Use and Care

Instructions

for your new

PowerPal™

T8 & T16 Turgo
Micro-hydroelectric Generator

Models: MHG-T8
MHG-T16

Asian Phoenix Resources Ltd., Canada

READ THIS FIRST

This manual contains important information concerning your new PowerPal T8 or T16 Turgo micro-hydroelectric generator. It covers Models MHG-T8 and MHG-T16. 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 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 PowerPal generator may be irrepairably 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 220V. Otherwise, the life of lights and appliances may be reduced.

POWERPAL COMPONENTS

Inside your PowerPal box you will find:

- 1 x generator-turbine assembly
- 1 x penstock adaptor flange
- 1 x gate valve
- 1 x rubber gasket
- 6 x M24 foundation nuts and bolts
- 1 x control panel including electronic load controller
- 2 x ballast load elements
- 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) should be made from steel. Your PowerPal dealer can advise you about this.

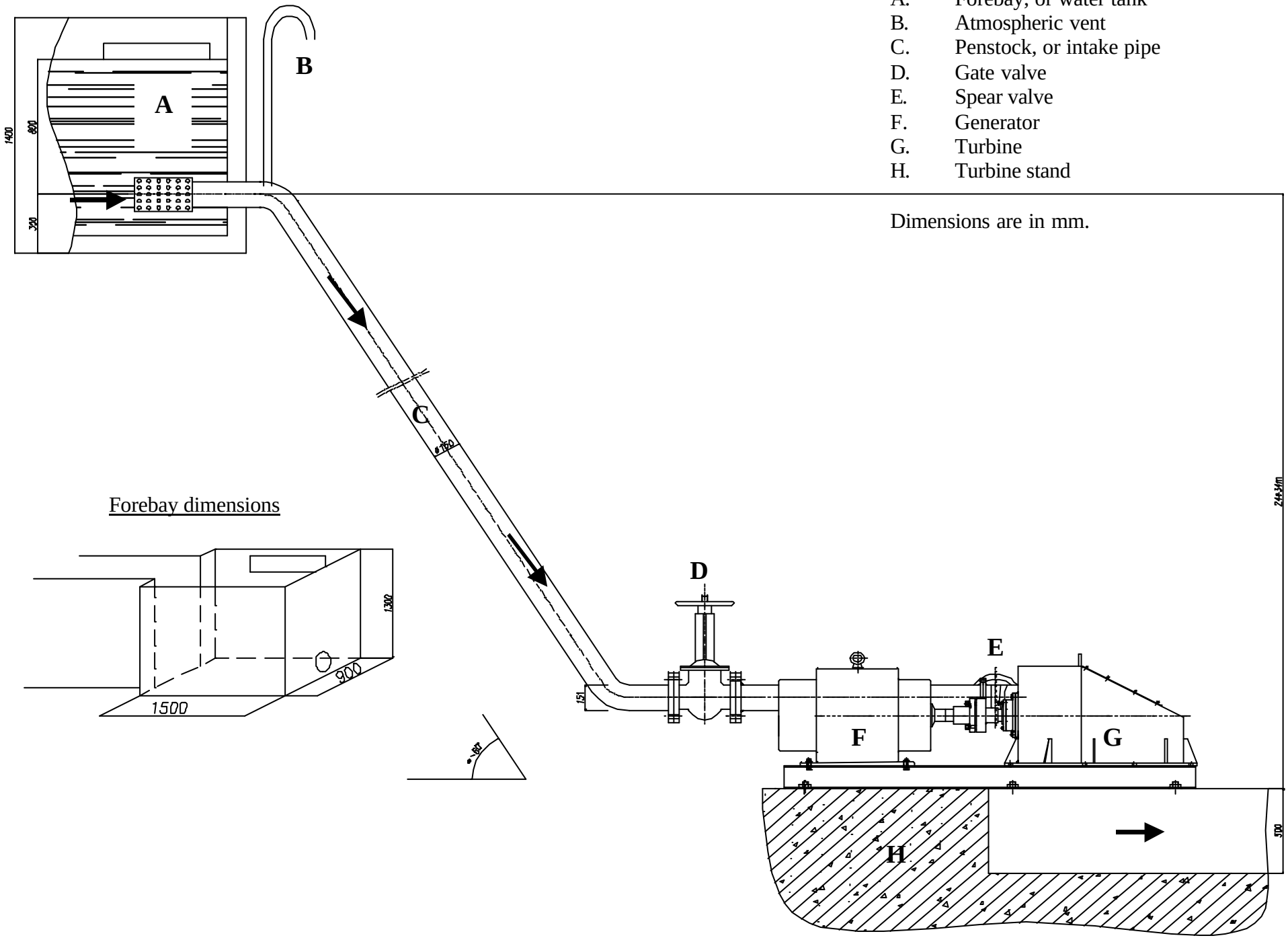
Therefore, other parts which are not included in the box but which are required to make PowerPal work are:

- a 28m – 40m length of 4mm steel pipe with internal diameter 150mm.
- 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. Additional drawings are found in Appendix A.



A. Forebay, or water tank
B. Atmospheric vent
C. Penstock, or intake pipe
D. Gate valve
E. Spear valve
F. Generator
G. Turbine
H. Turbine stand

Dimensions are in mm.

Forebay dimensions

SELECTING A SITE

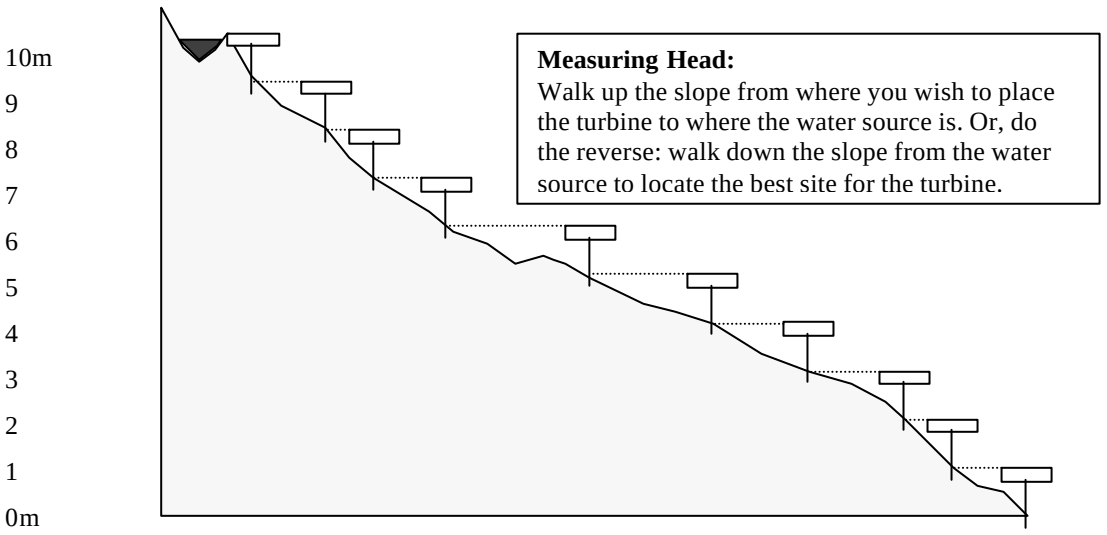
PowerPal is designed for use in a wide range of locations. There are two critical factors that influence power output – head and flow. Head is the vertical distance between the turbine and the water source (forebay), measured in meters. Flow is the amount of water that passes through the turbine at any 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:

	MHG-T8						MHG-T16					
Water head H (m)	24m	26m	28m	30m	32m	34m	24m	26m	28m	30m	32m	34m
Water flow Q (l/sec.)	33.3	34.6	36.0	37.2	38.4	39.6	66.6	69.2	72.0	74.4	76.8	79.2
Turbine output (kW)	5.9	6.6	7.4	8.2	9.0	10.0	11.8	13.2	14.8	16.4	18.0	20.0
Gen. output (kW)	4.7	5.3	5.9	6.6	7.2	8.0	9.4	10.6	11.8	13.1	14.4	16.0

For example, if your site has available 24 meters of head and a water flow of 33.3 litres per second then a PowerPal MHG-T8 will produce up to 4.7kW of electricity.

Measuring Head

The net head is the vertical height from where the water flow enters the penstock 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. 34 psi for a head of 24m to 48 psi for a head of 34m.

This head should be between 24 and 34 meters for both the MHG-T8 model and the MHG-T16 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.

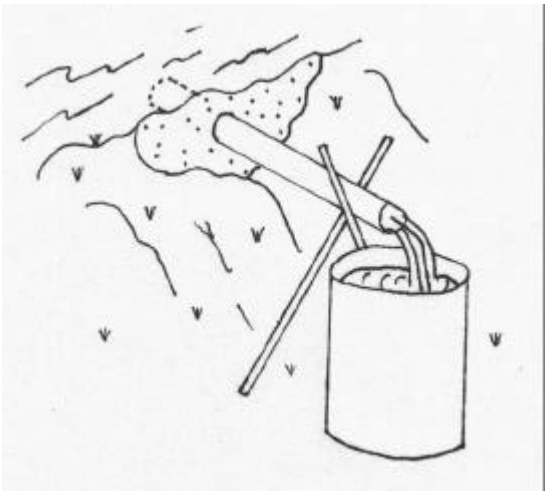
Do not attempt to exceed the recommended head height.

Measuring Flow

While the range of head for both T8 and T16 models is the same, the main difference between them is one of water flow. For flows less than 66 l/sec a MHG-T8 is required and for flows greater than 40 l/sec the MHG-T16 is recommended.

The best way to measure the water flow is to use the 'weir method', which is beyond the scope of this manual. Your PowerPal dealer should be able to advise you about flow measurement otherwise contact the manufacturer. Another method is the 'container method'. 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). 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:

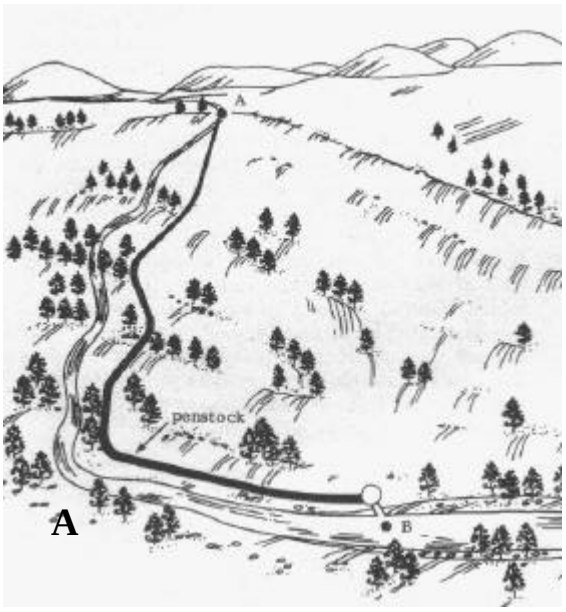
$$\text{Flow} = \frac{\text{volume of bucket (litres)}}{\text{time to fill bucket (seconds)}}$$

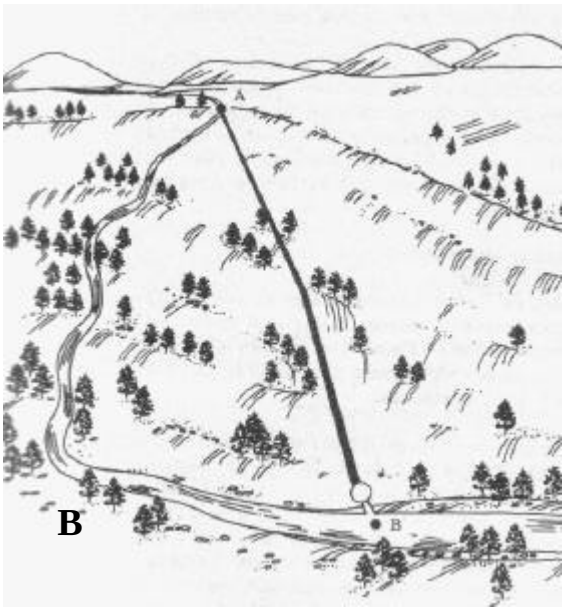
SITE PREPARATION

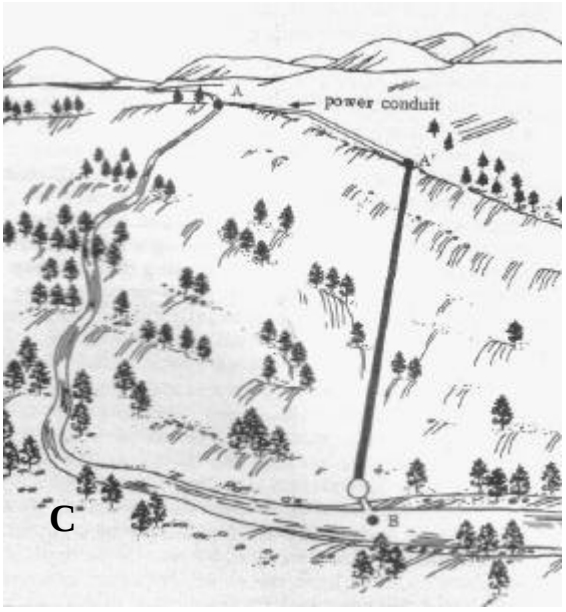
Once the correct head and flow have been located then the length and position of the penstock can be determined. While vertical head is important, the horizontal slope and penstock length may vary although penstock inclination should be >60°.

The penstock should be made of steel with internal diameter of 150mm and thickness 4mm. The gate valve (included) must be installed at the high-pressure end of the penstock for closing whenever servicing the turbine.

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 is designed to contain a water volume of approximately 2.5x the volume of water in the penstock i.e. 1750 litres. Dimensions of the ideal design are shown in the system diagram although the main point is to ensure that the forebay won't become empty.

The top of the penstock is typically placed not at the bottom but some way up the forebay wall so that the bottom of the forebay 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 B for the ideal forebay design.

SYSTEM INSTALLATION

Mechanical Aspects

After locating a suitable site and completing the civil works, your PowerPal is ready for installation. To do this:

1. Bolt the turbine to a turbine stand or base which allows at least 500mm clearance between the turbine and the ground. This clearance is required to prevent splashback that will disrupt turbine performance. The turbine stand should be made from concrete with the six M24 foundation bolts embedded.

2. Attach the gate valve to the nozzle injector pipe followed by a ~120° elbow bend which will connect to the penstock. The angle will depend on the site slope.

3. Affix a 120° (or other) elbow bend 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.

4. Start installing the penstock. Assembly can begin from either direction. 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. Several people may be required to install the penstock until it is fitted into both elbow bends.

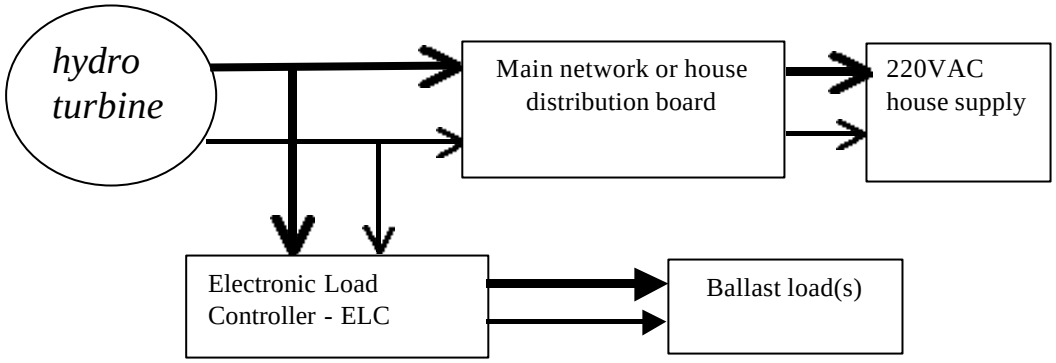
Electrical Aspects

The generator is of permanent magnet, synchronous type. Load is controlled by an electronic load controller (ELC) which is installed as part of the control box. The ELC is designed to maintain constant voltage and near-constant frequency by keeping a constant electric load on the generator. To do this, the ELC switches any power not being used by the consumer to air-heating ballast loads (supplied) where the surplus energy is burnt off as heat.

Two ballast loads are supplied, one main and one supplementary. The main ballast load accounts for 66% of the total while the supplementary ballast load account for 33%. Although optional, the supplementary ballast allows the generator to run at a lower temperature. The wave form distortion caused by switching off the triac or thyristors causes the generator to run hot. This can be reduced by having part of the ballast load switched to zero so that the voltage across the ballast gives a good

waveform. This is where the supplementary ballast is used. If the power dissipated in the main ballast is over a certain limit then the additional ballast is automatically switched on and when its power drops below a certain limit it automatically switches off.

The ELC is wired in parallel with the generator output so that it can't be inadvertantly switched out of the circuit. The system is connected as follows:



To connect the electrical components, please follow these steps:

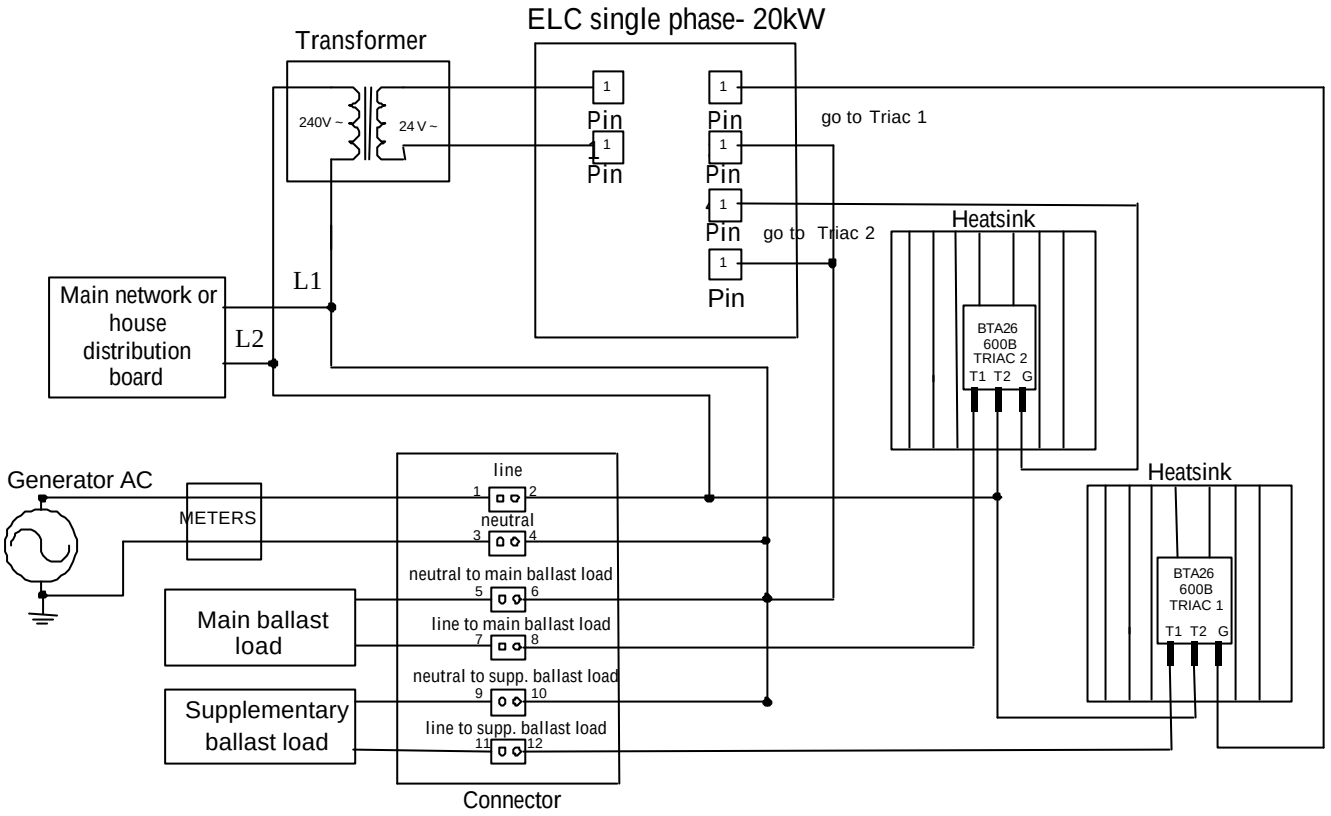
The electrics should be installed by persons competent in mains voltage wiring. This system operates on a switched neutral basis. Neutral and phase connections to the load elements should be treated as live at all times!

1. Install the control box in a convenient location that is protected from rain and sun. This may be either in a powerhouse along with the turbine or else in a house at the user's end.

2. Earth-bond (ground) PowerPal. Do this by attaching one end of a suitable length of 16mm^2 wire to PowerPal and the other end to a metal object or metal stake in the ground nearby PowerPal.

3. Connect the generator to the control box. All wiring from the generator to the control box, from the control box to the user load and from the control box to the ballast load should be done using insulated multistrand copper wire, the size of which is given in the Technical Specifications part of this manual.

   The following wiring diagram shows the location of all connection points but note that most components are already wired and installed within the control panel.



4. Connect the user load cables L1 and L2 between the control box and the house.

5. Connect the main and supplementary ballast loads to the control box as shown. The combined (total) ballast load is rated 10-15% (maximum) higher than the rated power output of the generator e.g. 11kW or 12kW for a 10kW generator. The main ballast load will be approximately 7kW or 8kW (approx. 66%) while the supplementary ballast load will be approximately 3kW or 4kW (approx. 33%). The ballast loads will become hot, up to 100°C. To prevent injury and the risk of fire, they must be installed in a safe place and preferably in an additional enclosure.

6. Close the control box door. The system is now ready for its first operation.

OPERATION

1. Check that the power conduit and forebay are free of debris.

2. Ensure that the turbine is shut down and that all supply lines are electrically dead. The switch on the door of the control box must be in the ‘off’ position.

3. Fully open both the spear valve and gate valve. The gate valve is always opened when the turbine is operating and is only closed when servicing or repairing the turbine.

4. 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). Once the water is flowing freely the electrical testing may begin.

5. As the water flow starts to create electric power, the voltage will rise until the voltmeter on the control box reads 230V. If the voltage continues to rise, adjust the water flow with the spear valve so that the voltage stays at 230V. The voltage will then fall to 220V after a minute or two.

Always turn the valve handles slowly and smoothly to avoid sudden changes to water pressure in the penstock. Sudden changes can cause a 'water hammer' effect and rupture the penstock.

6. Operate like this for 15 minutes while observing any unusual noise, excessive temperature or other problems and if OK then use the switch on the control panel door to switch on the power to the user. Up till now the ballast load has been receiving all the power and should be hot, but once switching on the user load the power to the ballast load will fall.

7. The voltage should remain stable as loads are switched on or off. If the voltage falls below 220V then check the water flow conditions. The voltage may need to be checked and adjusted if the water flow rate changes e.g. a prolonged dry period may gradually reduce it.

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

Do not plug appliances directly into PowerPal without using the load controller. Incorrect voltage may result, which can damage your appliance.

8. Whenever shutting down the system, first close the spear valve to reduce the flow rate and once the voltmeter shows 100V, switch the control box to the 'off' position. Then slowly close the spear valve and then gate valve fully to stop the system.

CARE AND MAINTENANCE

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

Install PowerPal in a place that is unlikely to be flooded. A simple shelter with a roof is required to protect the generator from rain or else a small shed can be built and locked (preferable). If the inside of the generator assembly does become wet it will require drying. No permanent damage will result, but check the bearings to see if they have collected water. Do not try to dry it near a fire. 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, which is 'tropicalized'.

Greasing the Bearings

PowerPal has two bearings in the turbine that require periodic attention – one near the runner inside the turbine casing and the other where the turbine shaft attaches to the generator. Both have been greased in the factory ready for use but require re-greasing

every 3 months of continuous use. To do this, clean the nipples and apply extra grease with a grease gun. The turbine should be stopped prior to greasing. The generator bearings are maintenance-free.

Failure to grease the bearings on time will shorten their life and require their replacement. The increased friction will also reduce power output. Always clean the nipple before greasing.

Changing the Bearings and Seal

Apart from greasing the bearing, there are only two tasks that must be completed at regular intervals. These are the changing of both turbine bearings and the bearing seal 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.

To replace the bearings and seal, follow these steps:

1. Shut down the electrical system.
2. Slowly close the gate valve to stop the water supply to the turbine.
3. Disconnect the power cable at the generator.
4. Wait until little or no water flows out of the turbine and the runner stops rotating.
5. Disconnect the direct coupling between the turbine shaft and generator shaft.
6. Disconnect the runner from the turbine shaft.
7. Disconnect the bearing near the runner by pulling the turbine shaft towards the generator.
8. Disconnect the bearing near the generator by pulling the turbine shaft towards the turbine.
9. To replace the bearing seal, push it out of the bearing casing with a small steel rod.
10. When reassembling, make sure that all parts are correctly in place and that all bolts are tightened.
11. Slowly reopen the gate valve until normal water flow resumes. Wait until this occurs before reconnecting the cable and restarting the system.

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 by following the steps once more.

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 fuse in the electronic load controller will break. This will stop the electric current. It is important to replace this fuse with another of the same size (see Technical Specifications below). If the fuse breaks and an oversize fuse is inserted then the generator windings may be damaged in the future. If that happens the generator will need rewiring by an experienced motor rewinder.

3. *Voltage is 220V under zero-load conditions but falls when a load is applied.*

Excessive load has been applied. Reduce the load consumption to see if voltage stabilizes and if not have the control box examined by a competent electrician.

4. *Testing in the stream showed that PowerPal was capable of producing the rated output power (4.7kW to 16kW, 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. For log wire runs it is possible to increase the cable diameter.

5. *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. Also check that the inside of the turbine casing is free of leaves and other debris and that the turbine bearing has enough grease.

TECHNICAL SPECIFICATIONS

		MHG-T8	MHG-T16
1	Rated power output	4.7kW to 8kW	9.4kW to 16kW
2	Maximum allowable load	As above +15%	As above +15%
3	Intended voltage	220V~	220V~
4	Frequency at rated power output	50 Hz	50 Hz
5	Frequency at runaway speed	70 Hz	70 Hz
6	Runaway speed	1500rpm	1500rpm
7	Height	1000mm	1000mm
8	Weight	80kg	100kg
9	Turbine runner type	Turgo	Turgo
10	Runner diameter	270mm	270mm
11	Number of buckets	20	20
12	Number of nozzles	1	2
13	Generator	Synchronous permanent magnet	Synchronous permanent magnet
14	Load controller fuse	According to size	According to size
15	Generator end bearing size	SKF 46208	SKF 46208
	Turbine end bearing size	SKF 46208	SKF 46208
16	Seal size	38x58x10mm	38x58x10mm
17	Recommended cable	16mm2	mm2
18	Operating temperature	5 to 50 ° C	5 to 50 ° C
19	Operating humidity	0 to 90%	0 to 90%

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.

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

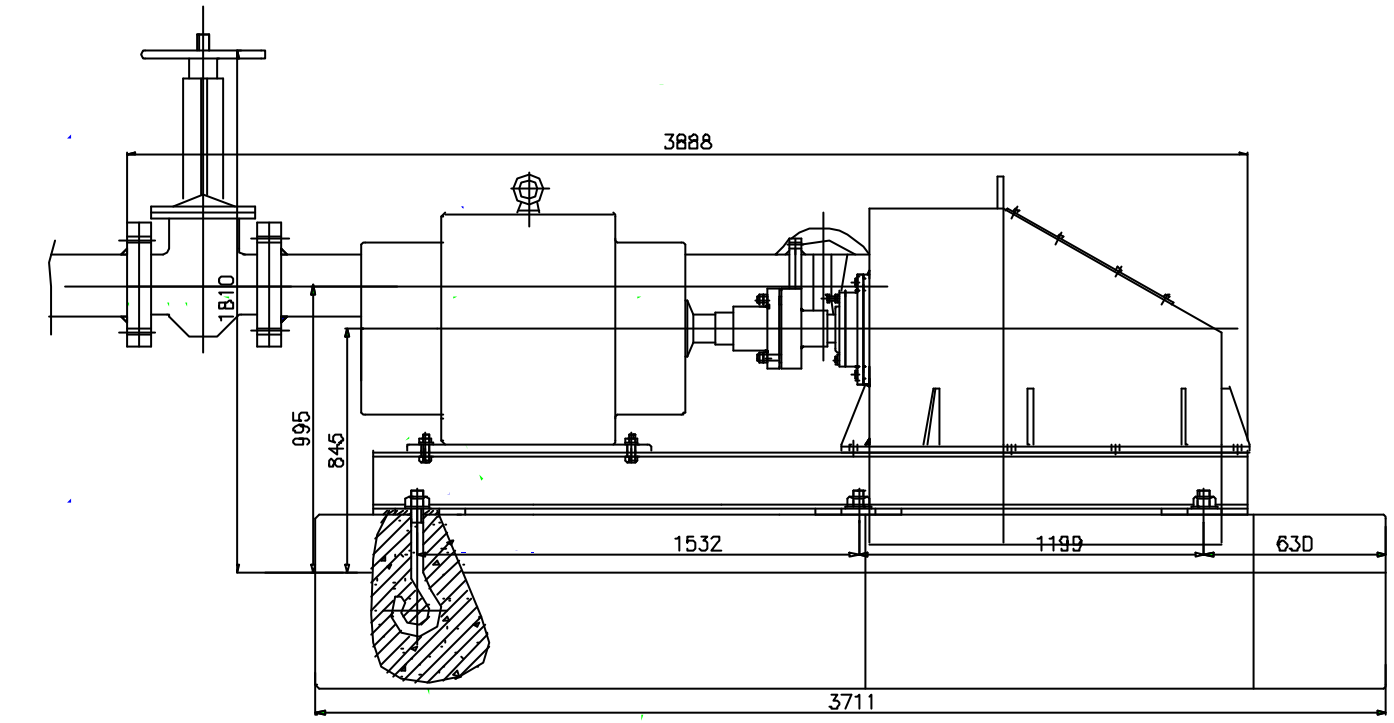
15. We recommend SKF brand or similar high quality bearings.

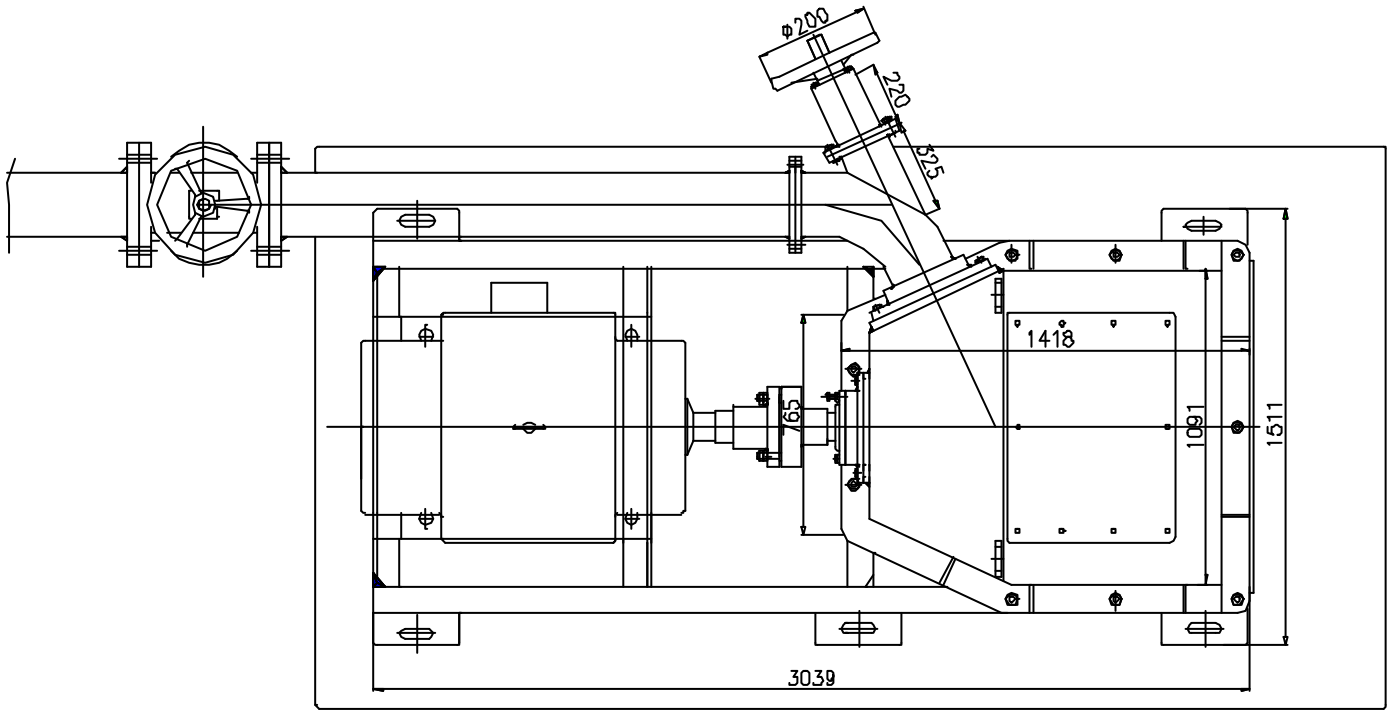
Also, the diagrams and much useful information on pages 7 and 16 are taken from *Micro-hydropower Sourcebook – A Practical Guide to Design and Implementation in Developing Countries.* NRECA, 1986.

APPENDIX A - ADDITIONAL DRAWINGS WITH DIMENSIONS

The PowerPal T8 Turgo model (single nozzle) is shown here. The T16 Turgo with twin nozzles is shown in the photograph on the cover.

Dimensions below are in mm.



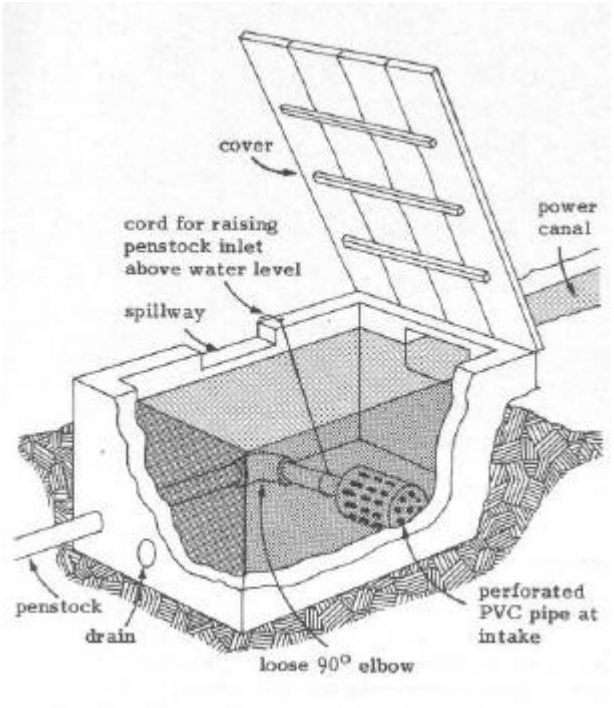


APPENDIX B – FOREBAY DESIGN

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 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 of holes is important so that flow is not obstructed and 50% of the pipe end's surface area should be drilled with 1cm holes.

The cover will help keep the forebay clean and may be locked to keep away children.