Use and Care Instructions for your new

PowerPal™

High Head

Micro-hydroelectric Generator

Models: MHG-200HH

MHG-500HH

Asian Phoenix Resources Ltd., Canada

READ THIS FIRST

This manual contains important information concerning your new PowerPal high head micro-hydroelectric generator. It covers Models MHG-200HH and MHG-500HH. You should read this manual carefully before installing PowerPal or allow a trained technician from your local PowerPal Service Center to install it for you.

Your PowerPal generator is designed to be simple to operate and easy to maintain. If used in accordance with these instructions your PowerPal will give you many years of service. PowerPal is also designed with safety in mind, but any electric device can be dangerous if not used correctly. At several points in this manual, instructions requiring special attention that must be followed are shown as:

Warning symbol - beware of hazards or unsafe practices that may cause injury or death.

Caution symbol – beware of hazards or unsafe practices that may damage the product.

SAFETY FIRST

While electricity improves your life, it can also be dangerous if simple precautions are not followed:

• Never allow electrical contacts to become wet. Beware of electrocution.
• Never attempt to cut electrical wires or open appliances for repair if the generator is working. Unplug the main cable first.
• Inform children of the dangers of electrocution. Never allow them to play with electrical connections.
• Keep fingers away from the moving turbine runner. If partly blocked with debris, stop the water flow before cleaning.
• If you have any questions about safety, please ask your PowerPal Service Center.
• Product must be earth bonded (grounded).

OPERATING CAUTIONS

Your PowerPal generator is designed for simple operation and low maintenance. However, the following operating cautions must be followed to ensure a long life for PowerPal:

• Under conditions of higher water heads than given for each model in this manual, PowerPal is able to generate higher power outputs than rated. This can also occur if the intake pipe diameter exceeds the recommended diameter. If maximum power consumption listed in this manual is exceeded then the copper coils in PowerPal may

be irreparably damaged and require total rewiring. See the section on 'Technical Specifications'.
• Do not forget to grease the bearings at the recommended times. Failure to do this will result in excessive wear on the bearings and shorten their life. Always ensure that the Electronic Load Controller is set at approximately 110 or 220V, depending on your country. Otherwise, the life of lights and appliances may be reduced.
• Low frequencies will result if the generator rotor is rotating slower than usual. Low frequencies may prevent proper functioning of appliances such as televisions and will harm electric motors. PowerPal is designed to stop working if the rotor speed becomes too low, as the drag on the rotor becomes too great to sustain its rotation. This in-built mechanism is there to avoid problems associated with low frequencies. High frequencies will occur if the rotor is rotating faster than usual. This is due to either a high head or water flow rate or the use of a small load. It can be corrected by adjusting the spear valve, or by turning on another appliance to increase the load. Sustained high frequencies may overheat some electric motors or affect television picture quality. Light bulbs are not affected by frequency but are affected by voltage.

POWERPAL COMPONENTS

Inside your PowerPal box you will find:

- 1 x generator-turbine assembly
- 1 x penstock adaptor flange
- 1 x electronic load controller
- 1 x replacement bearing seal
- 1 x Guarantee Card
- 1 x this instruction manual.

Please advise immediately if any parts are missing. Complete your Guarantee Card and have it signed by your PowerPal dealer.

The PowerPal system consists of two major components – a hydroelectric generator and an electronic load controller. Other components are necessary and these can be purchased locally. The penstock (intake pipe) can be made of PVC plastic (recommended), steel, reinforced concrete, fired clay water pipe or bamboo. Your PowerPal dealer can advise you about this.

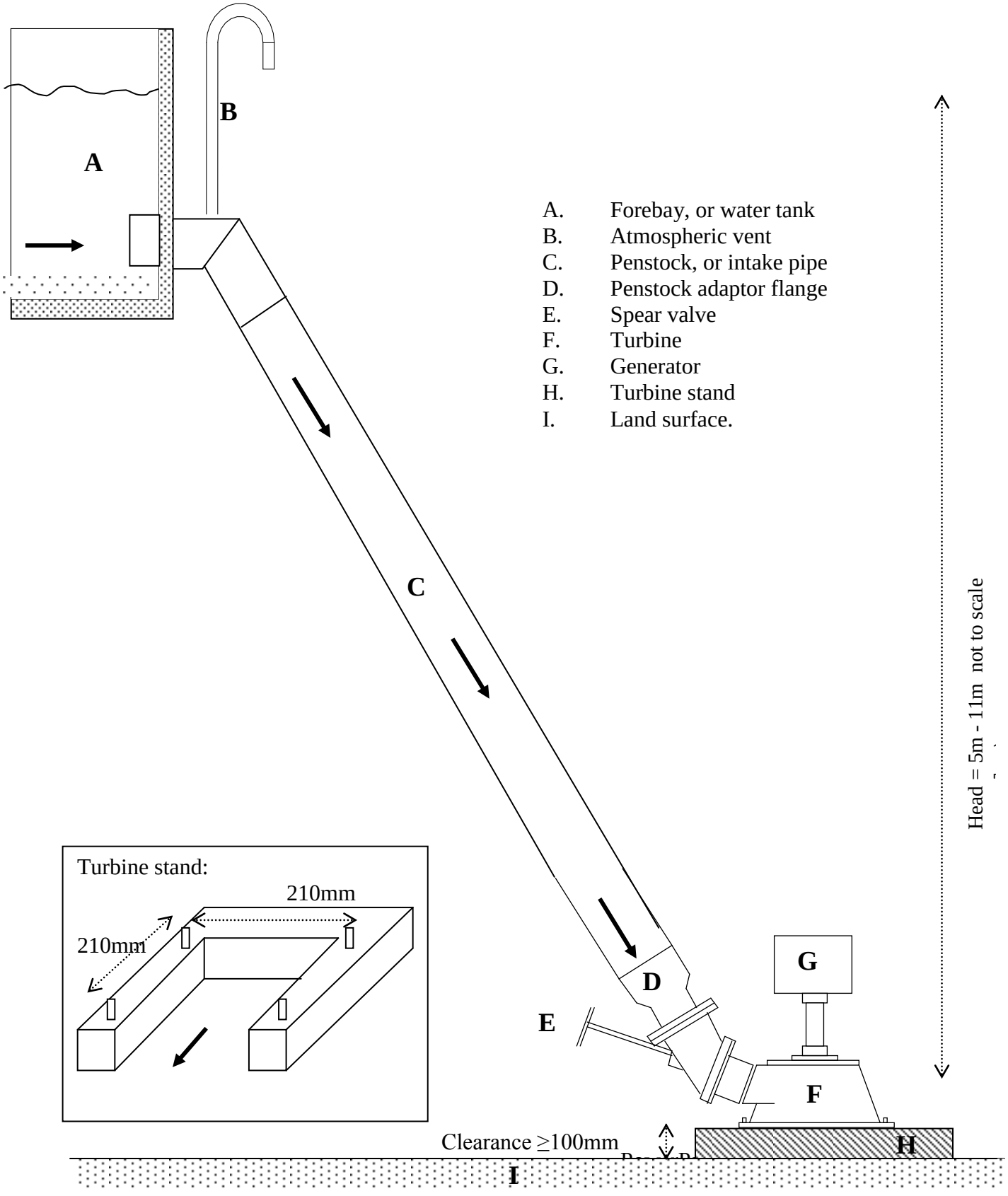
Therefore, other parts which are not included in the box but which are required to make PowerPal work are:

• a length of PVC or other pipe.
• electrical wire from generator to house. See the section on 'Technical Specifications' for the correct wire size.
• household wiring.

These are available from your dealer or local electrical store.

SYSTEM DIAGRAM

The following diagram shows how the non-electrical components fit together. Further reading of this manual will provide the necessary explanations. The components are:



SELECTING A SITE

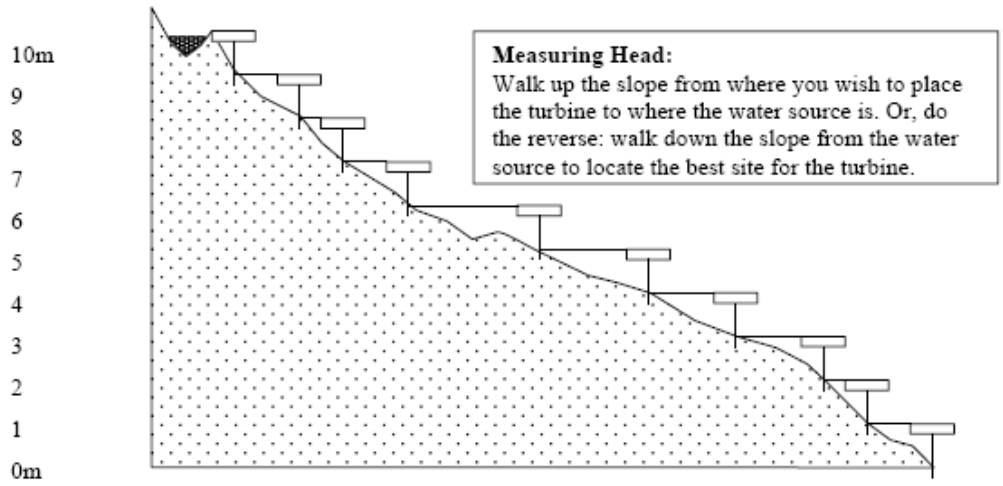
PowerPal is designed for use in a wide range of locations. There are two critical factors that influence power output – head and flow. Head is the vertical distance between the turbine and the water source (forebay), measured in meters. Flow is the amount of water that passes through the turbine at any instant, measured in litres per second (*l*/sec). The following table shows the various combinations of head and flow to achieve certain maximum power outputs for each model:

Turbine	MHG-200HH		MHG-500HH				
Water head H (m)	5	6	7	8	9	10	11
Water flow Q (*l*/sec.)	6.3	6.4	7.4	7.9	8.4	8.9	9.1
Power output (W)	160	200	275	325	390	460	520

For example, if your site has available 11 meters of head and a water flow of 9.1 litres per second then a PowerPal MHG-500HH will produce up to 520W of electricity.

Measuring Head

The head is the height from the water surface in the forebay down to the level of the turbine. It is shown in the System Diagram. To measure this, use a tape measure and a clinometer or spirit level etc. A less accurate but useful alternative is to make your own level from a transparent tube half-filled with water. Attach this to the top of a 1m long stick and then point this horizontally at a point further up the slope as though it were a spirit level. By going to that point and repeating the process the total head can be measured – see the drawing below.



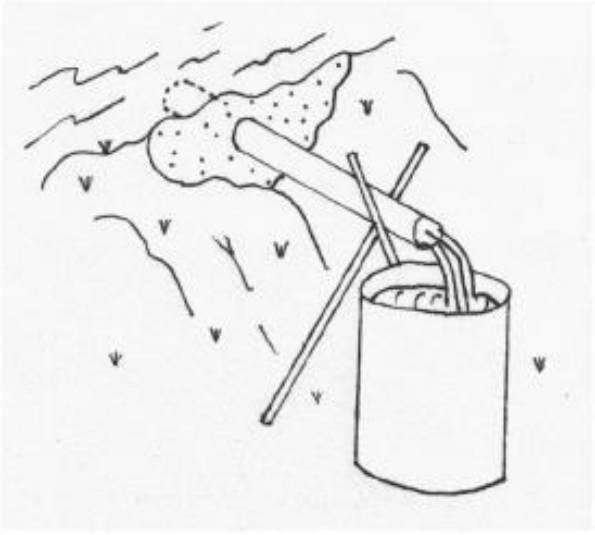
Another method is to use an accurate pressure gauge and a length of hose. Run a water-filled hose from the forebay to the turbine site and attach the pressure gauge to the bottom end. The pressure gauge shows 1.422 psi / meter of head e.g. 7.11 psi for a head of 5m to 15.64 psi for a head of 11m.

This head should be between 5 and 6 meters for the MHG-200HH model and between 7 and 11 meters for the MHG-500HH model. If it is smaller then the power output will be

reduced. If it is larger then your power output will be increased. While increased power output appears desirable, if the head is too large then the rotor will turn too fast and reduce the life of the bearings. For heads less than 6 meters a MHG-200HH is the recommended model and for heads greater than 6 meters the MHG-500HH is required.

Do not attempt to exceed the recommended head height.

The best way to measure the water flow is to take a piece of pipe the same diameter as the penstock, insert it in the stream or dam where the flow is expected to come from, and measure the flow from there.
In the diagram below, a short length of pipe (less than 1 meter) is buried into the side of a small 'dam' using mud or improvised sandbags. The top end of the pipe is completely submerged and part of the normal stream flow is diverted through the pipe. When this is flowing smoothly, a bucket of known volume is quickly placed to collect this flow and the time it takes to fill the bucket is recorded. The ideal bucket size would be 100 or 200 litres (half or a whole empty oil drum), but smaller buckets will work. Divide the volume of the bucket (in litres) by the time it takes to fill the bucket (in seconds) to get the approximate flow rate in litres per second.



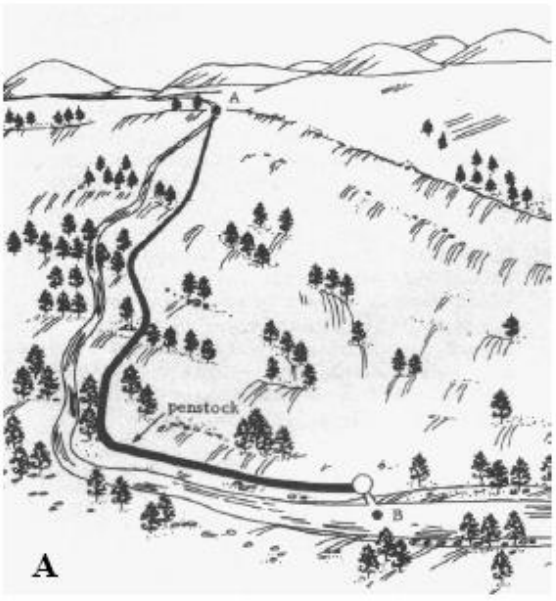
Measuring Flow:

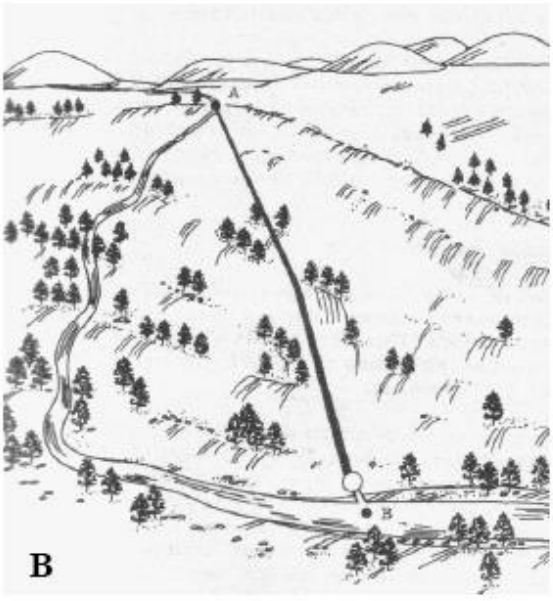
$$\text{Flow} = \frac{\text{volume of bucket (litres)}}{\text{time to fill bucket (seconds)}}$$

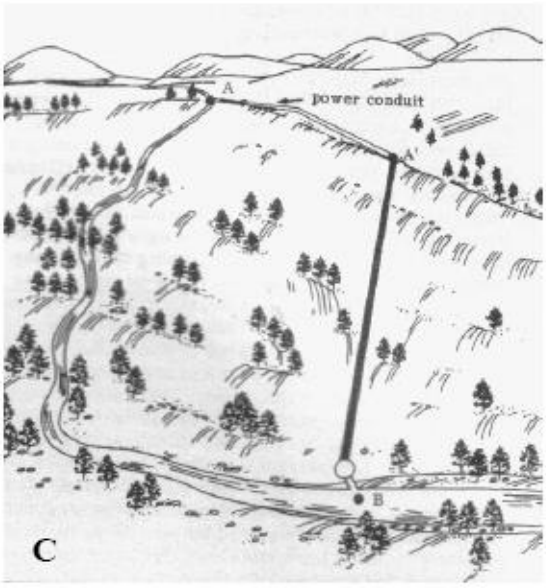
SITE PREPARATION

Once the correct head and flow have been located then the length and position of the penstock can be determined. While vertical head is important, the horizontal slope and penstock length may vary.

A good way to reduce penstock length is shown in the following diagram.







The penstock is shown by the black line A-B. In the first diagram (A) the penstock follows the stream. This may lead to unnecessary length and cost. In diagram B, the most direct route is selected to reduce length and cost. Diagram C shows the best alternative where a side channel or 'power conduit' is cut into the side of the hill. This carries the water to a point as close to above the turbine as possible and best reduces the length of penstock required. The power conduit roughly follows the hill's contour and need only be a simple ditch say 30cm x 30cm in section.

When installing the penstock, try to keep it as straight as possible and avoid sharp turns or angles. To do this, part of the hillslope may need excavating while in other places the penstock may need supporting with poles etc. Steeper terrain has advantages over more gentle terrain as cost is reduced by the use of a shorter penstock.

The forebay, or water holding tank at the top of the penstock can be as simple as a deep part of a flowing stream or power conduit. It is a good idea to give some permanence to this structure so that a constant water source is available and so the top of the penstock is always submerged. A small dam is the best method and need only be 1 meter high. The top of the penstock is typically placed not at the bottom but some way up the dam wall so that the bottom of the dam acts as a sink for rotting leaf litter, deposited sand and mud etc. This sink may need periodic cleaning out. Another good idea is to cover the end of the penstock with a piece of wire mesh (debris screen) to keep leaves etc. from flowing in and clogging the turbine. See Appendix A for the ideal forebay design.

SYSTEM INSTALLATION

After locating a suitable site and completing the earthworks (if any), your PowerPal is ready for installation. To do this:

1. Bolt the turbine to a turbine stand or base which allows at least 100mm clearance between the turbine and the ground. The turbine stand should be sturdy and made from concrete or steel as shown on page 4 of this manual. Bolt spacing is 210mm as shown in the diagram.

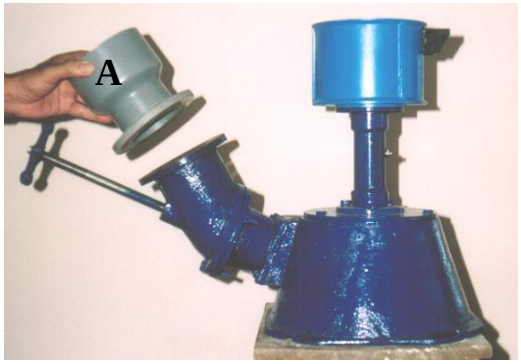
2. Bolt the turbine to the penstock adaptor flange (A – see below). The optimal diameter of the penstock and PVC fittings is 110mm, to produce the most power. The minimum diameter is 76mm but less power output may be expected.

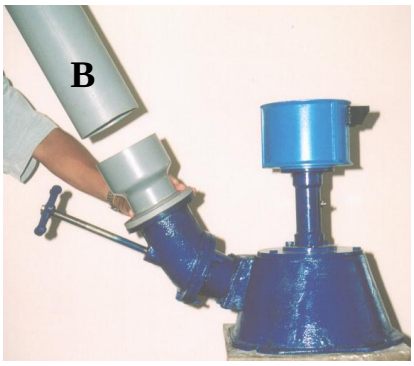
3. Turn the handle of the spear valve anticlockwise until the valve is fully open.

Always turn the handle slowly and smoothly.

4. Affix a 135° (or other) elbow bend of PVC into the forebay wall. This should be fitted with an atmospheric vent (hollow bent pipe), which allows air to escape from the penstock. The upper opening of the atmospheric vent should be higher than the water level in the forebay. Divert water away from the forebay or else block the top of the penstock pipe during the installation procedure.

5. Start installing the penstock. Assembly can begin from either direction but it is usually easier to begin uphill – the turbine is much easier to move around than the forebay is. The penstock should be well secured i.e. supported or buried at regular intervals to support its weight when full – this is particularly important at the bottom of the penstock so that PowerPal cannot be knocked over. At least two people should handle the penstock, one uphill and one downhill, until it is fitted into both the elbow bend and the penstock adaptor flange (B). If PVC is used for the penstock then use PVC glue to bind the joints but note that the PVC must be dry for the glue to work.





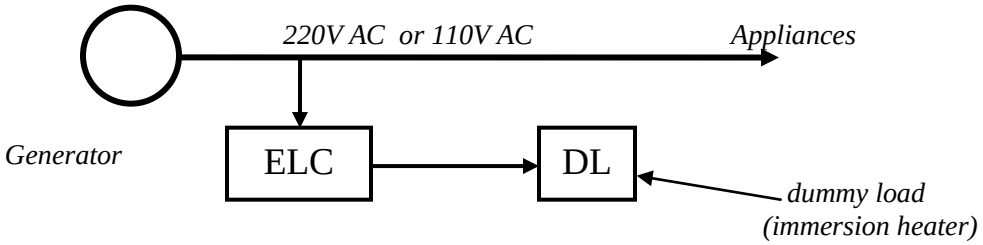
6. Once the glue is set the turbine can be started. Fill the forebay and allow the water to flow freely into the penstock. The turbine runner will rotate and spent water will flow out in front of the turbine stand (into an escape drain). An alternative is to allow the water to escape through the floor of a purpose-built platform. Once the water is flowing freely the electrical setup may begin.

7. Earth-bond (ground) PowerPal. Do this by attaching one end of a suitable length of 0.75 sq.mm/A wire to PowerPal and the other end to a metal object or metal stake in the ground nearby PowerPal. Although the risk of electric shock is already low, this earth-bonding is still best practice.

8. Run the required length of two-strand, jacketed electrical cable from PowerPal to your house etc. Use 3.75 Ampere wire (0.75 sq. mm / Amp) for both MHG-200 and MHG-500 models. This is thicker than is required but thinner wires are more fragile. Attach the electrical cable to the red and black connecting points on the PowerPal generator.

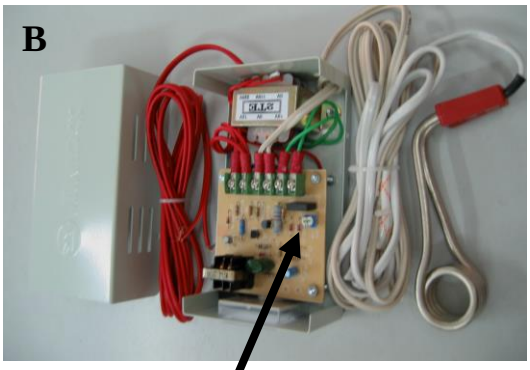
⚠ *Do not allow electrical contacts to become wet. Use dry hands. Beware of electrocution.*

9. Install the electronic load controller (ELC) in a dry place inside the house (or next to the generator) and connect the ELC's two red wires to the end of the electrical cable to the generator.

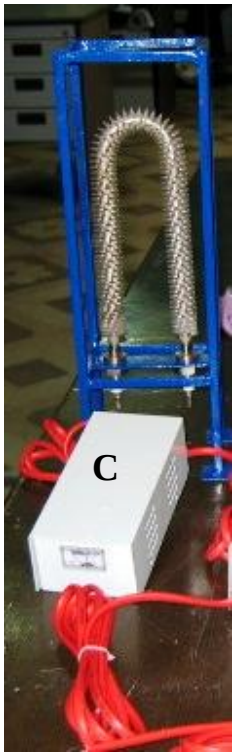


10. Place the dummy load (immersion heater) attached to the white cable into a water tank of minimum volume 50 litres. The tank should be made of non-conductive material and the dummy load should be fully immersed. The ELC is always positioned between the generator and any circuit breaker. Check all the connections again.

11. Observe the meter to check the operational state of the ELC - is the voltage at 220V or 110V (depending on your country) when the water is let into the turbine? If the voltage still increases, then stop and check the connections, and the voltmeter. Adjust the potentiometer on the circuit board (as in photograph) slowly until the voltmeter reads 220V or 110V.



Adjust voltage here



About the electronic load controller
The water turbine captures the water's energy and converts it into electricity. The generator's output voltage is dependent on the load consumption. When there is no power being consumed, the output voltage can reach 300V (or 150V). This output voltage will decrease with any increase in power consumption. The electronic load controller is used to eliminate this excess output voltage so that it is safe to use household appliances.

12. You can now plug lights and appliances directly into the ELC ready for use, with or without additional house wiring or a circuit breaker. The voltage needs only to be checked and adjusted if the water flow rate changes. Heavy rain may increase the flow rate, or a prolonged dry period may gradually reduce it. Check the voltmeter from time to time and adjust the ELC if necessary.

Avoid plugging appliances directly into PowerPal without using the load controller. Incorrect voltage may result, which can damage your appliance.

CARE AND MAINTENANCE

General care for your PowerPal will enhance its life. Following the instructions in this manual is important.

Try to install PowerPal in a place that is unlikely to be flooded. A simple shelter with a roof will also help protect the generator from rain or else a small shed can be built and locked if security is an issue. If the inside of the generator assembly does become wet, remove the cap and leave PowerPal in the sun to dry. No permanent damage will result,

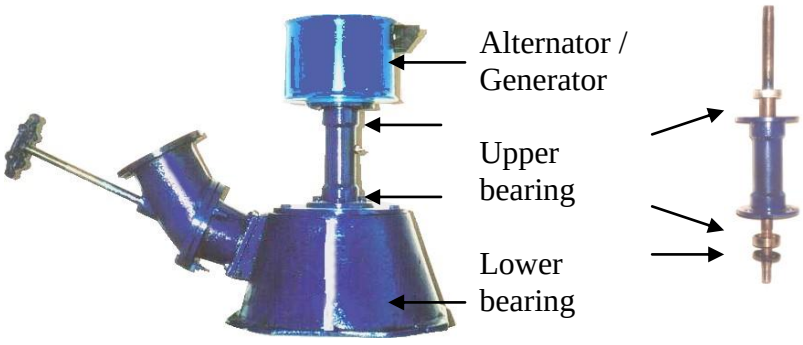
but check the bearings to see if they have collected water. If so, turn PowerPal upside down to drain and dry the internal shaft assembly. Do not try to dry it near a fire as the rotor is bonded with epoxy that could be damaged by excessive heat. Before using again, make sure that the power socket is also dry. Condensation inside the generator is normal in tropical areas and will not effect the performance of PowerPal.

There are only two tasks that must be completed at regular intervals. These are the changing of the bearings and the lower bearing seal.

PowerPal has two bearings, one at the top of the shaft below the generator and one at the bottom of the shaft above the turbine. Both are pre-greased and sealed and have a life of at least two years. They require no greasing, only replacing every two years. See the section on Technical Specifications at the end of this manual for part numbers. These are commonly available in most countries but if in doubt contact your dealer.

There is a black plastic seal below the lower bearing to prevent water entering the shaft. Because the axle rotates in the middle of this seal, it is prone to gradual wear and should also be replaced every two years of continual use along with the bearings. Two spare seals are included with your purchase. Additional seals for future use are inexpensive and readily obtainable.

Failure to change the bearings on time will increase friction and reduce power output. Always dry PowerPal before changing the bearings.



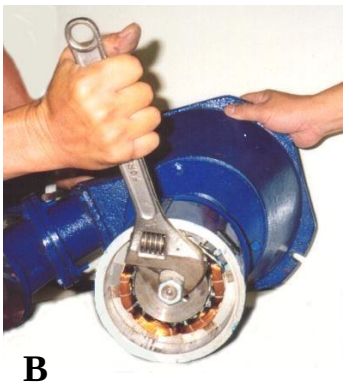
Changing the Bearings and Seal

To replace the bearings and seal, follow these steps:

1. Turn off all appliances and disconnect the power cable.
2. Drain the forebay so that the water flow stops. Do not simply block the top of the penstock. Leave the spear valve open.
3. Wait till the penstock is drained i.e. little or no water flows out of the turbine.

4. Unbolt the penstock adaptor flange at the turbine. Keep the penstock away from PowerPal to keep it dry.
5. Unbolt the turbine and remove from the turbine stand.
6. Remove generator cap (see photo A on page 12).
7. Turn PowerPal on its side.
8. While holding the runner, unbolt nut on top-center of the rotor (photo B). Unbolt clockwise. You can then release the runner.
9. Screw in 2 x M8 (13mm) bolts into holes in top of rotor, then pull the rotor out (photo C). This may require additional effort to overcome the magnet's effects.
10. Remove metal ring (tube) from the axle.
11. Unbolt the 3 bolts at the top of the shaft (photo D).
12. Remove the generator casing (photo E). The upper bearing is now visible.
13. Turn PowerPal on its side again.
14. While holding the runner, unbolt nut below the runner (photo F). Unbolt anti clockwise. You can then release the runner.
15. Remove runner (photo G).
16. Unbolt 3 nuts at base of shaft, above turbine (photo H).
17. Pull out axle (photo I).
18. Making sure that the bearing-shaft assembly is right way up, hit the shaft on a block of wood (not metal) to free the upper bearing from outer tube (photo J).
19. Remove the shaft and hit the lower bearings with a hammer and bar to remove the lower bearing and seal (photo K).
20. Install new bearings and seal. It is important to install the seal the correct way up.
21. When reassembling, make sure that all parts are correctly in place and that all bolts are tightened.
22. After PowerPal has been securely reconnected to the turbine stand and penstock adaptor flange the forebay is refilled and normal water flow is allowed to continue. Wait until this occurs before reconnecting the cable and appliances.


A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C


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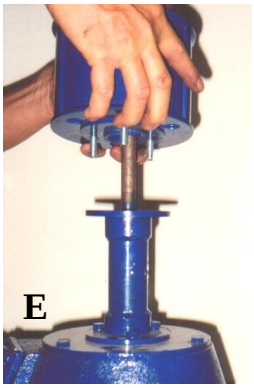
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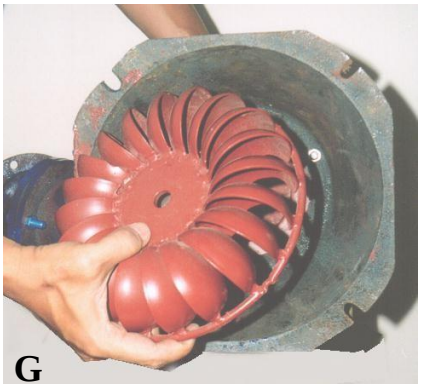

G


H


I


J


K

TROUBLESHOOTING

If any problems are encountered, check this section before contacting your Service Center.

1. Head and flow conditions appear to be OK, but PowerPal will not work.

It is likely that the system has been installed incorrectly. Check this. If still not working, remove the cap from the generator and use your fingers to quickly turn the nut on top of the rotor. If the rotor begins to spin freely then PowerPal is working.

2. PowerPal has provided electricity for a while and suddenly the electricity stops.

If this instruction manual is not followed and power consumption is too high, or if there is a short circuit in an appliance the over-current protection relay on the electronic load controller will trip. This will stop the electric current. Locate and correct the problem and reset the relay switch.

3. *Testing in the stream showed that PowerPal was capable of producing the rated output power (200W or 500W, depending on model). However, after running the electrical cable to the house this output power was found to be less.*

Due to resistance from the cable, long cable runs will result in a small loss of output power. Power loss over a 100m cable run is approximately 10W. If the loss is greater than this it means that the wrong diameter cable was used.

4. *Power output has been falling recently.*

Falling output suggests that the turbine is rotating more slowly than usual. Make sure that the enough water is entering the forebay and ensure that the source river is adequate for the flow being consumed. Otherwise, check the forebay and penstock filter and clean if necessary. Lastly, check that the runner is free of leaves and other debris and that the lower bearing has enough grease.

5. Frequency varies too much to safely use an appliance that is rated for use at a specific frequency.

If an exact frequency is required for frequency-sensitive appliances it will be necessary to attach a battery system.

6. An appliance is supposed to be grounded (earthed).

PowerPal is not grounded by its position in the stream. If grounding is required for certain appliances it will be necessary to ground them separately. The usual method is to run a wire from the earth pin to a metal stake in the ground outside – consult your dealer for further details.

TECHNICAL SPECIFICATIONS

		MHG-200HH	MHG-500HH
1	Rated power output	200W	500W
2	Maximum allowable load	250W	650W
3	Intended voltage	110 / 220V~	110 / 220V~
4	Frequency at rated power output	50-60 Hz	50-60 Hz
5	Frequency at runaway speed	70 Hz	70 Hz
6	Rotor runaway speed	1400rpm	1400rpm
7	Weight	34kg	36kg
8	Turbine runner type	Turgo	Turgo
9	Runner diameter	180mm	180mm
10	Number of buckets	20	20
11	Bucket diameter	68mm	68mm
12	Number of nozzles	1	1
13	Jet diameter	28.5mm	28.5mm
14	Generator	Single phase permanent magnet alternator	Single phase permanent magnet alternator
15	Rotor characteristics	NdFeB 3-pair pole permanent magnet	NdFeB 3-pair pole permanent magnet
16	Stator wire size	0.5mm	0.7mm
17	Upper bearing size	6203 2RS	6204 2RS
18	Lower bearing size	6203 2RS	6204 2RS
19	Seal size	17x40x7mm	20x47x7mm
20	Recommended cable	0.75 sq.mm/A	0.75 sq.mm/A
21	Operating temperature	5 to 50 ° C	5 to 50 ° C
22	Operating humidity	0 to 90%	0 to 90%
23	Bearings	2 x 6203 2RS (Each lower bearing & Upper bearing)	2 x 6204 2RS (Each for lower bearing & Upper bearing)

Notes:

1, 2. Rated power output is the manufacturer's specified output for the given head and flow conditions. A higher output is possible if the head is greater or the flow is faster than recommended. If the maximum allowable load is exceeded then permanent damage to the stator may occur.

3. Is approximately 110 / 220V when the ELC is used.

5, 6. Runaway speed is the speed of the rotor if no load is applied. This speed is reduced under load.

17, 18. We recommend SKF brand or similar high quality bearings.

Also, the diagrams and much useful information on pages 7 and 15 are taken from *Micro-hydropower Sourcebook – A Practical Guide to Design and Implementation in Developing Countries.* NRECA, 1986.

Special thanks go to David Willcox of the UK for his invaluable input and suggestions.

APPENDIX A – FOREBAY DESIGN

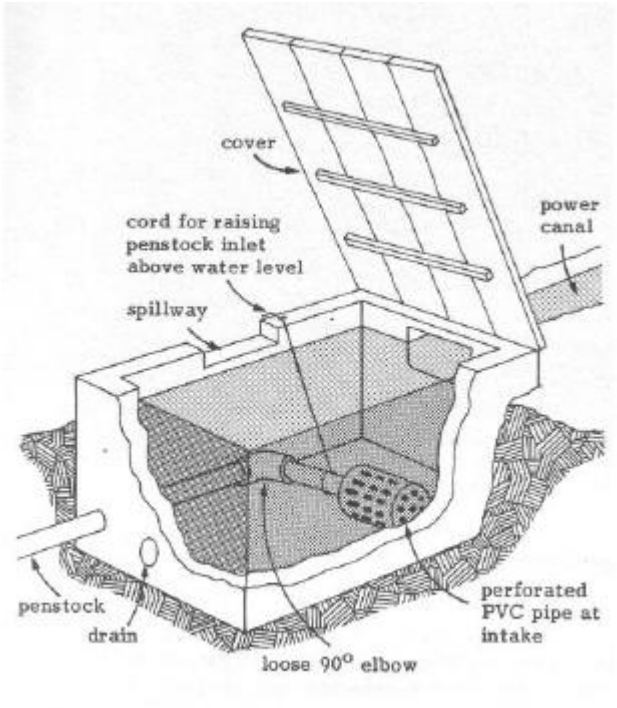
The instructions given on page 7 of this manual to design the forebay are adequate for most cases. The most important aspects of forebay design are:

1) To allow a continual flow of water to the penstock so that the turbine keeps functioning.

2) To have sufficient safeguards to prevent sand, vegetation and other debris from entering the penstock which could cause blockages and disrupt the turbine. This includes a safety aspect to keep away children and animals that could possibly be injured by the suction of water entering the penstock.

3) To have an easy way to stop the water flow when changing the bearings etc.

The following diagram shows a simple forebay design that may be used to achieve all the above goals.



Here, the forebay is made of a waterproofed box situated between the power canal (power conduit) and the penstock. A loosely fitting PVC elbow is inserted between the penstock inlet and the main penstock pipe. Flow to the penstock is cut off by pulling the cord so that the inlet is out of the water. The plugged drain is used to periodically empty out sand and leaves or else this can be shoveled out. The perforated pipe end further reduces litter intake. Here the number and size of holes are important so that flow is not obstructed. For 110mm PVC pipe there should be 110 drilled holes of 12mm diameter. The box need only be say 40cm x 40cm x 40cm and may be locked to keep away children etc.

DECLARATION OF CONFORMITY

We,
Asian Phoenix Resources Ltd.
2-416 Dallas Road
Victoria, BC V8V 1A9
Canada
Declare that the products described within are, in accordance with Directive 73/23/EEC – the Low Voltage Directive, in conformity with the following standards:
EN 61116:1995 Electromechanical equipment guide for small hydroelectric installations and
EN 61362:1998 Guide to specification of hydroturbine control systems.

CE

D.L Seymour
Authorized signatory
25th March, 2008