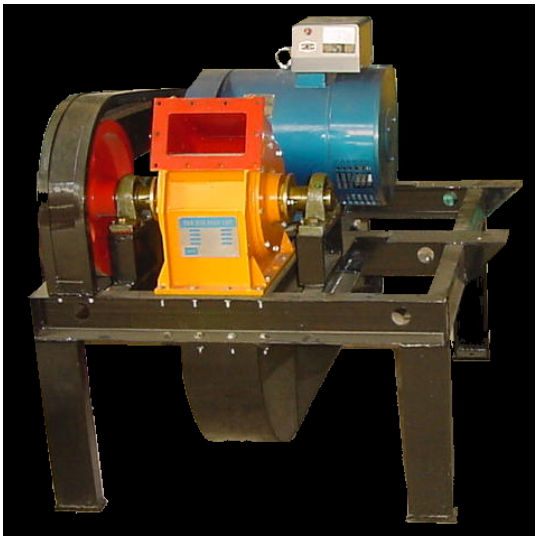
# Use and Care

# Instructions

# for your new

PowerPal™

# CF2 Cross Flow
# Micro-hydroelectric Generator



Models: MHG-CF2/5
MHG-CF2/10
MHG-CF2/15

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## READ THIS FIRST

This manual contains important information concerning your new PowerPal CF2 Cross Flow micro-hydroelectric generator. It covers Models MHG-CF2/5, CF2/10 and CF2/15. 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 and/or electronic components may be irrepairably damaged and require total rewiring.
- 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.

## POWERPAL COMPONENTS

Standard shipped components are:

- 1 x generator-turbine assembly
- 1 x penstock adaptor flange, gaskets, manometer
- 1 x discharge valve
- 1 x draft tube
- 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.

Other parts which are not included in the box but which are required to make PowerPal work are:

Construction materials for the forebay

- a suitable length of 4-6mm steel pipe penstock with internal diameter 208mm or 258mm depending on model.
- construction materials for the forebay
- electrical wire from generator to house. See the section on ‘Technical Specifications’ for the correct wire size.
- household wiring.

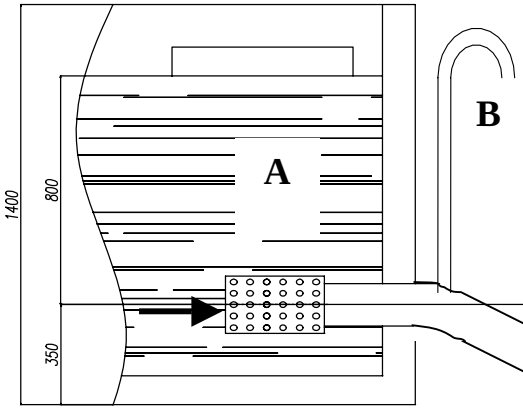
These are available from your dealer or local electrical store.

## 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. ButterflyValve
E. Turbine
F. Generator
G. Control Panel
H. Draft Tube

Forebay dimensions are in mm.







Forebay dimensions

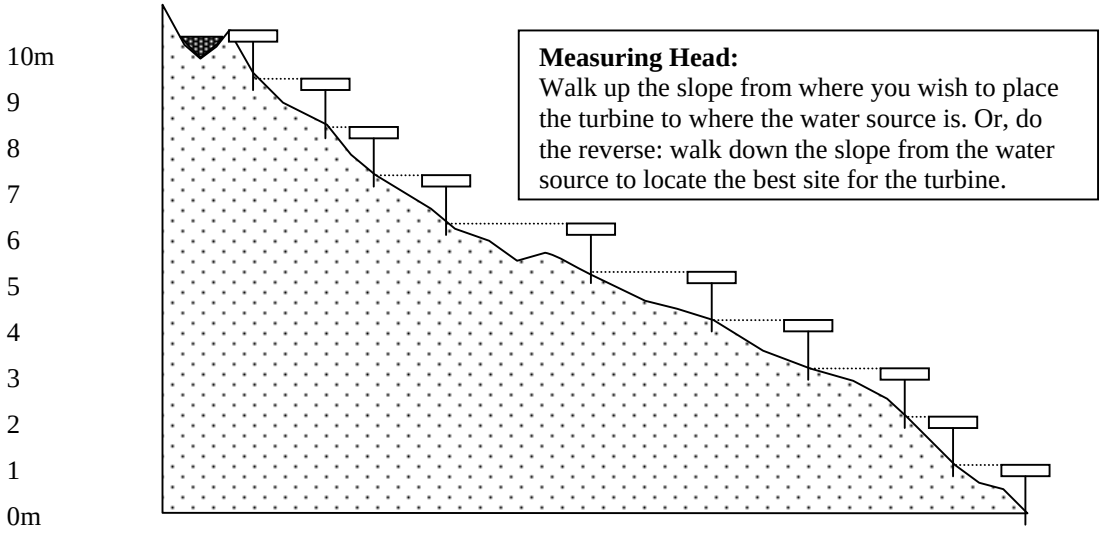
## SELECTING A SITE

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:

| Model / Specification | MHG-CF2/5 | MHG-CF2/10 | MHG-CF2/15 |
|---|---|---|---|
| Head (H) | 10m | 16m | 22m |
| Flow (Q) | 90 l/sec | 120 l/sec | 235 l/sec |
| Capacity (P) | 5 kW | 10 kW | 15 kW |

### 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. 14 psi for a head of 10m to 31 psi for a head of 22m.

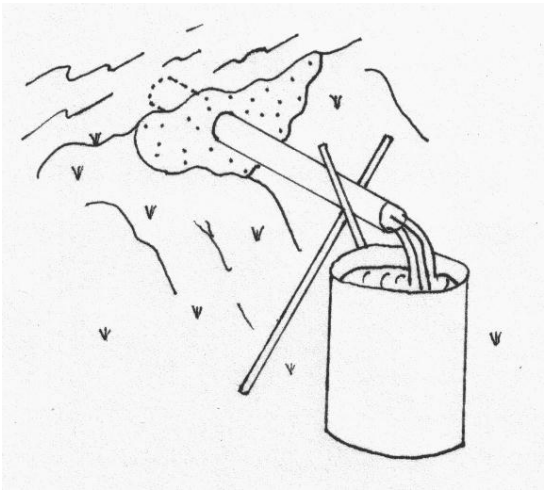
This head should be between 10 and 22 meters depending on the model. If it is smaller then the power output will be reduced. If it is larger then your power output will be increased. While increased power output appears desirable, if the head is too large then the rotor will turn too fast and reduce the life of the bearings.

*Do not attempt to exceed the recommended head height.*

**Measuring Flow**

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:**

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

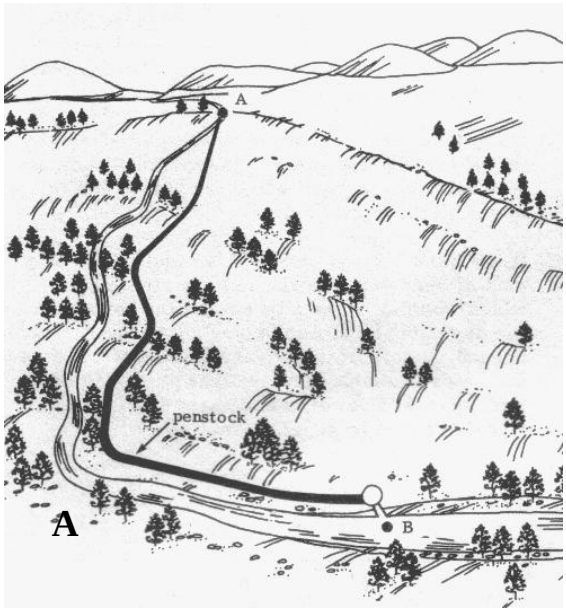
**SITE PREPARATION**

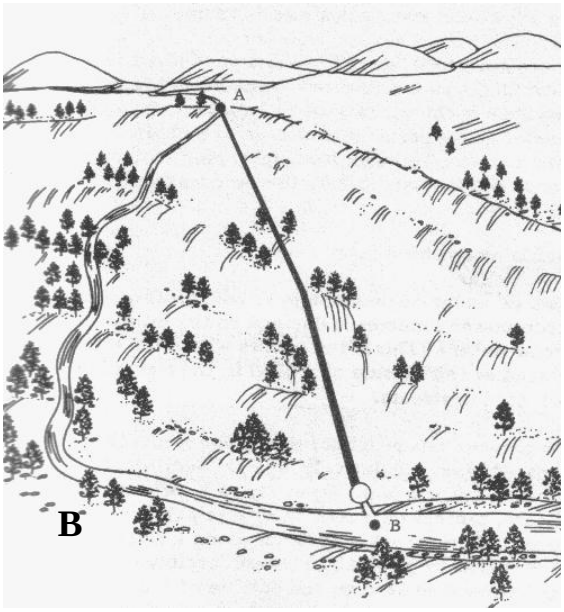
Once the correct head and flow have been located then the length and position of the penstock can be determined. While vertical head is important, the horizontal slope and penstock length may vary.

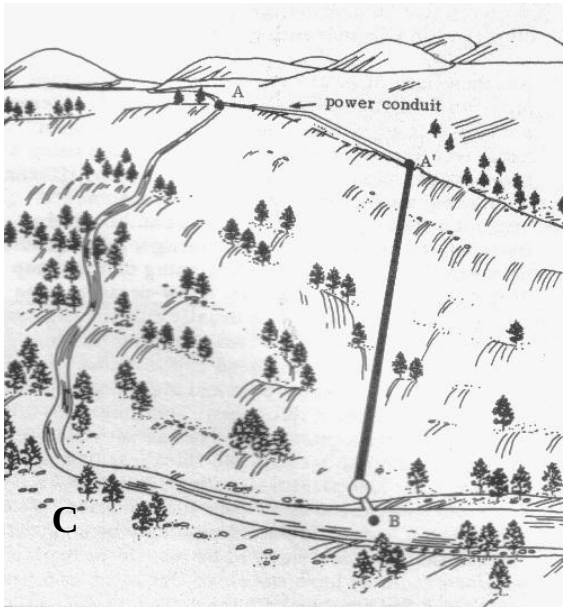
The penstock should be made of steel with internal diameter of 208mm and thickness 4mm (Models CF2/5 & CF2/10) or diameter 258mm and thickness 6mm (Model

CF2/15). The butterfly 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. 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.

1. The turbine, generator and control cabinet are already assembled and bolted to the frame. This frame should be installed on location so that the turbine is level. The tolerance for error here is 0.1mm/m.

2. The frame is designed to allow sufficient clearance for the draft tube. Bolt the frame to a concrete base.

3. Bolt the flow guide flange & butterfly valve to the turbine intake, ensuring that the turbine runner can rotate freely.

4. 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.

5. 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 at both ends.

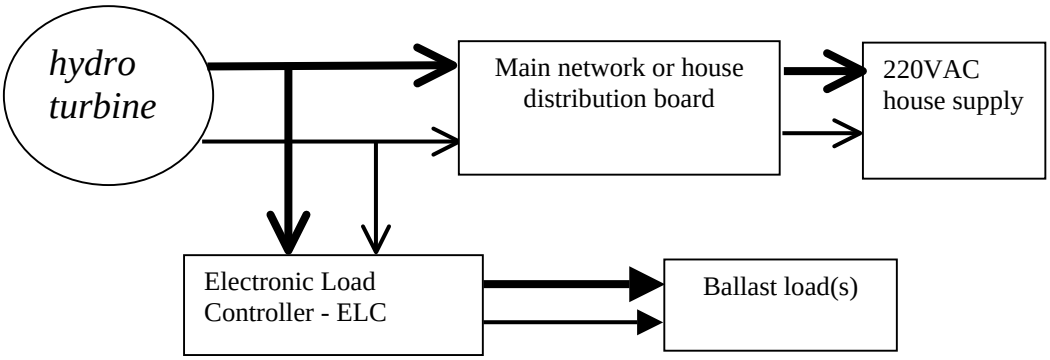
6. The draft tube should ideally be extended away from the frame, to avoid splashback.

### Electrical Aspects

The generator is of single phase, synchronous type. Load is controlled by an electronic load controller (ELC) which is installed as part of the control cabinet. The ELC is designed to maintain constant voltage and 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 two water-heating ballast loads (also known as dummy loads), supplied, where the surplus energy is burnt off as heat.

The ballast loads are connected to the penstock or the draft tube so that a constant supply of cool water passes the heating elements and is discharged as warmer water downstream.

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. Ensure that the control cabinet is protected from rain and sun. A powerhouse or even a simple roofed structure is required here.

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

3. Connect the ballast loads to the control cabinet. All wiring from the generator to the control cabinet, from the control cabinet to the user load and from the control cabinet to the ballast loads should be done using insulated multistrand copper wire.

4. 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.

5. The system is now ready for its first operation.

## OPERATION

The following steps should be undertaken after installing your new system to allow it to break in smoothly.

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. Slowly open the butterfly valve to allow water flow to enter the turbine. Check for any unexpected noise, leakage or overheating of the bearing. The valve is always left in the open position when the turbine is operating and is only closed when servicing or repairing the turbine. When closing the valve, always do this slowly over a period of say 30 seconds to avoid sudden pressure build up in the penstock.

4. Once the turbine is found to be running smoothly without any electrical load, testing of the electrics may begin.

5. As the water flow starts to create electric power, the voltage will rise until the voltmeter on the control box reads 220V and frequency reads 50Hz. Voltage and frequency will not rise above these preset values unless your system has been specifically designed to operate in countries that use slightly higher voltages.

*Always close the valve 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 press the green button on the control panel 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. Start testing with small user loads and gradually build up to full (rated) load over the course of several hours.

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.*

8. Whenever shutting down the system, first switch off appliances, then switch off power at the control panel (red button) and then slowly close the butterfly valve.

9. Once this initial startup test is successful, any future stop – starts will not require such lengthy startup periods. Usually, only a few minutes will be required to restart 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'.

After some weeks of operation, the screws making the electrical connections are likely to loosen. Loose connections cause the wires to get hot and burn out. Check each connection carefully and tighten it. This includes the connections inside the generator casing, and all other parts of the PowerPal system, such as the controller, ballast load, switches, MCBs and the overhead line. While doing this, clean the insides and the outsides of the control cabinet and the generator.

It's also a good idea to occasionally walk along the length of the distribution wires, inspecting each connection and trimming any encroaching tree branches etc.

Bearings should be greased every 3 months or sooner if required.

## 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 miniature circuit breaker (MCB) in the control panel will trip. This will stop the electric current. Turn off all appliances and reset the MCB on the control panel. Then turn on appliances again, ensuring that the system power rating is not exceeded.

3. *Testing in the stream showed that PowerPal was capable of producing the rated output power (5kW to 15kW, 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.

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. 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-CF2/5 | MHG-CF2/10 | MHG-CF2/15 |
|---|---|---|---|---|
| 1 | Rated power output | 5kW | 10kW | 15kW |
| 2 | Intended voltage | 220V~ | 220V~ | 220V~ |
| 3 | Frequency at rated power output | 50 Hz | 50Hz | 50 Hz |
| 4 | Runaway speed | 650rpm | 800rpm | 950rpm |
| 5 | Penstock diameter | 208mm | 208mm | 258mm |
| 6 | Penstock thickness | 4mm | 4mm | 6mm |
| 7 | Turbine runner type | Cross-flow | Cross-flow | Cross-flow |
| 8 | Runner diameter | 200mm | 200mm | 200mm |
| 9 | Number of stainless steel blades | 24 | 24 | 24 |
| 10 | Width of nozzle & runner | 170mm | 170mm | 170mm |
| 11 | Generator | Single phase 230/400V 1500rpm | Single phase 230/400V 1500rpm | Single phase 230/400V 1500rpm |
| 12 | Turbine bearing size | YSA-210/45-2RF | YSA-210/45-2RF | YSA-210/45-2RF |
| 13 | Operating temperature | 5 to 50 ° C | | 5 to 50 ° C |
| 14 | 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.

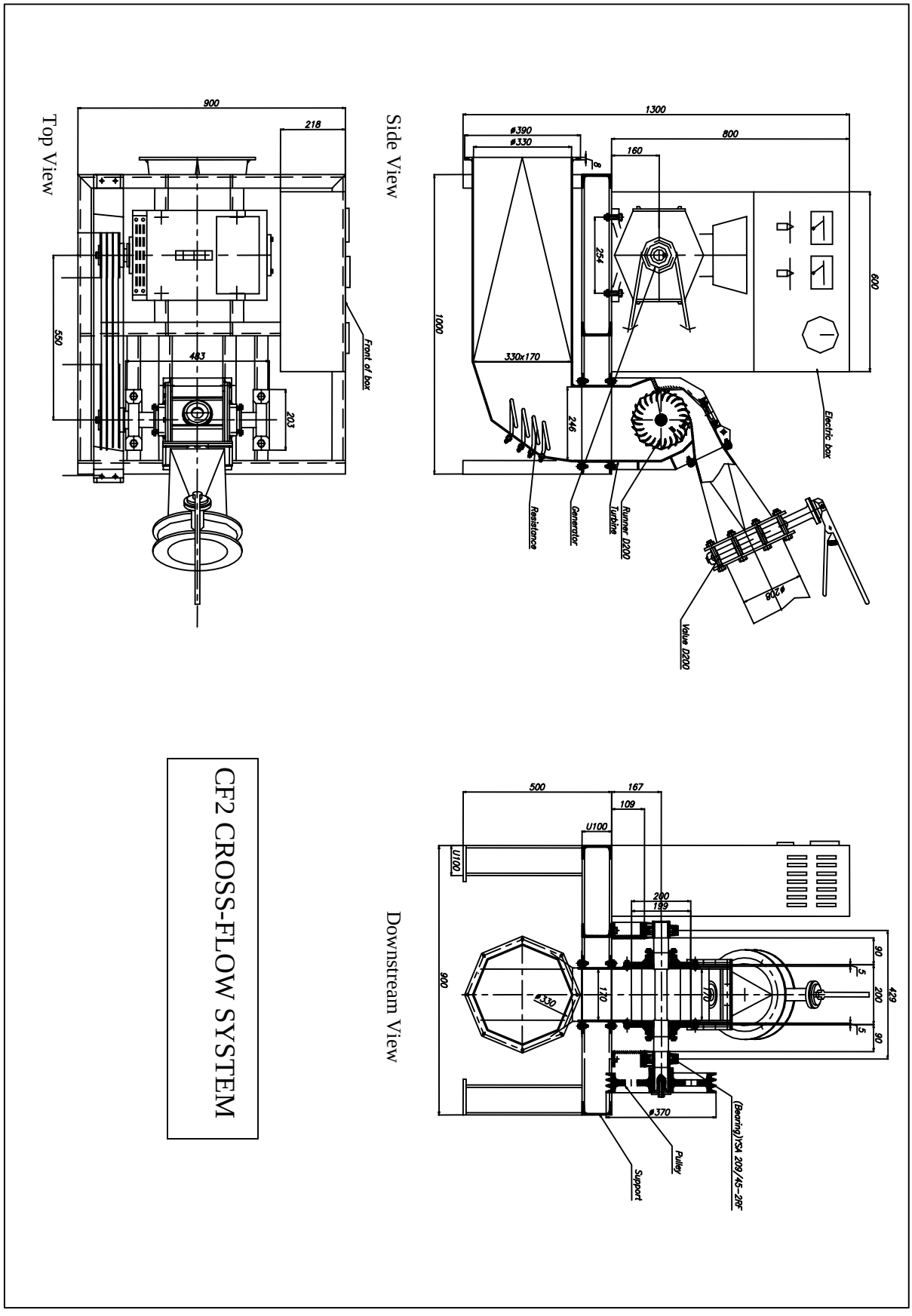
5,6. Runaway speed is the speed of the rotor if no load is applied. This speed is reduced under load.

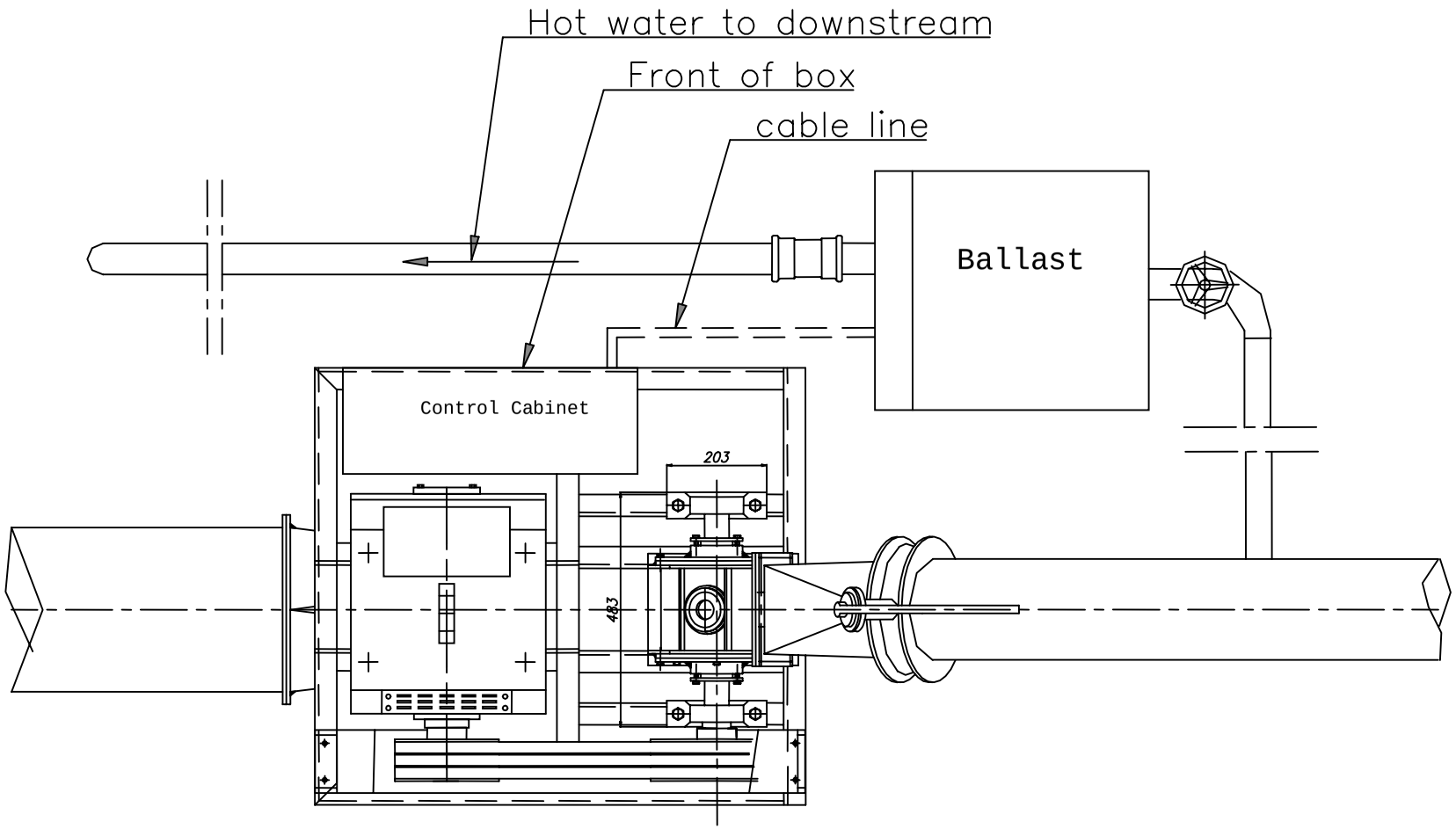
15. We recommend SKF brand or similar high quality bearings.

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

## APPENDIX A - ADDITIONAL DRAWINGS WITH DIMENSIONS

Dimensions below are in mm.




Hot water to downstream
Front of box
cable line
Ballast
Control Cabinet
203
483

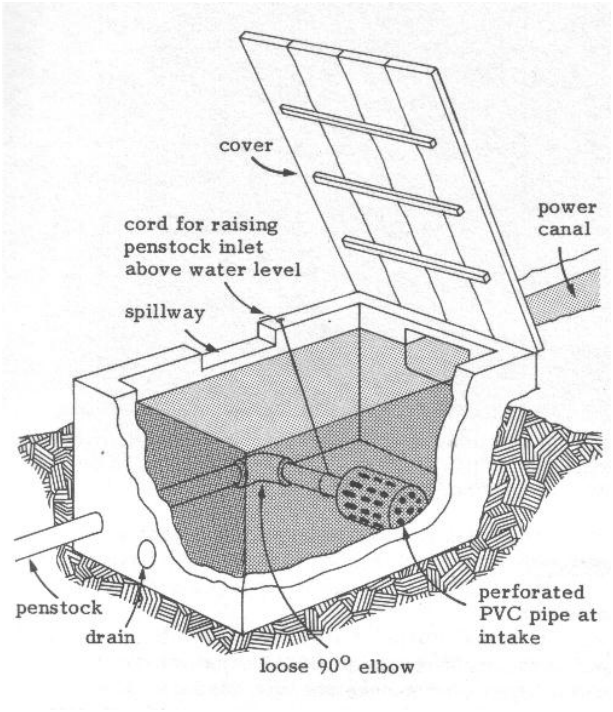
Plan View

## 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.