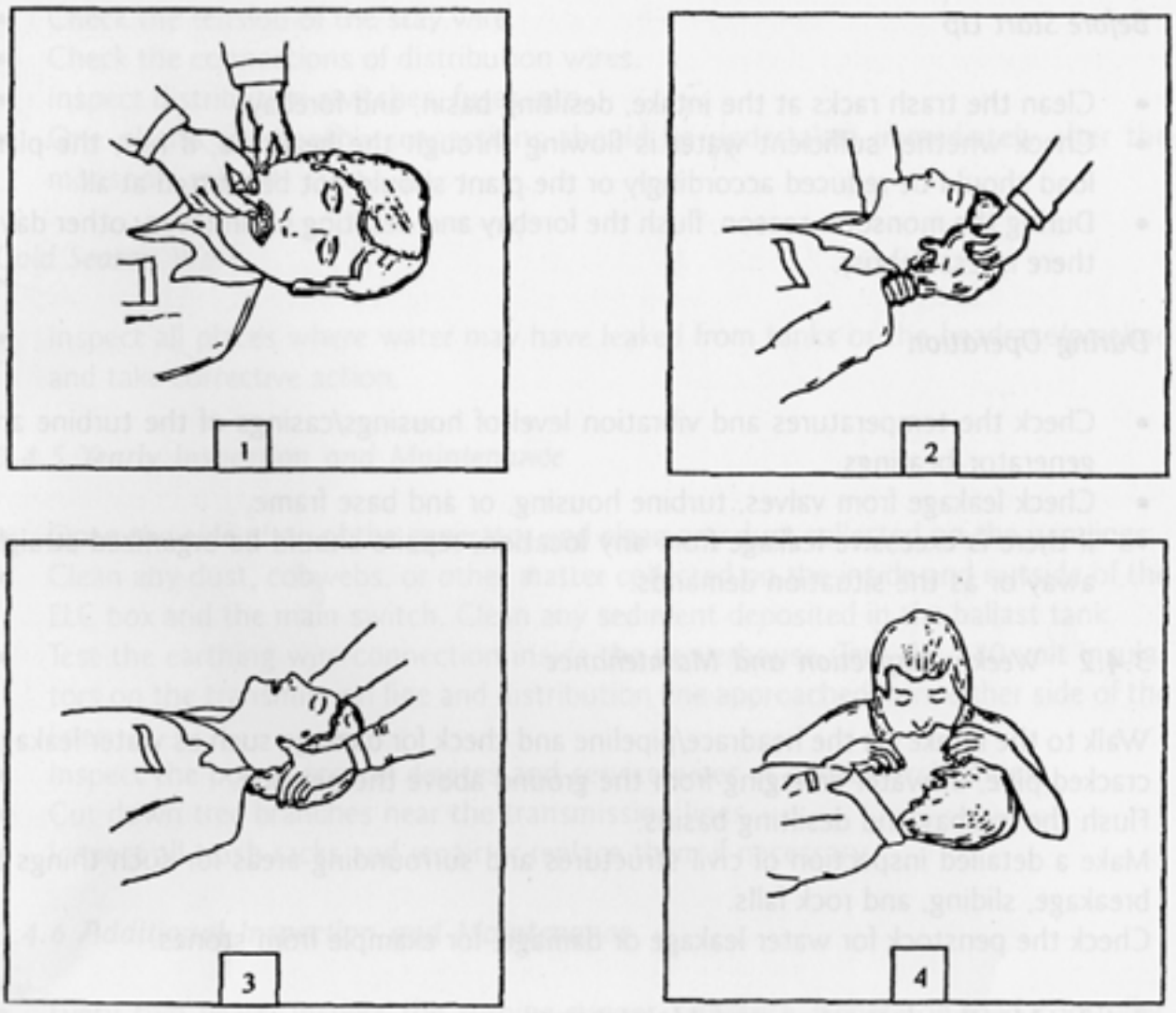

Figure 3.2: Mouth-to-Mouth Resuscitation

3.4 Routine Inspection and Maintenance

The operator should check the following items inside and outside the powerhouse on a regular basis to ensure reliable operation. The suggested frequency of checking for different items is given below. Any damage noticed during these checks should be rectified as soon as possible to prevent the problem from getting worse.

3.4.1 Daily Inspection and Maintenance

The following items should be inspected every day and corrective action taken if necessary. See also section 3.1.2.

Before Start Up

- Clean the trash racks at the intake, desilting basin, and forebay.
- Check whether sufficient water is flowing through the headrace. If not, the plant load should be reduced accordingly or the plant should not be started at all.
- During the monsoon season, flush the forebay and desilting basin (every other day if there is less debris).

During Operation

- Check the temperatures and vibration level of housings/casings of the turbine and generator bearings.
- Check leakage from valves, turbine housing, or and base frame.
- If there is excessive leakage from any location, repairs should be organized straight away or as the situation demands.

3.4.2 Weekly Inspection and Maintenance

Walk to the intake via the headrace/pipeline and check for damage such as water leakage, cracked pipe, or water emerging from the ground above the pipeline.
Flush the forebay and desilting basins.
Make a detailed inspection of civil structures and surrounding areas for such things as breakage, sliding, and rock falls.
Check the penstock for water leakage or damage, for example from stones.

3.4.3 Monthly Inspection and Maintenance

- Walk from the powerhouse along the penstock to the forebay and check all expansion joints, flanges, and welds for leakage.
- Close all the turbine valves and open up the bearings and put two fingers full of grease in each. Do the same for the generator bearings using a grease gun.
- Inspect the generator, MCB switch, and ELC box and feel the cables to check if they are very hot. Also check to see if the colour of the cables has changed.
- Check the fencing around the high voltage transformer if installed.
- Inspect all the civil structures, including the penstock and surrounding areas, for landslides and damage, or impending signs of landslides.

3.4.4 Six-monthly Inspection and Maintenance

- Inspect the condition of poles and repair any damaged ones.
- Check the clearance of the transmission line from the ground and tree branches.
- Check the line connections of lightning arrestors and jumpers.

- Check the tension of the stay wire.
- Check the connections of distribution wires.
- Inspect distribution switches, fuses, etc.
- One of the six-monthly inspections should be undertaken immediately after the monsoon season.

Cold Season Work

- Inspect all places where water may have leaked from tanks or the headrace/pipeline and take corrective action.

3.4.5 Yearly Inspection and Maintenance

- Open the side plate of the generator and clean any dust collected on the windings.
- Clean any dust, cobwebs, or other matter collected on the inside and outside of the ELC box and the main switch. Clean any sediment deposited in the ballast tank.
- Test the earthing wire connection inside the powerhouse. Test the 240 volt insulators on the transmission line and distribution line approached from either side of the lines.
- Inspect the power control devices and service wires at consumers' homes.
- Cut down tree branches near the transmission lines.
- Inspect all trash racks and repair or replace them if necessary.

3.4.6 Additional Inspection and Maintenance

- Every two years, inspect the turbine runner, penstock, generator, load controller, and all civil works. If possible, this inspection should be carried out by a competent consultant.
- Every two years, dig up all earthing plates and inspect them for excessive corrosion. If necessary, the plate (s) should be replaced, and several layers of salt and charcoal or coal dust placed in the hole, one after the other, above the plate. If the earth plate connection is loose, it should be tightened or redone.
- Every four years repaint the penstock completely.

3.4.7 Additional Suggestions for Operation and Maintenance

- Except during the cold months of December and January, the penstock should not be left empty on any sunny day when the plant is not running (because the steel pipe can heat up and the expansion may damage the penstock).
- The overflow from the forebay should be as little as possible; to achieve this, allow a small amount of excess water to come from the desilting basin gate.

- If the powerhouse is to be closed for longer than one hour, the flush gate from the desilting basin should also be left open.
- If the powerhouse is to be closed for a full day or longer, the water flow from the source should also be minimised or stopped if possible.
- During operation, adequate ventilation should be provided in the powerhouse so that the generator receives the necessary cooling air.
- The gate valve should be inspected daily to ensure that sufficient water is flowing to the ballast heater tank. If the water flow is insufficient, the valve and union should be removed, tested, and repaired if necessary.

3.5 Log Book

A log book should be kept by the manager/operator in order to keep track of such things as routine maintenance, problems, breakdowns/shutdowns, and repairs undertaken. Only unusual happenings or actions should be recorded in the log book. The log book should also contain a complete list of the technical specifications of the plant. The details needed are shown in Table 3.1. An example of a filled page of a log book is shown below.

Date ..... Time..... Power output .....

Bearing temperature of left hand (LH) side of the turbine is hotter than usual. It should be replaced soon.

Date ..... Time..... Power output .....

There was excessive leakage from the LH side of the turbine. Plant was stopped and the sealing packing was changed. LH side bearing had also been giving trouble for about three weeks; therefore, it was also replaced.

No further problem at these points.

Date ..... Time..... Power output .....

The plant had to be stopped for two hours because there was not enough water. The diversion barrier at the intake mouth needs to be extended and the weir height needs to be increased .

Date ..... Time..... Power output .....

The plant was shut down for two days to carry out the six-monthly routine repairs. The trash rack at the penstock mouth was repaired. The bolts on the first expansion joint were tightened to reduce leakage. The plant was restarted on ..... (date) at ..... (time) and was working fine.

Table 3.1 The Technical Specifications to be Recorded in the Log Book for the MHP Plant

1. Intake

Type: .....
Weir Type: .....
Diversion details: .....

2. Canal

Canal length	----------m
Silt basin(s)	number ----------
HDPE pipe	dia---------- ; length ---------- m
Flush pipe	number----------; dia.----------
Gate valve/sluice gate	number----------; dia.----------

3. Forebay tank

Trash rack(s)	size -------- X; ---------- no.
Flush pipe(s)	dia.----------;no.----------*
Air vent pipe(s)	dia.----------; no.----------

4. Penstock pipe

Steel	thickness ---------- mm; length ---------- m; dia.---------- mm	
HDPE pipe	weight--------- kg/cm^2; length---------- m; dia.---------- mm	
Expansion/joint	dia. ---------- mm	
Butterfly valve(s)	number ----------; dia. ---------- mm	
Flat gasket for		thickness ---------- mm
O ring gasket for		dia. ---------- mm
Anchor blocks	number ----------	at ..... metres
Support piers	number----------	at.....m intervals
Bends	number----------at ----------	(length from forebay)

* dia. = diameter; no. = number

5. Turbine

Type---------- size----------
Turbine bearing(s) type---------- ;number ----------;catalogue no.----------
Turbine pulley type---------- ;dia.---------- mm
Generator pulley type ---------- ;dia.---------- mm
Turbine shaft dia. ----------mm
Belt type ---------- ;size----------mm

6. Driving system

Line shaft dia.---------- mm; length ---------- m
Pulley on line shaft dia.---------- mm
Pulley on turbine dia.---------- mm
Bearing type ---------- no.---------- catalogue no. ----------
Belt type --------- size ----------

7. Generator

Manufacturer's name: ----------
Type ----------
KVA ----------
Phase ----------
Frame No. ----------
Serial No. ----------
Generator bearing drive end ----------
Generator bearing non drive end ----------
AVR type ----------; size ----------

8. Electronic load controller

Manufacturer's name: ----------
kW ----------
MCB ----------Amps ---------- phase
Fuse ----------Amps
Immersion heater ---------- kW ---------- number----------

9. Ago-processing machines:

1. Oil expeller --------- bolts Brand --------- size ---------kW
2. Rice huller ---------catalogue no. Brand --------- size ---------kW
3. Grinder ---------inch/mm Brand --------- size ---------kW
4. ———————— Brand --------- size ---------kW

10. Transmission Line

Main switch: current ---------Amps; phase ---------; number ---------

11. Conductor

Type	---------
Length (m)	---------
Size	---------
Service wire	X-section area---------mm^2
Transmission poles	type ---------length ---------m
Distribution poles	type ---------length ---------m

The main aspects of the specifications of the power plant should be clearly written in the Operation and Maintenance Manual provided by the manufacturer/installer to the owner/manager. These specifications should help the plant manager to operate the plant properly, organize repairs, and order spares.