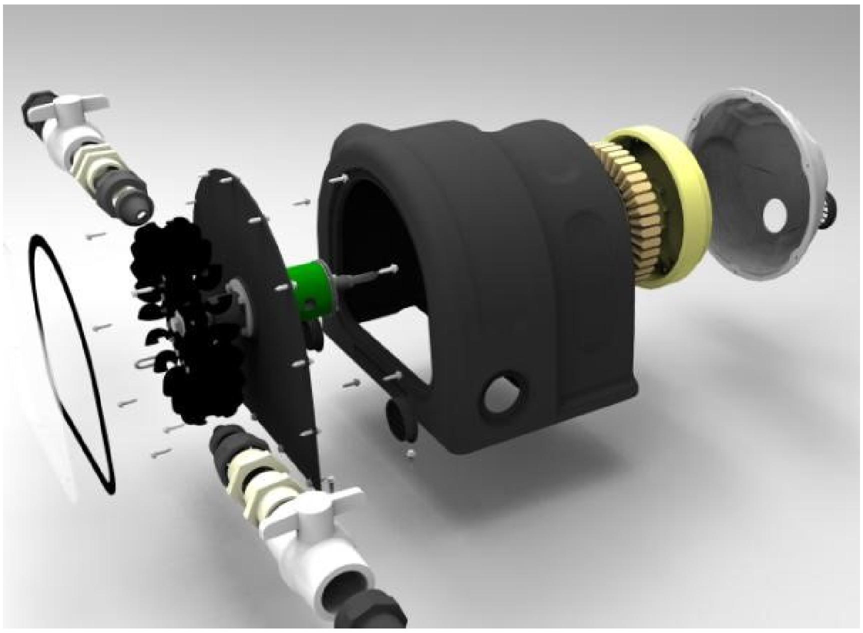
PowerSpout
WATER GOES IN POWER COMES OUT

PowerSpout Turbine Installation Manual
PowerSpout PLT



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Revision history:
2/12/18 by ML corrected links for new shopify web site.
29/8/19 by ML O-ring not need with camlock connection to case.

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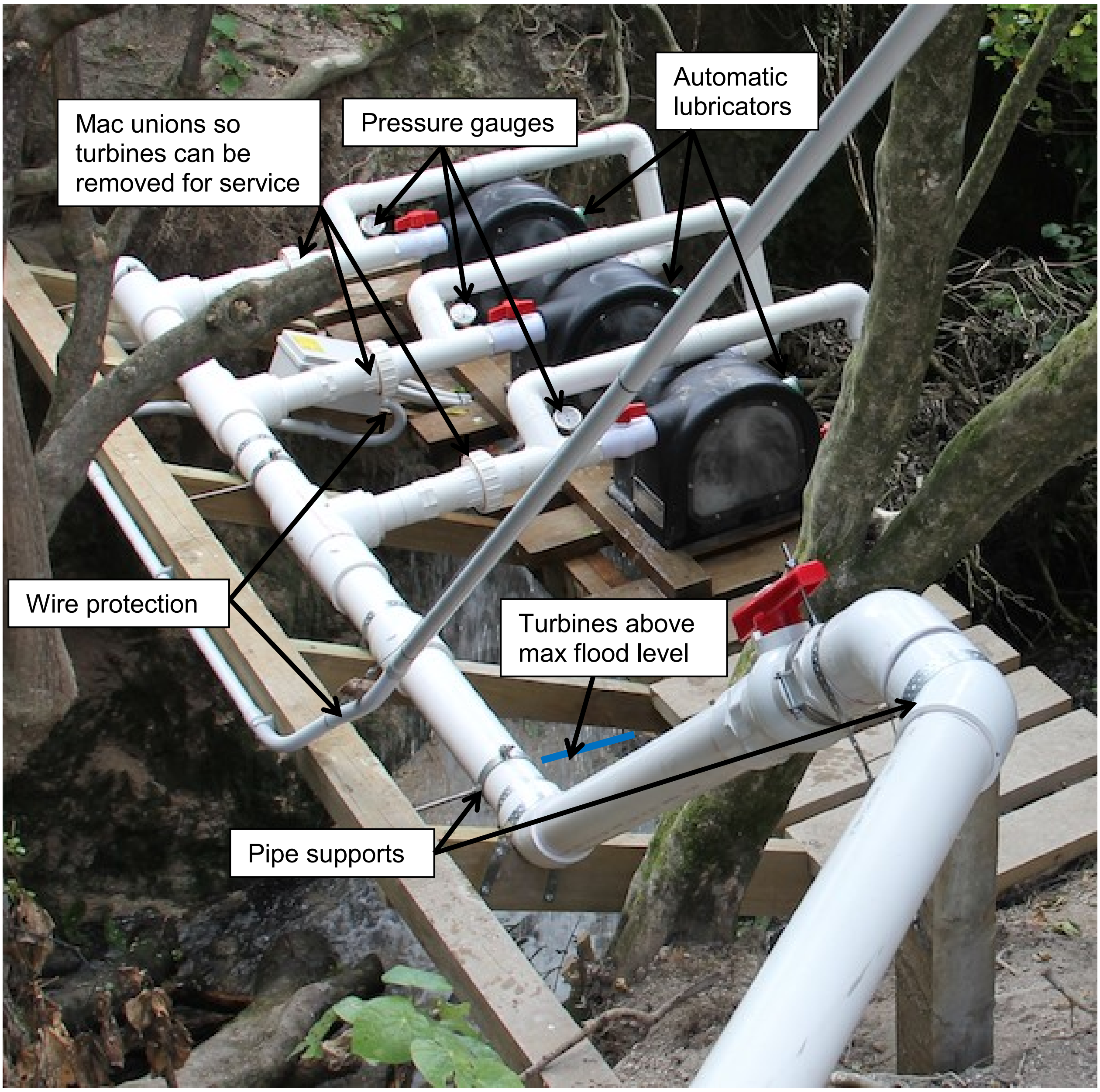


Does your installation look like this?
If it does you can expect a long trouble free life

1. Introduction

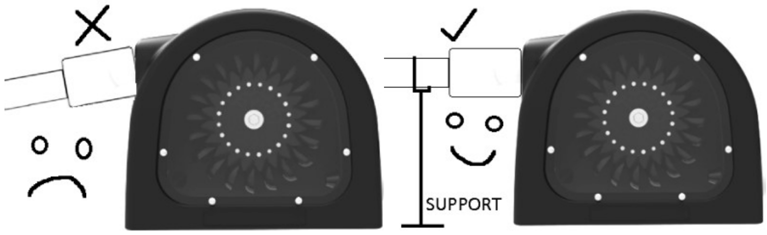
1.1. Please read this first

We pride ourselves on the free documents that we provide, but we also note that owners and installers rarely read and follow the advice contained in them. PowerSpout turbines can give years of trouble-free operation with correct installation and care. Here is a list of vital points that you must be aware of:

- A pressure gauge is supplied with the turbine and you must install this, and take note of the pressure with valves closed and valves open. (See 2.1.3) Without this you are flying blind.

- Some turbines produce lethal voltages, especially when overspeeding, so you must avoid contact with any wiring whether direct or indirect. (See 1.4.1)
- Before connecting your turbine to any charge controller or inverter you must check the open circuit voltage, or you risk destroying the electronic device and there is no warranty cover for this damage. (See 2.3.5)

- Use a grease gun to fill the bearing block with grease so that you can see it emerging, and make sure it is greased regularly by hand or automatically thereafter. (See 2.1.10)
- Support the flexible pipes leading to the turbine jets, or they will sag over time and distort the casing, which can seriously reduce the turbine output. (See 2.1.6)



- Take note of the pressure, voltage and power readings during your commissioning tests and send them to your dealer by email along with photos of the installation, so that we can help you get the best from your PowerSpout.
- Mount your turbine onto a solid base (see 2.2.1). When operating there must always be a 100mm gap between the base of the turbine and the exhaust water level. You need to carefully consider flooding levels, as once the level of the turbine casing is reached it can fill with water. Such a flood event will initiate corrosion in the bearings which can then fail some months later. This will be evident once the bearings are cut open and inspected. Owners are often unaware that their turbine had been partially submerged in a heavy rain event.

1.2. This manual and other information sources

This document is part of the product. It has 3 sections.

1. Scope, certification, identification and safety (this introduction).
2. The parts of the turbine, how to assemble, install and operate it.
3. Reference material.

We offer a wide range of other free documents in pdf format, and some videos. All relevant manuals are considered to be part of the product.

Have a look at our Document Index for further reading and videos on specific topics relevant to your situation. Here is a brief summary of documents that will answer your questions:

1.2.1. When planning your system

- Site assessment guide
- Intake guide and Coanda intake guide
- Manifold guide
- Hydro design and calculator manual

You can estimate your site's generation potential and even design the whole system painlessly using our online Advanced Calculator Tool. To get the best out of it please read the Hydro design and calculator manual first.

1.2.2. When installing an off-grid system

- Power conversion equipment guide
- Battery guide
- Charge controller guide
- System wiring guide
- Powershed design guide
- Diversion load guide

1.2.3. When operating and maintaining your PLT turbine

- Your log book
- Bearing care guide

Our worldwide network of dealers can also help you with system design and choosing the best equipment for your situation.

1.3. Product scope and specification

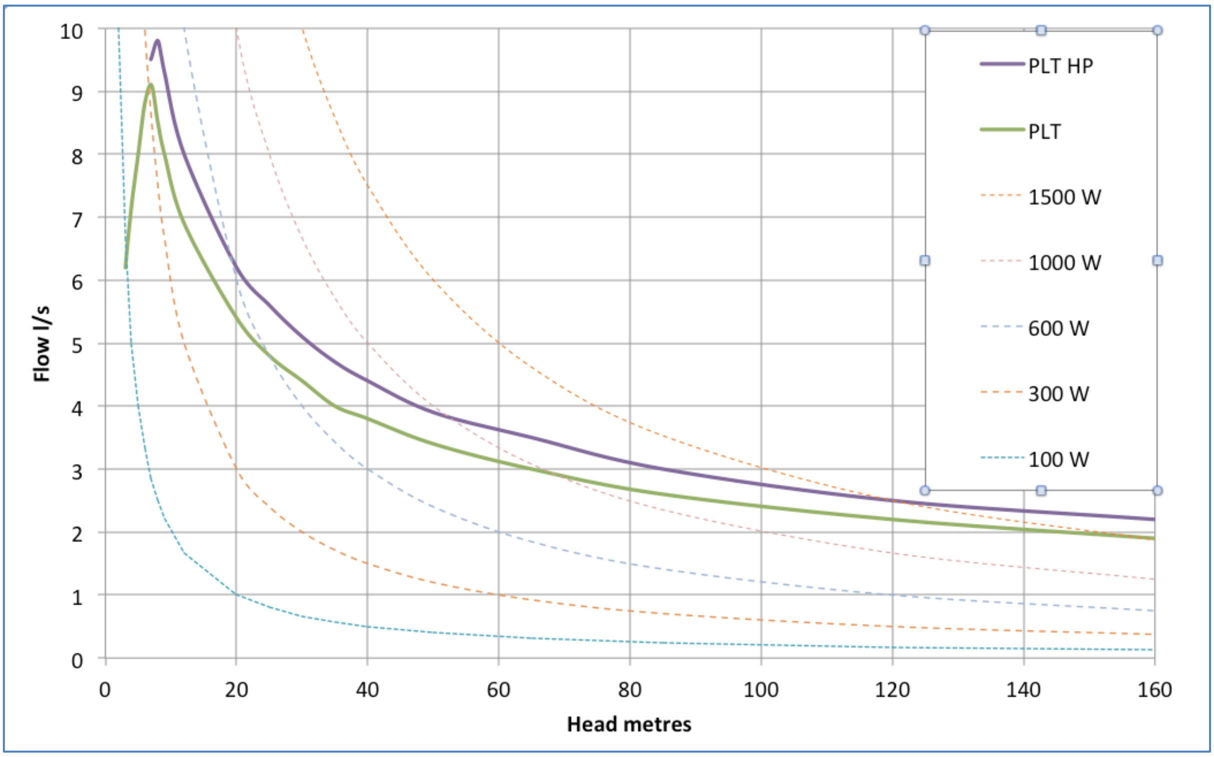
1.3.1. Scope of application

PowerSpout turbines convert waterpower into electricity. The product is custom-built to match your specific site conditions and requirements. Therefore customers or dealers must provide us with site data (head, flow, pipe dimensions, cable dimensions and type of inverter or controller) with each order.

PowerSpout turbines will not be supplied to customers who propose to use the electrical output of the turbine to pump water that in turn supplies the turbine itself. We refuse to support applications that have no external source of energy. Demonstration units operating from independently pumped sources of water will be supported where the customer understands that no net energy will be generated.

The installer must:

- Check for any transit damage to the product prior to installing it. If damaged it must not be installed. If the turbine is being freighted on to the end client then you must check it prior to this next freight leg.
- Connect equipment in compliance with the relevant national standards.
- Read and comply with this installation manual.



Limits of head and flow, with estimated power shown as contours (dotted)

1.3.2. CE and FCC Declaration

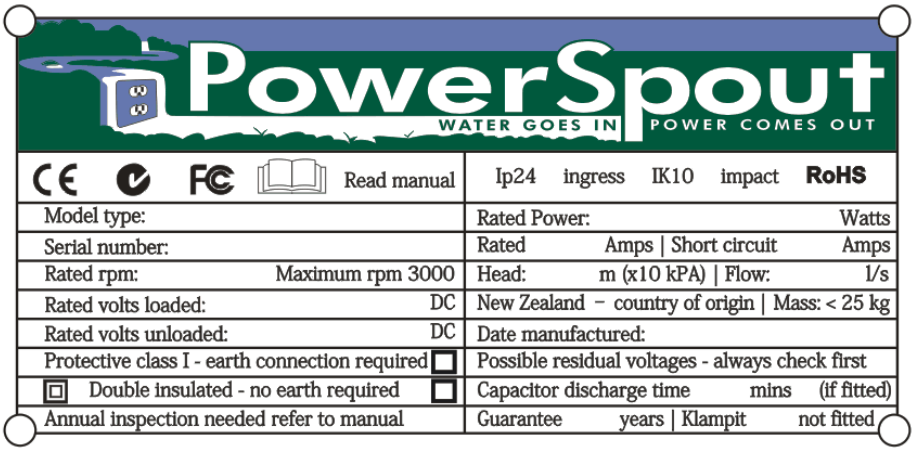
Refer to our compliance declaration documentation and EMC test reports.
PowerSpouts products are CE, FCC and C-tick compliant.
PowerSpout dealers may request to see the Compliance Folder if required by authorities.

1.3.3. Standards and certification

All PowerSpout turbines have been evaluated against major international standards.
Refer to compliance declaration documentation and EMC test reports.

1.3.4. Turbine serial numbers

All turbines have identification plates and serial numbers.



For example:
You might see 100-7S-2P-S HP F 3061 A as the serial number.

This means you have a 100 series stator, connected 7 **S**eries and 2 **P**arallel fingers per phase, **H**igh **P**ower rotor upgrade, Filter installed for conducted emission compliance, invoice number 3061 and other identical units were supplied at the same time labelled A, B, C, D etc.

If you ever need to query an installation or order spares for a product take a picture of the identification plate and forward it with your query. The generator code is also engraved on the back of the PMA stator.

1.4. Safety

This section addresses safety concerns as required by international standards.
If you are not technically competent, experienced and qualified you should not install this equipment alone and should engage the services of a suitably trained professional.

Electrical equipment can be installed or operated in such a manner that hazardous conditions can occur; compliance with this manual does not by itself assure a 100% safe installation. If the equipment is properly selected and correctly installed and operated according to this manual, then any such hazards will be minimized.

The installation shall be carried out by installers with recognized and approved qualifications, and experience relating to general electrical installations and micro-generators.

The following safety warning signs are used throughout this manual.

Caution
Risk of electric shock that could result in personal injury or loss of life

Caution
Cautions identify condition or practices that could result in damage to equipment or personal injury, other than by electric shock.

1.4.1. Electrical hazards

Protect the supply cable in conduit as per local wiring rules, ensure wiring, insulation, conductors and routing of all wires of the equipment is suitable for the electrical, mechanical, thermal and environmental conditions of use. Finger-tighten all cable glands to secure the supply cable.

Shock hazards

DC voltage from turbines is volatile, and can reach three times higher than the rated operating voltage under some conditions. Controllers and inverters contain capacitors that can store and deliver lethal voltages through wiring.

All exposed wiring and connections must be inaccessible. Covers may only be removed when the turbine is stopped and a suitable time has elapsed for capacitor discharge.

Class I equipment must be suitably earthed/grounded (turbine bulkhead).
Do not connect a DC pole of the turbine to earth - unless local rules require it.

Provide a suitable DC-rated disconnection device close to the turbine that is clearly labelled. (A 2-pole DC breaker is the good recommended solution.) In general, hard wiring is required. However “MC4” type waterproof connectors may be used provided they are never opened under load. (Turbine must be stopped before unplugging.)

Fire hazards

Wiring must be adequately sized to carry short-circuit current from the turbine (listed on the identification plate).

Loose connections can cause electric arcs to occur that could ignite flammable materials. Tighten all electrical connections inside the turbine very securely during installation.

Assess fire risk of the installation site, and if high implement extra fire precautions as appropriate. In environments where combustible materials are present the turbine must be mounted in a concrete or metal enclosure. If your hydro turbine is situated in a very dry bush/forest environment where the fire risk is high, then a ground-fault protection device (GFPD) should also be installed.

1.4.2. Lead Acid battery safety

- Batteries store energy in chemical form and can release this as electricity very quickly if there is a short circuit. A short circuit can convert a steel ruler or spanner to molten metal spray and cause significant personal injury.
- Batteries contain explosive gasses that can be ignited by sparks to create an explosion that scatters sharp debris and acid.
- Protection from falling objects is required. Metal objects falling into contact with the battery terminals could cause a fire.
- Never leave a cable loose at one end whilst connected to a battery at the other. It can all too easy flop against another terminal and strike an arc.
- Never disconnect cables from a battery that is being charged/discharged as this creates a spark.
- Batteries give off hydrogen and oxygen gas during charging in the correct proportions for an explosion. Ventilation of the enclosure is required.
- Terminals should be checked annually for tightness and clean if any corrosion is observed.

- Batteries are not maintenance free. All batteries need to be checked periodically for individual voltage and flooded batteries also need to be checked with a hydrometer.
- "Flooded Lead Acid" (FLA) batteries need to be checked for electrolyte level regularly and topped up. If this is not done they will be ruined and the risk of explosion increases. It is important to plan the accommodation of the batteries so that topping up with water is easy to do. Batteries will use more water as they age. Consider fitting battery recombination vents to significantly reduce the need to top up with water. Watering intervals can be as long as 12 months with such vents fitted.
- Batteries are not for anyone to touch. Sufficient security is required to prevent a child or unknowing adult from tampering with them.
- Not everybody understands batteries. There are recommended safety signs that must be displayed above your battery bank warning people of the possible hazards.
- Batteries are heavy and need a solid flat supporting surface. Good access for installation and replacement to avoid lifting injuries is required.

You should always take care when working with batteries. Burns, acid splashes and even electric shocks can occur. If you do not have sufficient skill and/or experience to install and care for this equipment you should engage a renewable energy professional to do it for you.

1.4.3. Mechanical hazards

Once the turbine has been commissioned, any glazing and fairing needs to be fastened in place with the fixings provided.

PLT turbines have quick release toggle latches. The toggle latches are intended for commissioning and jet optimisation. Once this is complete permanent fixings need to be used in addition to the toggle latches. This precaution ensures that children cannot remove the front cover and be exposed to a rotational hazard. The Pelton runner spoons are sharp and could cause serious hand injury.

The turbine installer should ensure that the turbine is mounted such that children cannot reach up under the turbine and be able to touch the spinning rotors.

1.4.4. Water hazards

Ensure you install pipe with the correct pressure rating. Allow for pressure surges in operation that result from closure of valves.

Legislation covering pressurised pipes applies in most countries for pipe pressures over 10 Bar. The PowerSpout runs at less than 10 Bar in most approved applications. Check with your local authority if you have any legal requirement that may concern this installation in your country.

Generally there is little risk at less than 10 Bar pressure. The biggest risk is insecurely fastened pipe joiners that blow off, with the free end of the pipe hitting people. Securing the pipe at regular intervals, particularly near the joins, and checking all joiners are tight will eliminate such risks.

1.4.5. Installation and maintenance hazards

Penstocks (pipelines) are often routed through steep locations with various hazards including danger of falling from heights, or rocks etc falling from above. Take care to prepare suitable access to the site and install safety ropes, steps, etc.

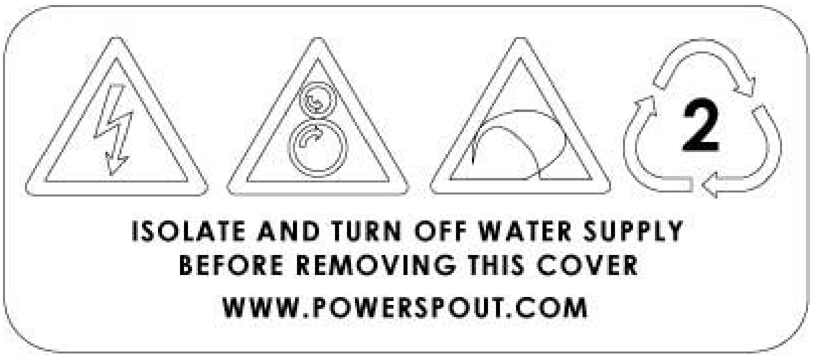
Polyethylene pipe can be hazardous when uncoiling. The pipe behaves like a spring that can recoil with surprising violence and cause injury. Take care when releasing the binding from coils of pipe. Take care when straightening pipes that they do not spring back and hit somebody. Give the pipe time to change shape. Warmer temperatures speed this process up.

Commissioning hazards and safe practices

- Securely fix the turbine base prior to operation.
- Do not intentionally run turbine unloaded (for other than short duration VOC testing).
- Do not run turbine at a head significantly above the nameplate rating.
- In a turbine runaway situation turn off the water supply by closing the water supply valve(s).
- Check for excessive noise.
- Complete turbine testing and commissioning and ensure that all protective fairing/enclosures are in position after commissioning and prior to client hand over.
- Comply with signage requirements as listed in relevant national standards.
- Complete all documentation as required in this manual and local wiring rules.
- Make relevant notes in the manuals that will be of assistance to future service personal.
- Train the end owner/user of the turbine in routine care, safe handling and maintenance of the hydro system.

Fairing safety warnings

The fairing on your PowerSpout turbine forms part of an electrical enclosure and carries the following warning signs. There are both rotational and electrical hazards present. Turbines must be turned off at the valve and the electrical breaker turned off prior to removing this cover.



- Electrical hazard
- Rotating machinery hazard
- Made in New Zealand identification
- Recycling identification

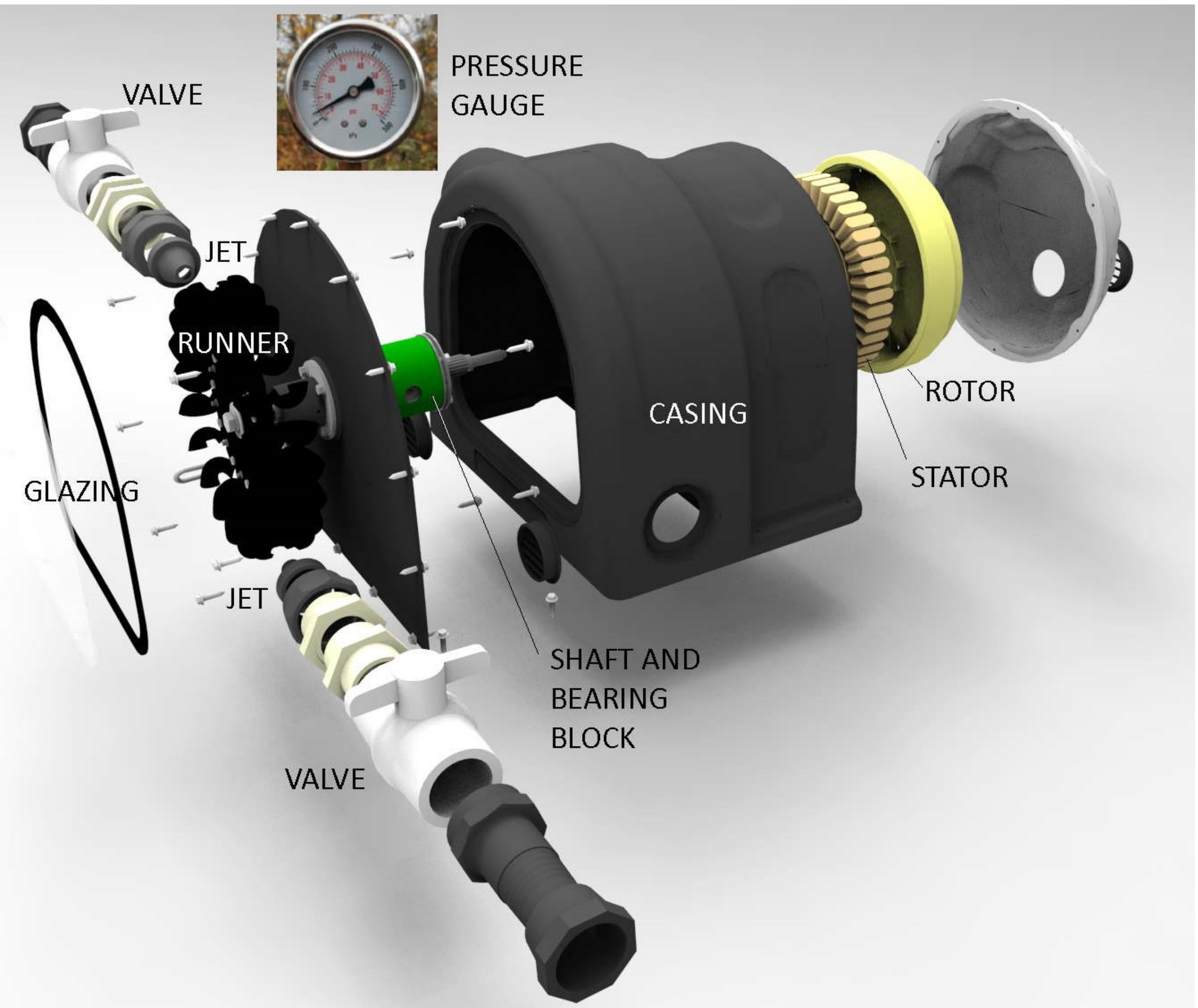
2. Your PLT turbine

2.1. Parts, functions and assembly

Congratulations on your choice of a PowerSpout turbine. This ingenious little device will give you years of trouble free generation, avoiding the need for expensive generators or power bills. Not only does the PowerSpout give you renewable energy, it is also made of predominately recycled materials, making it one of the most eco-friendly micro-hydro generators available on the global market.

This section is a guide to the parts of the turbine and what is supplied with it.

If you disassemble your turbine, take careful note of the positions of parts including any washers. Take photographs to remind you of the details.



Pelton (PLT) turbine exploded

Your turbine will arrive assembled other than jets and valves, but we recommend that you remove the magnetic rotor whilst greasing for the first time (shaft spinning). You may need to remove the stator so as to connect wiring to the rectifier or EMC filter. You will need to assemble the jet holders and learn to change jets. To get the best from the turbine you should read this manual and get to know its parts.

Note that it is normal to feel some resistance when spinning the magnetic rotor by hand. You will hear a slight humming sound. The rotor will slow to a halt after 2-3 seconds.

Each PLT turbine comes with:

- 2 Jets (cut to size) and 2 valves (2" BSP standard - NPT optional)
- A mid-range oil filled pressure gauge
- Manual grease fitting as standard (automatic greasing option available as extra)
- 2m of 4mm^2 tinned PV wire for +/-/earth
- 2 x MC4 cable connectors
- 4 x Tek screw fixing kit
- 4 spare uncut jet inserts
- Rotor packing set kit included if we consider them likely to be required
- 3 year warranty on standard (under 1200W) and 2 years on turbines over 1200W power output. See our separate document **Warranty and terms** in the index.

2.1.1. Turbine protective casing

The PowerSpout PLT is encased in a very durable LDPE housing, ensuring all internal parts are protected from rain, rodents, children and UV etc. The turbine can be installed outside as it is protected from sun and rain by its housing.

The LDPE enclosure also helps reduce noise and dampens any slight vibrations. The main benefit, however, is that there are no exposed rotating hazards that might catch the fingers, clothes or hair of interested children - ensuring a very safe product. Access to the rotating parts is only achieved with the use of a tool to remove the covers.

The internal aluminium bulkhead has been designed to help control the temperature in the enclosed generation compartment of the PowerSpout. The Smart Drive generator has a peak efficiency of up to 80% and will get warm. Heat is dissipated from the generator core by rotor airflow. The water-cooled aluminium bulkhead and the cooler outside air acting together ensure sufficient cooling for up to 1600 Watts of generation per turbine.

2 x side air vents
1 x rear lid air vent

This warm enclosure together with a drainage hole in the base combine to ensure that the generator and electrical junction box do not become corroded from moisture ingress.

The generator temperature should always be checked as part of the turbine commissioning by the installer, particularly when high power turbines are installed in very hot climates. More vents can be added if required.

The fairing on your PowerSpout turbine forms part of an electrical enclosure. In many cases there will be lethal voltages present during operation.

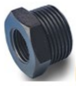
Quick release glazing tabs

These tabs are provided with the PLT turbine to secure the glazing during commissioning. Use them during set up, as they make it easy to remove the glazing. The other fixings should also be fitted later, for safety and sealing, if children have access.

2.1.2. Valves

Two valves are supplied with your PLT turbine.
Thread is female 2" BSP (or NPT can be supplied by order). More about thread sizes.
Used as on/off control of flow to jets.
Can be mounted directly on PLT jet-holders, but when used with camlocks and hoses we recommend fitting the valves at the supply pipe end of the hoses instead.
Grease the threads well.

Valve



Reducing Bush

2.1.3. Pressure Gauge

Supplied with turbine.
Thread is 1/4" BSP male.
To be mounted on penstock or the manifold pipework upstream of the valves.
Normally this is done with a saddle, reducing bushes, (and optionally a valve), as shown above right. (These fittings are not supplied).
Can also be mounted in a hole (drilled and tapped) in pipe or fittings.

PRESSURE GAUGE INSTALLATION EXAMPLES

Pressure gauge installed in a tapped hole - Gauge installed in a reducing bush

Convert the units of pressure:

- 9.8kPa = 1 metre of head
- 43 PSI = 100 feet of head

The pressure gauge is absolutely essential for commissioning, troubleshooting and flow management, so you must install it.

The gauge is slightly affected by temperature changes, so for maximum accuracy you should vent it by pushing the rubber bung aside with a thumbnail. This allows air to enter or leave the casing. Or snip off the nipple on the top of the plug, if plug is uppermost and turbine is not installed outside.

Measure the static pressure (valves closed) and compare this with the design calculation. If it is low then check for air trapped in the supply pipeline (called penstock). If it is high then be ready for more power than expected (for a given size jet). Your circuits and equipment need to be fit to carry this extra load or you need to use smaller jets.

Measure the dynamic pressure (valves open) and compare this with static pressure to calculate the pipe efficiency percentage. Does this match the calculation?
If turbine output is low then the pressure gauge helps you find the cause.

- Low pressure could mean blocked filter, lack of water flow, or trapped air in the pipe.
- Higher than usual running pressure could mean an obstructed jet.

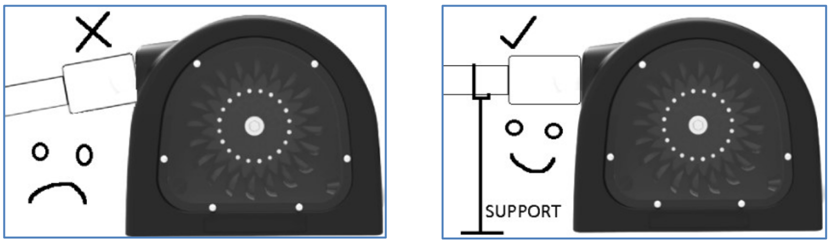
2.1.4. Camlock fittings (optional extra)

These quick-release fittings are ideal for connecting flexible 50mm (2”) ID hoses to your turbine. Grease the threads liberally. Soften the hose in boiling water, push or hammer the hosetail in, and secure with clamps. Ensure that there is no stress in the pipe where the camlock fittings lock together.

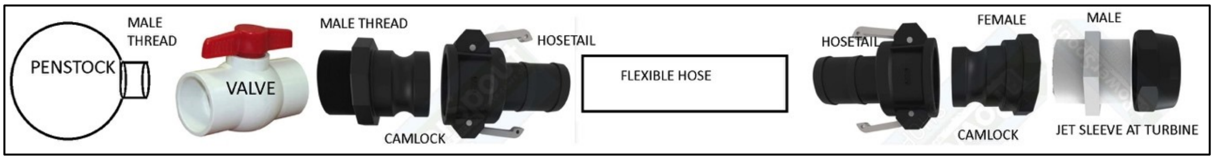
Our camlock fittings are rated for up to 6 bar (87 PSI or 60m head) and include 1 male and 1 female thread. Be aware that at flows exceeding 3 litres/second per jet you will suffer some loss of head in these small-bore fittings. This may mean that the turbine output is less than predicted.

Do not forget to fit the pipe supports. There are none in the photo above. Also the valve is better placed at the upstream end so that you can detach your turbine from the pipework for servicing.

In every case where flexible pipes are used for the manifold you must support them to take the weight off the turbine casing.

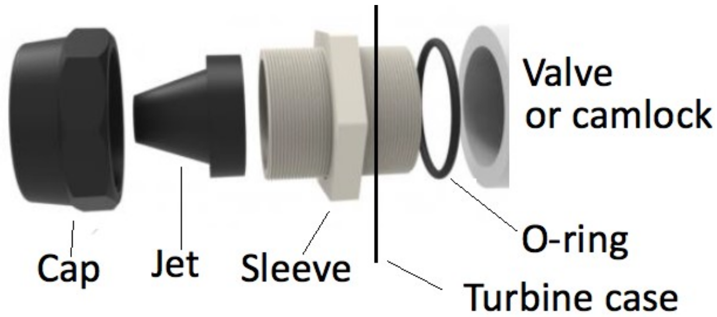


The diagram below shows the sequence of connections between the penstock (supply pipe) and turbine. You can use one of our pipe saddles to provide a male thread on the penstock and mount the valve on that, followed by the camlock-hose-camlock sequence, leading to the jet sleeve on the turbine.



2.1.5. <u>Jet sleeve and cap</u>

Supplied with turbine.
Fit the O-ring on <u>outside</u> of PLT casing if mounting a valve.



Grease threads liberally. Tighten the valve or camlock onto jet sleeve outer end with a wrench, but not too tight as to displace the O-ring seal.

Jet cap should only be hand-tightened, to retain jet insert on the inner end. But take care it does not fall off and get washed away.

Note O-ring is not required if a camlock is fitted on the outside of the turbine case.

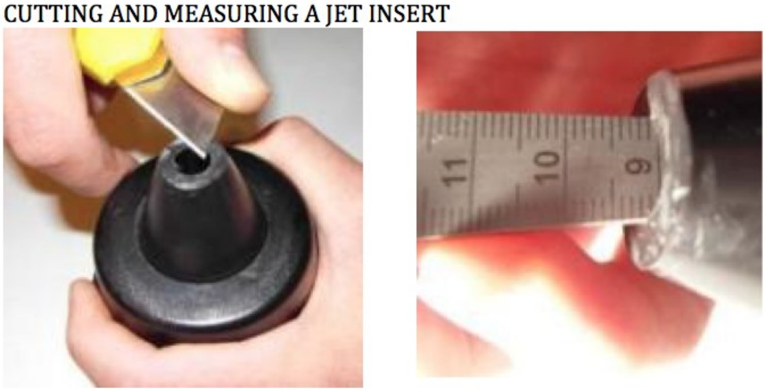
2.1.6. Jet inserts

The jets control the flow rate. A larger orifice results in more flow. Use a suitable size and number of jets to harvest most of the available flow at any given time. If the available flow is sometimes insufficient to feed your chosen jets, then air will enter the penstock, reducing the efficiency of the turbine. Then you must use fewer and/or smaller jets to get the most power from your diminished flow.

You will be supplied with jets that will deliver the correct flow for your site as you have reported it.

Four spare jet inserts are also supplied with your turbine. The hole inside is tapered. Enlarge the jet by shortening the plastic insert on site with a sharp knife. The inserts are inexpensive so a trial and error approach can quickly determine the correct jet size.

CUTTING AND MEASURING A JET INSERT



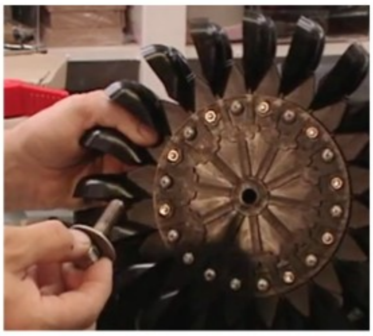
It is important to cut your jet to the correct size cleanly so that the water jet can break smoothly without spray. We recommend using a sharp knife and paring away at the jet, cutting from the inside edge out. With practice a very accurate and sharp edged jet can be prepared in the field. The taper gauge and knife supplied in the optional PLT tool kit helps to make this task easy. If you do not have a taper gauge then you can test the hole size using the shank of a drill bit inserted gently (<u>not</u> drilling a hole) to check the size.

Holding the plastic jet within a spare holder sleeve and end cap will ensure the jet is held firmly while you cut it to size. Take care, as it is easy to slip, which could result in a significant flesh wound. If you have Kevlar gloves, wear them.

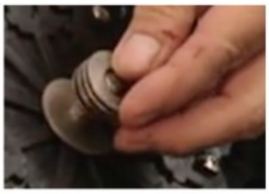
2.1.7. Turbine runner/rotor mounting

The wet side rotor, or "runner" is fitted to the "wet end" of the shaft.
Take care that the runner is the right way around to spin clockwise as shown.
Fit the spring washer and one large "flange washer" washer to the M12 bolt, and insert it.
Fit second large "flange washer" and some smaller "shim washers" as supplied at the back.

MOUNTING THE PELTON RUNNER



The shim washers set the correct position of the runner relative to the jets.



Tighten the bolt to 50 Nm torque or "very tight". The runner may be damaged if it slips.
(50Nm/37ftlb is the same as 25kg weight at the end of a 20cm long spanner or wrench.)

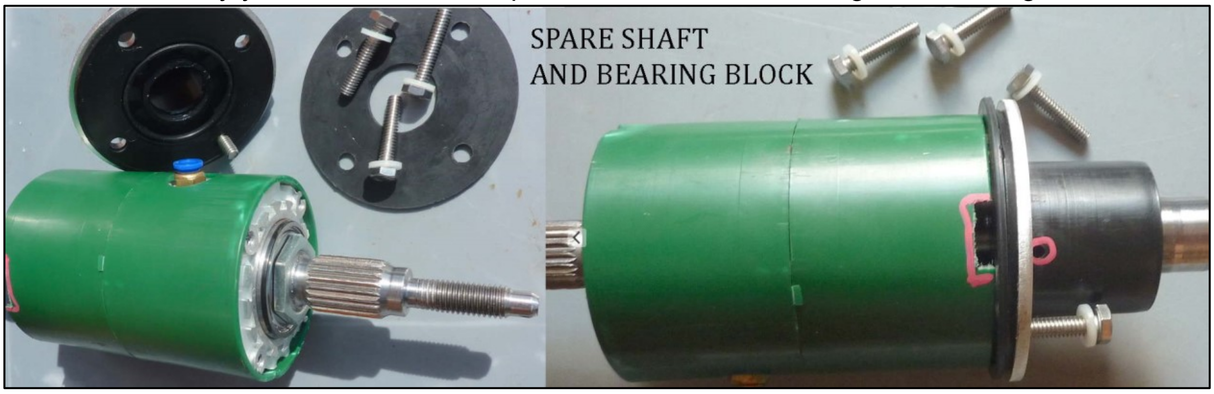
Pelton Runner Alignment

You can view the Pelton runner by looking through the jet as shown. The water jet needs to hit the middle of the Pelton spoon splitter. If the jet is misaligned then pack the runner across using the washers supplied. You can see in the picture that the Pelton runner needs packing to move the rotor to the left.

If the manifold is built with flexible pipes then you can optimise the angle of the jet during commissioning by trial and error movements of the incoming pipe angle. Always support this pipe at the optimum angle as part of the commissioning process.

2.1.8. Shaft and bearing block installation

You need to remove and refit the shaft and bearing block assembly in order to change the bearings. YouTube link. It's a good idea to order a spare shaft and bearing block with your turbine. That way you can be back in operation at once and change the bearings later.



Coming from the "dry side", push the shaft through the bulkhead hole. Make sure that the drainage notch (outlined with pink pen above) is on the underside. Fit the rubber gasket and the top hat assembly (liberally greasing the gasket and seal) over the protruding end of the shaft.

Rotate the top hat until the drain hole is also at the bottom. Use a screwdriver to align holes in all the parts, and then fit the first 1/4 inch screw. Fit the other three screws and tighten evenly with a 7/16" or 11mm socket wrench. Tighten to 5Nm (4 ftlb). Do not over-tighten as this may damage the rubber and cause leakage.

Connect the grease hose to the bearing block.

2.1.9. Changing the bearings

Bearings should be checked at each service and replaced as required when slack or noisy. If bearings are used for more than one year without purchasing and fitting three of our automatic grease canisters then there is no warranty cover for any damage resulting from bearing failure. However bearings can last more than one year with care at your discretion. Refer to bearing care guide for more information.

Bearings specifications:

Front 6205-2Z OD 52mm ID 25mm, and rear 6005-2Z OD 47mm ID 25mm
Select premium quality bearings.
Steel shields (denoted by letter 'Z') are preferable to rubber seals (that have higher friction).

Removing old bearings

Slacken the retaining nut by holding it in a vice whilst turning the shaft's wet end with a pair of grips. Use the jaws of the vice (not tightened) as a support for the block. Then strike the end of the shaft to drive it out of the block. Knock the shaft out of the wet end bearing in the same fashion. Youtube link.



Use a suitably long bolt as a drift to hammer the remaining bearing out of the block.
Tap the new ones in taking care to strike only the outer race and not damage the shield.
A large socket (if available) can be used as a drift for the recessed bearing.




Clean the housings and the shaft to remove traces of retaining compound and any grease. Apply fresh retaining compound Loctite 680 sparingly as shown below (also to the thread). Drive the shaft fully into place with a hide mallet (or put a block of plastic over the wet end to protect it from your hammer).




Finally tighten the locknut on the dry end, using the same technique as used to remove it. Do not over-tighten. You want the bearings to spin freely

2.1.10. Greasing the bearings

Grease type

- Any grease is better than no grease.
- Quality is less important where canisters ensure a steady flow.
- If possible, use waterproof grease.
- Where the turbine power output is low you will benefit greatly from using a low viscosity grease.
- We recommend SKF LEGA 2 grease for all PowerSpout applications or a close equivalent.

Manually applied lubrication

Sealed bearings do need to be re-greased at times, because hydro turbines run 24/7 and see very high cycle rates. The PowerSpout is provided with a re-greasing nipple so this can be easily done. Do this with the shaft spinning (driven either by water power or using a cordless drill with a 19mm socket attachment).

Pump into the bearing block about 40 ml of grease when first commissioning. This is normally about 40-60 pumps of a domestic type grease gun. Grease the bearings with the magnetic rotor removed. Once you see grease on the dust shield you can stop. (Perform any checks of output voltage before doing this. as the grease will affect the maximum off-load speed.)

Subsequent re-greasing should be about 5 ml of grease (about 5-8 pumps) with the shaft spinning.

You should lubricate your PowerSpout bearings when you first use it and then (at least):

- Every 12 months for generation up to 300 W.
- Every 6 months for generation up to 600 W.
- Every 3 months for generation up to 1600 W.

Auto-grease cans

If you purchase 3 auto-grease cans at the same time as your turbine, all you have to do is replace and activate the grease can every year; the bearings can then be replaced every 3 years. An annual inspection is still required.

Before activating the auto-grease canister, you have to manually charge the bearing block as described above, or an early bearing failure may occur.

Spring-loaded re-usable cans

The spring-loaded reusable cans that we can also supply do not extend bearing warranty and are not suitable for cold climates (as grease flow is too slow), but on most sites they will work for most of the year. This is a much cheaper reusable option and better for the environment provided you remember to:

- check the movement of the plunger,
- top them up on a regular basis,
- and to revert to manual greasing in colder weather.

2.1.11. <u>The stator</u>

Electrical power is generated in the stator.

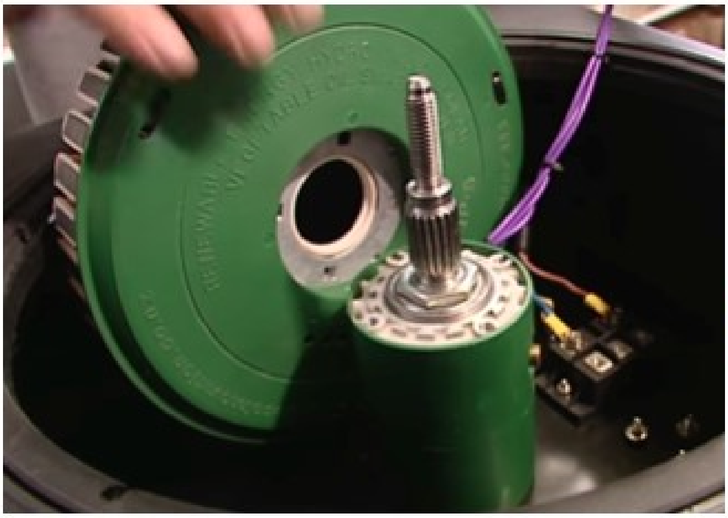
Your stator is chosen (from a huge range of options) to produce the correct voltage and power at the correct rpm, <u>which in turn depends on the head of pressure</u> behind the water jet that spins the turbine runner.

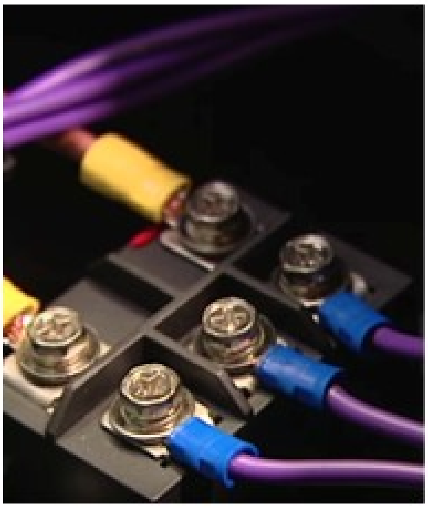
If you change the operating voltage <u>or</u> the head then you may need a different stator. The nominal voltage of the turbine (for example 80V for a PLT80) is based on operating it at the head of pressure that you reported at the time of purchase.

It is possible to make some small adjustment to the voltage using washers behind the magnet rotor as described. This can be useful to protect your controller or inverter if the head is more than expected and the voltage is too high.

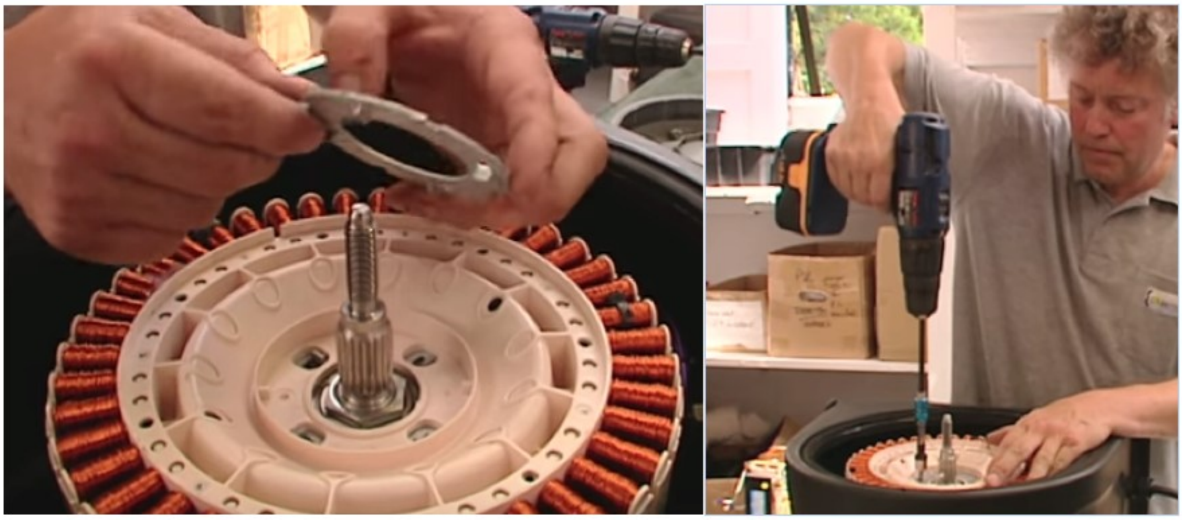
Assembly

Before mounting the stator to the PLT turbine, you must connect the three wires to the rectifier that is mounted on the bulkhead behind it. (Also connect the grease hose to the bearing block.)



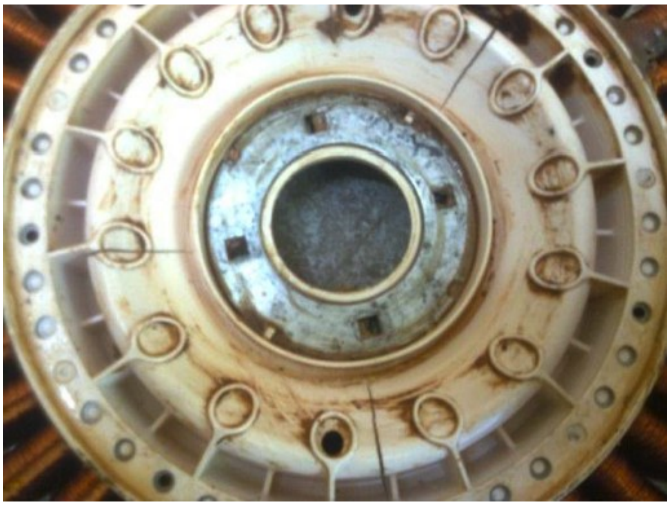


Place the stator on the "dry end" of the bearing block. Place the large galvanized washer on top (with its tabs downward). Rotate the stator on the bearing block, to gently wind the wires around the block loosely, so that there is not enough slack to possibly contact the moving rotor. Snuggly tighten the four machine screws that hold it down, using an 11mm socket spanner (7/16" wrench).



Stress Relief Cracks in Stator

You may notice if you service a PowerSpout that the stator may have developed some cracks.



These cracks are normal. You normally observe 1-4. They are caused as stresses in the steel/plastic molded assembly relax during operation.

These cracks do not result in failure and are only cosmetic - so no need to panic. We have been installing Smart Drives in hydro turbines for over 15 years and have not seen a failed one yet. It is normal to see about 4 cracks as per the picture. Generally units are sent out without cracks, but these will form in due course.

2.1.12. Rectifier

A rectifier within the PowerSpout converts the 3-Phase AC produced by the PMA to DC for supply to your battery bank or grid-tied inverter. Contrary to the common myth, it is more efficient to send DC along a cable than AC for the same cable size and RMS voltage.

RECTIFIER

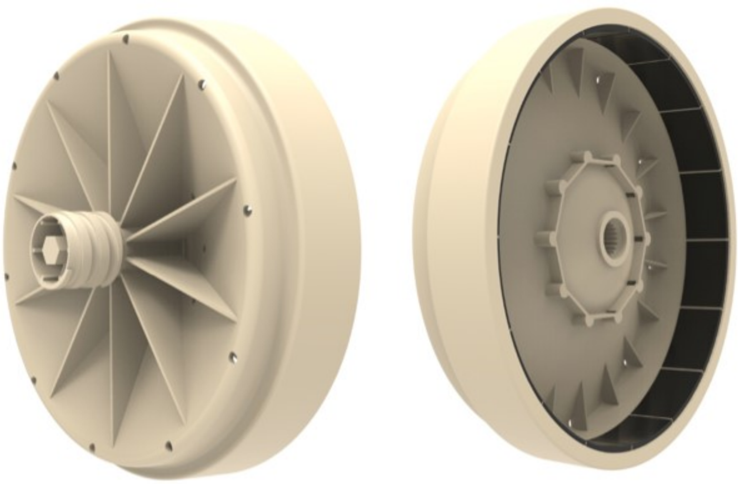
EMC FILTER

In order to comply with standards for conducted and radiated emission noise, the 3-Phase rectifier in your PowerSpout may include a noise-filtering module for conducted emissions. This EMC filter must be ordered if your turbine is to be used for a grid-connect application.

Rectifiers get hot due to power losses, and lower voltage systems have greater losses. In a 12 V system you lose approximately 10% of the energy you generate in the rectifier, whereas this figure is only 3% for a 48 V system.

2.1.13. The magnet rotor

The rotor is directly driven by the turbine runner via the shaft. By dragging a magnetic field through the stator it creates the electrical power output in the stator's coils.



Voltage produced depends on:

- Choice of stator (Selected in factory for best fit to site conditions)
- Output current (Voltage is highest when there is no output)
- Rotational speed in RPM (related to water pressure and output current)
- Magnetic field strength (from the magnet rotor).

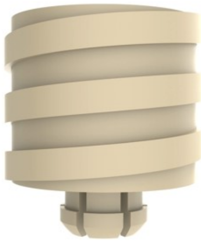
Magnetic field strength can be adjusted using packing washers (See section 2.3.4 or 2.3.5) to reduce the open circuit voltage if necessary to prevent damage to connected equipment.

These washers are also used to optimise the operating rpm in the case of direct battery-charging systems PLT14, 28 and 56.

The rotor is chosen to match the stator's pole pattern, and also the desired power output. Turbines with the HP option have a more expensive rotor than standard turbines.

The extractor knob

The extractor knob is a separate part that must be popped into the hole in the magnetic rotor (by pressing hard) prior to assembly. Its function is to make it easy to slide the rotor on and off the shaft despite the strong magnetic forces that pull it toward the stator.



Check for and remove any particles or debris adhering to the magnets before assembly. The rotor can now be fitted.

Fitting the rotor (always with extractor knob already fitted to rotor)

Grease the mating splines. Place the rotor on the "dry end" of the shaft and rotate it gently (whilst holding the runner at the wet end) until the spline engages and it locks on.

Rotate the knob clockwise to install the rotor. Keep going until it stops. Finger tight is fine. To remove the rotor simply reverse this process, turning the knob to the left, or (instead) hold the knob tight and spin the rotor to the right to pull it free of the stator.

Spin the assembled magnet rotor to check that it moves freely. It is normal for it to make a soft whine and slow down in a couple of seconds to a halt.

Rotor types

We use two types of stators in PowerSpout turbines (42 pole and 36 pole).
We use two types of rotor for each stator type.
Type 2 and 2+ are compatible with 42 pole stators.
Types 3 and 4 are compatible with 36 pole stators.

Stator type	Rotor type for 0.75W/rpm	Rotor type for 1.0W/rpm (HP)
42 fingers on stator	type 2 (default)	type 2+
36 fingers on stator	type 3	type 4 (default)

For more information about Smart Drive stators and rotors see the SD applications manual

2.2. Turbine installation

Before you can install and commission the turbine you must have in place a suitable **intake** that collects and filters the water (see document Intake guide and Coanda intake guide)

Lay a supply pipeline (or "**penstock**") that is completely filled with water. See the Site assessment guide. The internal diameter and length must match the figures in the calculation. Grade the pipe uniformly downward so that air can escape via the intake, or vent the high spots to remove trapped air.

The turbine must be connected to the penstock with a suitable **manifold** of pipes as discussed in our Manifold guide.

You must support all pipes close to where they connect with PLT turbines.
Adjust these supports as part of the commissioning process to obtain maximum speed, and thus achieve the best alignment.

Flexible pipe support

MDPE pipe supports (pipe that are more rigid)

Rigid PVC pipe not needing extra support - provided weight of penstock is supported

Install the **pressure gauge** close to the turbine, but on the penstock side (upstream) of the valves. Check that the water pressure corresponds to the correct head as specified in the design calculation file that you agreed to when placing the order. If it is below 80% of this then you may need to replace the stator in the turbine with a different one from the factory. If pressure is much higher than expected you may need to add packing washers behind the magnet rotor before you can safely connect the turbine to anything. Take care to check the open circuit voltage.

The **electrical equipment** to connect the turbine to your battery or utility grid is all described in our Power conversion equipment guide. In most cases there will be a shock hazard. You will therefore need an electrician. Cover up any exposed wiring and connectors before you start the turbine spinning.

Before commencing the installation process you should have selected the appropriate components and consulted your local regulations concerning use of water and undertaking electrical work. See our System wiring guide for help with circuit protection etc.

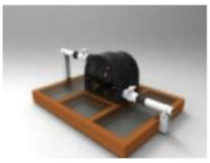
In many cases you can install the equipment yourself and then have the electrician complete the final hookup and turn on, but you should talk to your electrician before you start. The electrician will be responsible for your workmanship and may be reluctant to certify your workmanship, which may not be accessible after the work has started.

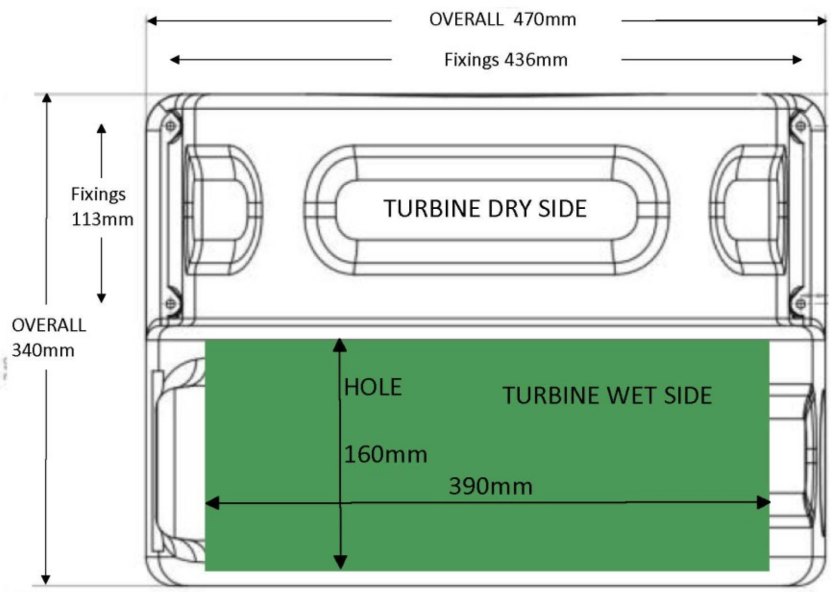
2.2.1. Mounting

Mount the turbine on top of a hole that the water can fall through. The base of the turbine should always be at least 100mm above water level below. Mount the turbine at low level to maximise head, but also remember to consider flood conditions. (See 2.4.10)

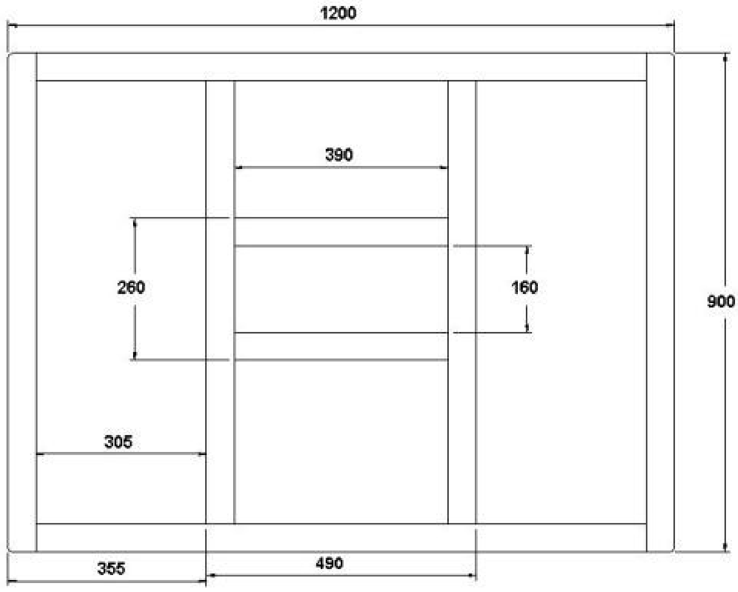
Clients often want to build the base for their turbine while their order is still being processed, but it is safer to wait until your turbine has arrived before you complete this detail. There is nothing to beat having the turbine on site to avoid errors. Do not try and be too clever. What follows is helpful dimensional information in the planning of your turbine location.

The main case dimensions (mm) and the four holes in the PowerSpout casing for turbine mounting are illustrated in the plan view below. Fixings are provided with the PowerSpout for connection to a timber-framed base. These dimensions are sufficient to plan for the mounting of the turbine prior to its arrival on site.





Plan view of a PowerSpout turbine



A framed timber base is typically made from 100x50 timbers and covered in 12-17mm thick plywood sheet on top with **a hole 160 x 390 mm** cut for the exhaust water.

Also drill a smaller hole (15-20mm) through the plywood and rear PLT dry side compartment at the lowest point (where water may pool), so that any condensation can drain out.

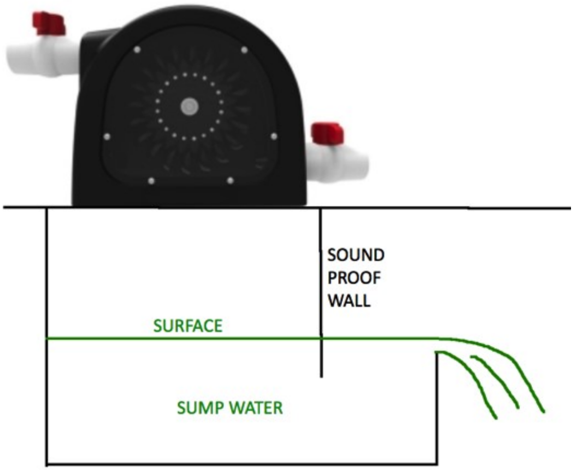
A PowerSpout PLT unit is 400 mm high.

Either allow for easy disconnection and removal of the whole turbine from the site, or for <u>easy on-site access</u> to dismantle the turbine and replace the bearings.

Sump and tailrace

Water falling from the underside of the turbine must be channeled back into a watercourse without causing erosion or flooding.

Often the space under the turbine is open to the surrounding air. If the noise level of the turbine is a critical concern then we suggest enclosing the sump to reduce noise emissions from the pelton rotor. Arrange for the water to drain out below the surface, creating a "trap" to prevent any air pathway for the sound.



Do not seal this sump chamber completely. Air must enter to replace bubbles swept away by the tailrace, or the level will rise and flood the turbine runner. The drainage hole in the dry side floor is suitable to vent this chamber.

Indoor turbine mounting

At sites where no water leakage can be allowed (slip hazards for staff etc) you can attach sealing strips of adhesive neoprene to the base of the turbine before bolting it down to ensure the turbine is completely sealed around the base. The hold-down fixings are at the rear of the case. To ensure complete sealing at the front of the turbine under the glazing you can remove front glazing and insert screws through the inside plastic lip to pull down the case at the front. We also advise that for indoors situation you have a perimeter lip on your turbine base. Some water seepage is inevitable over time. A lip will trap this seepage and it can then be drained off rather than spread over the floor.

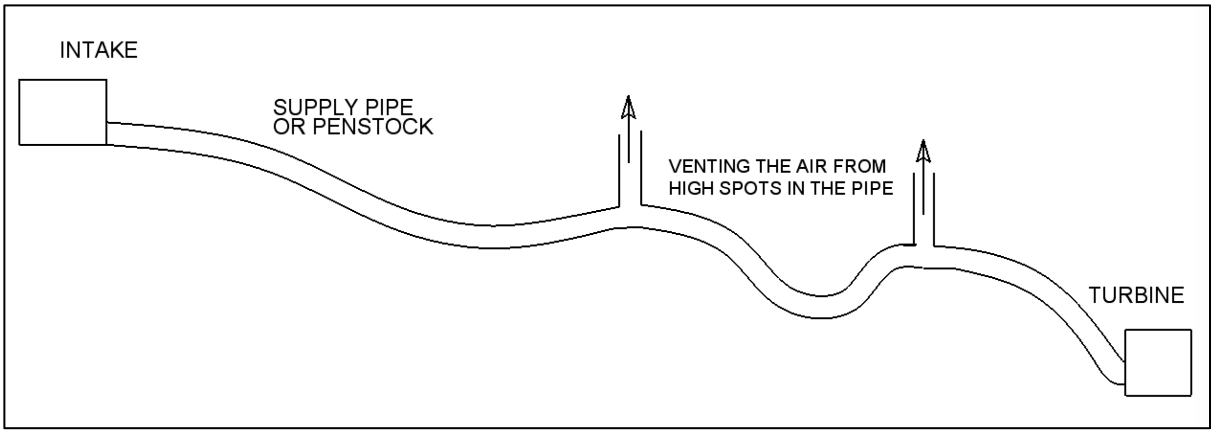
In situations where there is a high risk of dropping tools into the floor sump you should cover the floor opening with stainless steel mesh so that any dropped tools or parts will not disappear under the floor. This tends to apply to industrial sites, including common applications such as city water intake reservoir facilities for control valves and instrumentation power, and power for large hydro schemes at the intake. This precaution is not required at domestic sites where the turbines are typically mounted outside.

A mesh (or exhaust pipe) over the exhaust water opening will prevent access into the rotating parts from underneath, thus preventing serious damage to the fingers of inquisitive children. It is important that the installer makes the site safe and that no rotational or electrical hazards exist.

Flushing and bleeding your supply pipe (penstock)

When first installed, the pipe is quite likely to have collected small stones and other debris. If possible you should turn water through the pipe unobstructed (no jets in place) with a high flow rate for one hour or so, to flush out anything that might later come down and block the jets.

In some cases you can also flush trapped air pockets out of the pipe in this way. Often there is not enough flow available, or the pipe gradient is uneven so the air cannot be flushed downward. It is important to vent any high spots in the pipe to remove all of the air before commissioning the turbine. Air pockets cause significant loss of head and power output.



See our document Site assessment guide for more information.

It's very important to clear all the air out of the penstock before commissioning tests. You need to test the open circuit voltage with the maximum pressure. Often the air takes a day or so to escape (upward or downward), and the pressure (and hence the Voc too) after this process is completed will be higher.

2.3. Commissioning procedures

2.3.1. Electrical checks with covers off - before install.

These tests ensure you have completed the output connections and have no unwanted connections through wiring faults to the PowerSpout chassis. It may be easier to perform these checks before taking the turbine on site.

1. Connect a DC voltmeter to the DC output from the generator. Take great care to prevent any contact with bare wires that may be at lethal voltages. Voltage rises in proportion to RPM.
2. Use an electric drill with a 19 mm (3/4”) socket to spin the shaft by slowly driving the M12 bolt that fixes the wet side rotor into position. Never drive the PMA using the plastic rotor extraction knob, as you will damage the PMA.
3. Watch the voltmeter and increase the drill speed until the voltmeter reads close to your desired operating voltage.
4. The turbine should spin freely with little noise. A slight hum is normal. The shaft will slow and stop after about 3 seconds freewheeling.
5. Connect an ammeter (use a 10 A DC range) between the chassis ground connection and negative output and spin the turbine to near the same speed as in step 3 above.
6. The turbine should spin freely with little noise and the ammeter must read zero.
7. Repeat steps 5 and 6 above but with the ammeter between the chassis ground connection and positive output.

A short circuit in the wiring will cause an internal current that "brakes" the turbine (makes it harder to turn) and so these tests will reveal wiring faults. If any of these tests show mechanical or electrical problems, then remedy these before installing on site.

2.3.2. Turbine RPM and voltage

The rotational speed (RPM) of the turbine depends on the pressure of the water and on whether the turbine is correctly loaded on the electrical side of things. The water is like the accelerator/gas pedal and the electrical output is like the brake. If you open the valves when the wires are disconnected (open circuit) then the turbine will run away at nearly twice the best operating RPM.

If site head is above 60 metres then do not intentionally run the turbine unloaded except for tests. In a turbine runaway situation turn off the water supply by closing the water supply valve(s).

Head range	Operating rpm	Runaway rpm	Comment
0-25 m	0-800 rpm	0-1600 rpm	Can be allowed to run unloaded without excessive wear or noise.
25 - 60 m	800 - 1250	1600-2500	Safe to run unloaded but will reduce life of parts.
60 - 130 m	1250 - 1900	2500 - 3800	Do not run unloaded, apart from testing Voc.
above 130 m	above 1900	above 3800	Consult with PowerSpout.

Open circuit voltage (Voc) in the wiring will approach three times the normal operating voltage when the turbine is running away like this. So if your turbine is designed to work at

80V for example, the open circuit voltage may exceed 200V. This may be hazardous to personnel and equipment.

Do not operate the turbine connected to any MPPT controller or Grid-tie inverter without first checking and adjusting the open circuit voltage (Voc) as described below! If the voltage is too high then your controller or inverter will be destroyed and there is no warranty for this.

2.3.3. Commissioning the turbine

- Mount the turbine on suitable base with a drain hole in the floor under the dry side.
- The pipe should be attached, supported (if flexible or as required), secured, and purged of air.
- There must be a pressure gauge mounted on the pipework upstream of the control valves.

Ensure the above electrical checks (Section 2.3.1) have been carried out before field commissioning.

It is important to formally commission the turbine and associated system to ensure it is working correctly prior to leaving the site. It may take time to test everything because the pipe may need to be purged of air and the battery may need charging before the diversion loads can be verified as working.

Take photos and take notes of pressures, voltages etc. It is a condition of the warranty that you document this process and send the information by email to your dealer.

2.3.4. Commissioning (models PLT14, 28 or 56) connected directly to battery

Take a photo of the turbine identification plate for your records. Verify that the water pressure is as stated on the plate. If the water pressure is much lower then you should find and fix the cause, because otherwise you will need a different stator supplied.

Connect the power cable to the battery bank. Never connect your turbine to the system electronics without first connecting the battery or your electronics will be damaged by over-voltage.

You may now open the turbine valves slowly until completely open.

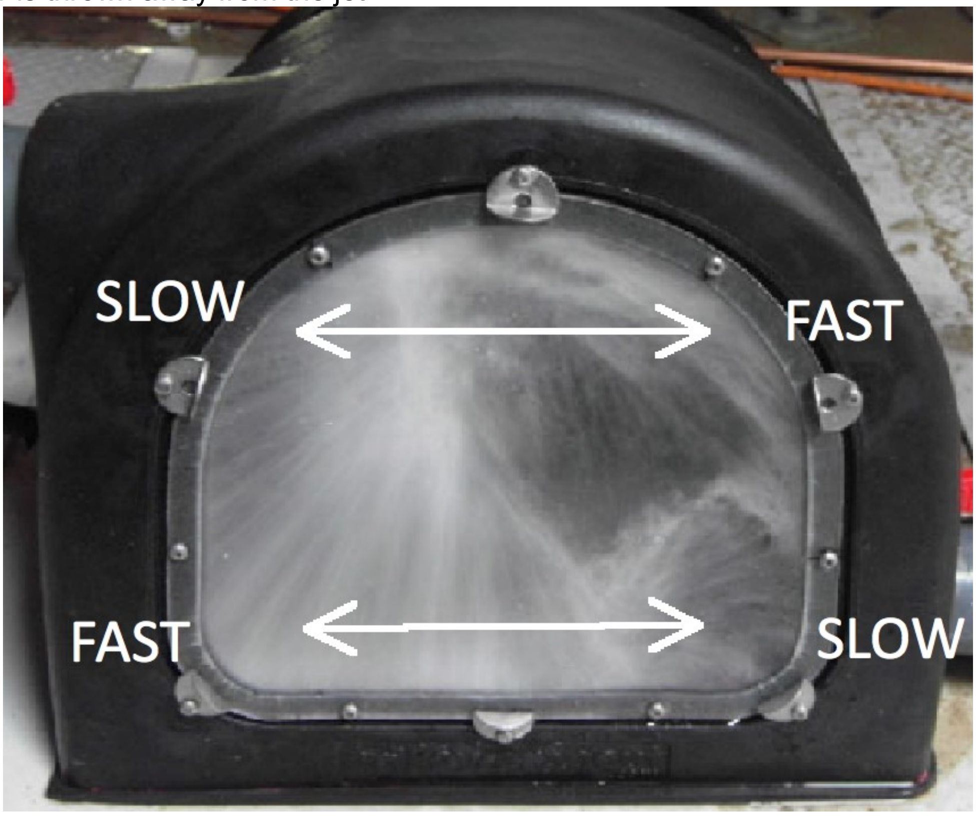
If you have not yet greased the turbine, do this now with turbine running and the magnet rotor off so that you can check for grease emerging. See section 2.1.10 for details.

When the valves are fully open, check and record the operating water pressure and the output current. If using flexible manifold pipes then adjust the pipe supports to fine-tune the jet alignment (to maximise the speed/power). Normally the output will equal or slightly exceed the value on the identification plate. But you may need to optimise the RPM first.

Check that the intake has surplus overflow water. If there is not enough water then the pressure will fall as air enters the pipe. In that case you may need to close some valve(s) or fit smaller jets before you can operate continuously.

Optimising the turbine RPM

Check the appearance of the spray pattern striking the clear plastic glazing to see if the water coming off the pelton runner is thrown to left or right. This will tell you whether the RPM is too slow or too fast. The photo below shows the direction the spray will be thrown for each case. To slow is where the water is thrown back toward the jet. Too fast is where the water is thrown away from the jet.



Turbine speed will vary with battery voltage and output wattage. Tests should be done under typical conditions.

Adjustment of turbine RPM using packing washers behind the magnet rotor
This is a trial-and-error process, but the spray pattern observations above will help you to make the correct adjustments. Moving the magnet rotor outward, away from the stator will increase RPM (if it is too slow) whereas moving it further onto the stator will reduce RPM.



Start by grasping the extractor knob and turning it anticlockwise relative to the magnet rotor. Keep a note of the number of turns. Optimisation is a trial and error process whereby you run the turbine, check the output current, stop the turbine, adjust the knob on the magnet rotor, run and test again. Once you have found the best position for the rotor you can pack behind it with washers to lock it gently in that position. Do not over-tighten the plastic nut. Each washer (supplied) is 1.75 mm thick, and each turn of the knob is 1.6mm. The red washer (if supplied) is fitted first.

Optimum magnet rotor position will vary slightly with changing pressure (smaller jets used for lower flows will increase the pressure by reducing losses) and also with changing battery voltage. You may need more washers at lower flows, or lower battery voltage. Optimisation can be repeated when flow conditions change markedly (differing jet sizes used) so you can decide what compromise to make with the packing and what penalty you will pay for not changing it. The extent of the impact will depend on whether your percentage pressure losses are large at maximum flow/power. Remove one washer for a 10% drop in pressure.

Take note of the number of magnetic rotor packing washers required for a particular jet size and when running on one or two jets. In some cases you may wish to change the packers with the corresponding jet sizes as your river flow changes with the seasons. Hang the jets and packing washers on nails in your power shed for wet, normal and dry period flows.

2.3.5. Commissioning (models PLT40, 80 or 200) connected to MPPT or GTI

Install an earth connection on the exposed metal bulkhead. A labelled earth connection point is provided - protective class 1. Do not connect a DC pole to earth at the turbine - unless local rules require it.

Provide a clearly labelled, DC rated, disconnection device at the turbine. A 2-pole DC breaker is best, but “MC4” type waterproof connectors may be used provided they are never opened under load.

All wiring must be enclosed for safety so that it is inaccessible to touch.

An EMC filter must be fitted in all grid-connected installations.

Do not operate the turbine connected to any MPPT controller or Grid-tie inverter without first checking and adjusting the open circuit voltage (Voc) as described below! If the voltage is too high then your controller or inverter will be destroyed and there is no warranty for this.

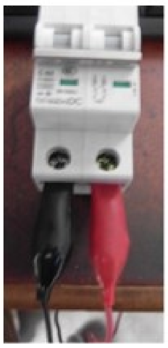
Take a photo of the turbine identification plate for your records. Verify that the water pressure is as stated on the plate. If the water pressure is much different then you should find and fix the cause, because otherwise you will need a different stator supplied.

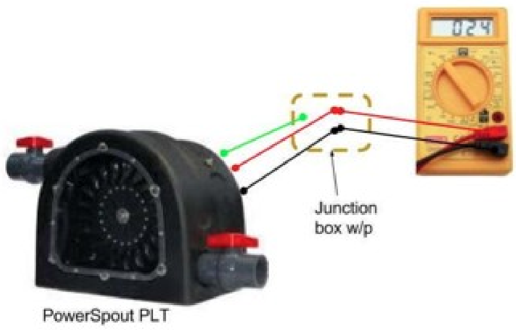
If using flexible manifold pipes then adjust the pipe supports to fine-tune the jet alignment (to maximise the speed). Apply downwards, upwards and sideways pressure to the jet to alter the angle slightly and see what effect this has on output. The jet position can be moved slightly within the casing. Once optimized, secure and support the pipe.

Check that the intake has surplus overflow water. If there is not enough water then the pressure will fall slowly as air enters the pipe. In that case you may need to close some valve(s) or fit smaller jets before you can operate continuously.

Checking the open circuit voltage (Voc)

You must check the Voc prior to connecting your MPPT or GTI, because excessive voltage will damage connected equipment. Connect the output wiring to a multimeter (on its highest DCV range). Do not connect any other equipment or wiring at this stage. Take great care that no person is exposed to lethal voltages. Perhaps you can insert the probes of a multimeter into your turbine circuit breaker in place of the transmission cable.





You may now open the turbine valves slowly until completely open.

Observe and record the maximum open circuit voltage.

Confirm that measured Voc is at least 10V below 90% of the safe limit for your MPPT controller or GT inverter. (This allows a margin for ripple in the voltage.)

The Midnite Classic and Kid have a "hyperVoc" feature that makes them less vulnerable, but other devices **will be damaged** if the peak turbine voltage exceeds their Voc limit.

If the Voc is too high then you must pack the magnetic rotor with washers to reduce the voltage as follows:

Packing the rotor (only if required):
Remove the back cover and magnetic rotor (holding central knob while turning the magnetic rotor clockwise). Add washers and refit the magnetic rotor. Use trial and error. Each packing washer is 1.75mm thick and it will reduce the voltage by about 5-10%. If you have been supplied with a red painted washer then put this on first. It will fit over the protruding thread at the base of the spline. Never over-tighten the rotor knob. Keep a written record of the washers used, and the voltage measured.



Pre-charge the bearing block with grease: Remove the back cover and magnetic rotor (holding central knob while turning the magnetic rotor clockwise). Open the valves and run the turbine while greasing for the first time. Pump grease until you just see it emerging from the bearing dust seal. See section 2.1.10 for details.

Check all connections are tight, the condensation hole is in the base of the turbine is clear, the bulkhead is earthed, wiring is well clear of rotor, and then fit magnetic rotor (with the extractor knob inserted first). The knob should be finger tight only. Run the turbine slowly and check for unexpected noises.

Having made sure that the Voc will do no damage, close the circuit breaker to connect your MPPT or GTI with the turbine running. You should soon hear the turbine slow down as it comes on load.

Verify that your controller/inverter tracks to the expected voltage and power. (This test may not work if the battery is already charged. If there is no diversion load in operation, use up some power by discharging the battery by turning on a large load. The MPPT display should read “Bulk”. If it reads “Float or “Absorb” then the turbine is not running under full load.)

For grid tied systems, inform the local Distribution Network Owner (DNO) within the time allowed.

Manual adjustment of MPPT settings to optimise turbine speed
Some MPPT controllers allow you to manually set their input voltage settings. If the controller is unable to automatically track the correct operating point this can be useful. Adjust MPPT set point (turbine voltage) from highest to lowest voltage and note power output at each setting. Then select best power result.

Some MPPT controllers can take minutes to locate the maximum PowerPoint, and certain models will sometimes go to sleep and not wake up. If this happens restart the MPPT controller (by removing all power from the unit or by selecting the restart option in the display menu), and on seeing a turbine voltage above the battery voltage it should wake up and track until it locates the maximum power point.

Here are examples of what you might see. In this example both MPPT units were connected to a PLT80 running at maximum output.

FM60 locating 1.6kW MPPT from a PLT80

MC250 tracking 1.23 kW MPPT from a PLT80

FM60 tends to track down from the Voc and MC250 (in hydro mode) tends to track up from the battery voltage. Once it gets to about 80 VDC input it will also have 1.6kW on the display.
For more detailed information on the set up of MPPT controllers see the pdf guides in the document index.
Here are links to some of these guides:
Outback FM60/FM80, Midnite Classic150/200/250, Midnite KID, Morningstar, Tracer, Studer, Schneider and Fangpusun

2.3.6. All turbine models - final commissioning checks

Check there is no water leaking from the drain hole in the rear bearing block. You can use a small mirror and light to see this. If you see a leak after reassembling the turbine, make sure you have installed the top cap seal correctly.

If operating above 1000 Watts in hot climates you must check the generator running temperature. If it is too hot to touch, then more ventilation is required.

Once the full output has been obtained, check that the circuit breakers ratings are 25% over the working current(s) in their circuits.

Check that battery charge controls are working correctly and any diversion loads are operating as expected.

Take photos and record operating voltages, currents and water pressures etc. for all configurations of jets turned on or off. Email this to your dealer. (This is a warranty requirement.) If you are getting less power than expected then see the trouble shooting section 2.4.8 for hints.

When turbine testing and commissioning is completed and documented, ensure that all protective fairing/enclosures are in position prior to client hand over.

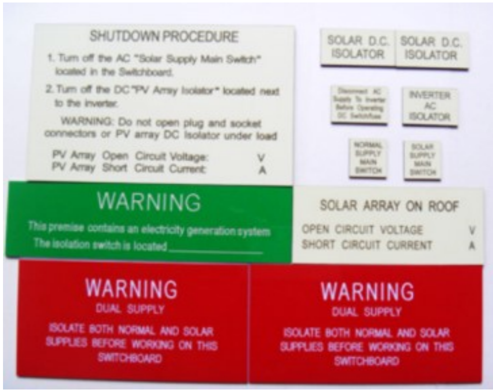
Comply with signage requirements as listed in relevant national standards.

2.3.7. Labeling requirements

Local codes and standards list many labels and notices that must be installed on these systems. Consult these documents and your local installer to make sure you comply.

Generally labels cover the following:

- Breakers should be clearly labelled and state what it is they do.
- DC wire should be clearly labelled to avoid confusion with AC wires.
- Emergency shutdown procedure should be clearly stated, markers on your property may be required to direct emergency services.
- Normal start up and shut down procedures should be clearly stated. System manual should be supplied.



Durable label kits for on-grid and off-grid solar PV systems are available for purchase that comply with relevant standards from your local renewable energy installer. Hydro systems should have similar labels.

Shutdown procedure notice

Your version of this should be displayed at the main switchboard, at the distribution board, and adjacent to equipment to be operated (e.g. battery overcurrent protection). The example below is to illustrate the general idea:

SHUTDOWN PROCEDURE

If possible:
You should stop the hydro turbine by closing the valves (slowly),
and switch the inverter off
prior to shutting down the DC electrical system.

1. Turn off the turbine circuit breaker.

2. Turn off all the battery circuit breakers.

3. Pull out the main battery fuse-holder to isolate the battery.

To start up, follow the above procedure in reverse.

2.3.8. Installation details

We recommend you take note of and let us know the final system details (as below) for future reference and to help with ordering replacements or upgrading the system.

This information and a picture of the final installation are required for all warranties greater than 12 months.

Installation details	Serial number ________________________
Date installed	
Location of installation	
Pipe inside diameter	m or inch
Pipe length	m or ft
Jet size	mm or inch
Static pressure on gauge (turbine off)	kPa or PSI
Dynamic pressure on gauge (turbine running)	kPa or PSI
System nominal voltage	V
Cable length	m or ft
Cable wire size	mm^2/conductor
Generator name (e.g. 100-14S-1P delta)	100/80/60/60dc - ____S-____P delta/star
Performance data	
Flow rate of water through turbine	l/s or gal/min
Voltage on DC rectifier pins at hydro	V
Voltage at battery terminals	V
Current generated	A

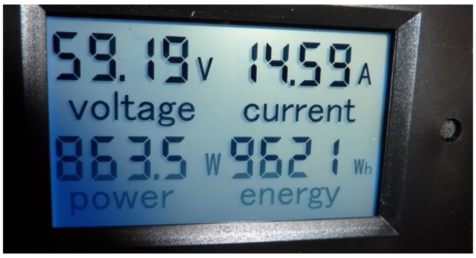
We would also like you to let us know your performance data so that we can determine conversion efficiency at your site. This helps us refine our calculations for future clients. As every site is different, efficiency will vary from site to site.


Good PLT installs

2.4. Turbine operation

2.4.1. Monitoring

The user will need to monitor the turbine power output and the pressure gauge to check that there is sufficient flow.



Often the MPPT controller will have a suitable display of output power/watts, but if not there are low cost products to be found on eBay with very acceptable accuracy.

A meter enables you to see any change in the output power, which could indicate a problem that needs your attention, such as:

- Blocked intake screen or
- Reducing river flow requiring smaller jets to be fitted.

You may notice a gradual decline in output power that may be due to sediment and organic growths in the pipeline. This may need to be cleaned out using a pipe pig or by flushing the pipe with high velocity water.

As the voltage of most systems is relatively constant, the output Watts is roughly determined by multiplying the system voltage and the generation amps. Annual output can be calculated as follows.

kWh/year = generation Watts x 24 x 365

For example a 500 W (0.5 kW) hydro will generate 4380 kWh/year

2.4.2. Intake cleaning

The intake filter will typically need to be checked and cleaned quite frequently at certain times of year. A low pressure reading normally means that there is air in the pipe due to insufficient flow or a blockage at the intake filter. If pressure is high but output is low then there may be a blockage in a jet due to debris coming down the pipe.

2.4.3. Operation of control valves

Control valves should be fully open or fully closed.

Operate them slowly. Abruptly closing a valve will cause a pressure surge that may rupture a pipe fitting.

Do not operate the turbine with any valve part-way closed. To control the flow you close the valve fully. You can then fit a smaller size jet if there is insufficient flow.

The flow of water through the PLT or TRG turbines depends on the head of pressure and on the size and number of jets that direct the water onto the Pelton or turgo runner. If there is not enough water entering the supply pipe at the intake to keep this flow supplied then air will enter and the pipe will gradually empty. This reduces the head and consequently the flow in the jets is reduced until an equilibrium is found. However this will not produce the best power output, due to reduced head. If the power output is observed to decline then the **user should intervene** and adjust the turbine jets to match the new flow. Closing one of the turbine's valves may be enough to reduce the demand enough that the penstock refills and full pressure is restored. Power output will be less than full power but at least with a full pipe the best use is being made of the available water.

The user should check the pressure gauge and make sure that the pipe is always full by choice of the number and size of jets in use. If the pressure is low then it may be a good idea to close all the valves and wait until the pipe refills before opening a reduced number of jets or changing to smaller jets to match the prevailing flow conditions.

On a good site this adjustment may rarely if ever be needed as there will always be sufficient flow of water to produce full power. But where necessary the PowerSpout can make good use of partial flows provided that the jets are adjusted to suit.

Experience over the year will tell you what to expect, as every site is different. Sometimes a good regime is to have jets of differing sizes. You can use the small, the large or both, giving three flow options. Asymmetric loading may affect bearing life, but this has not been found to be a serious issue.

2.4.4. Optimisation of jet size

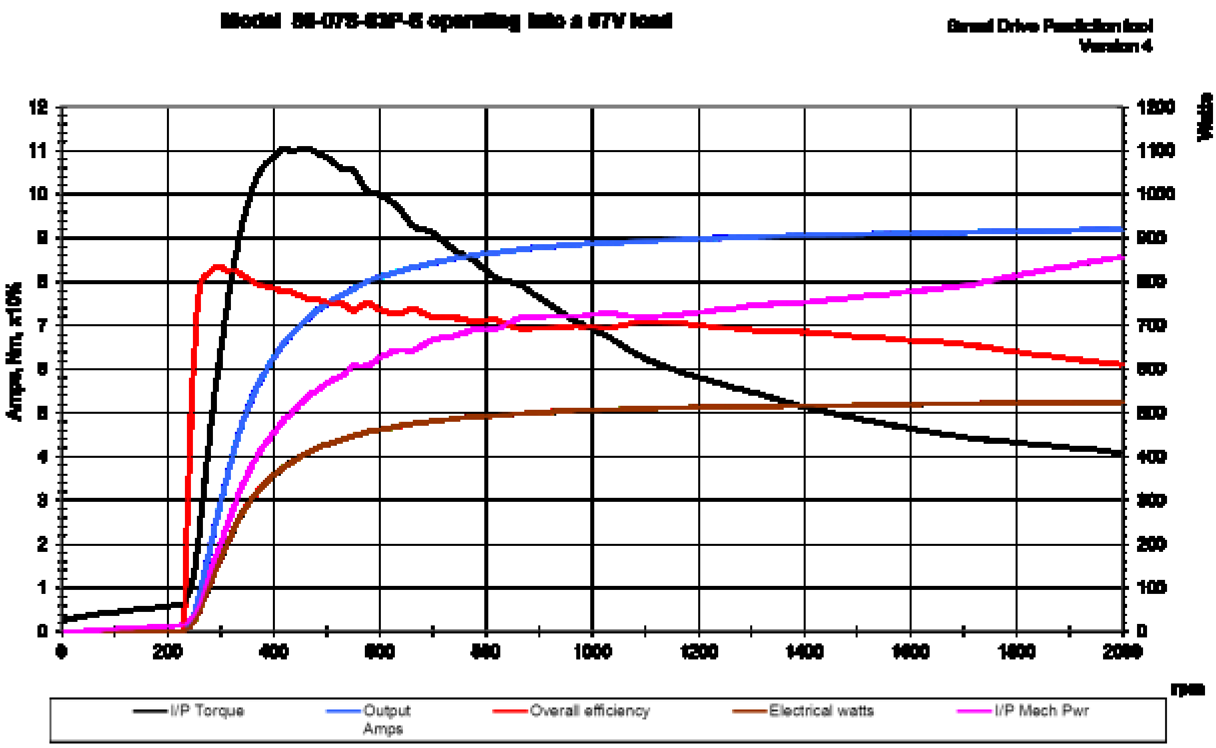
Where there is ample flow of water you may be able to increase the power output from your turbine using larger jet sizes. There comes a point when the increase in flow rate causes a dramatic drop off in pressure due to increased pipe friction losses. The maximum potential output from a given pipe occurs when the pressure in the pipe (just prior to the jet) drops to 2/3 of the static pressure (pressure when valve closed). When this point is reached, increasing the jet size further will actually reduce the power output but consume even more water. When using the online calculator you will find that you cannot increase flow beyond this point where the pipe is 66% efficient.

Note that your stator has been designed to work at the specified head of pressure and your chosen cable voltage. If you "max out" the pipe to 2/3 pressure when using a stator that is designed to work at 90% of pressure then it may not be able to deliver the desired voltage. It's important to tell us that you plan to do this in advance and we can supply a stator that will work at such a low net head. You will then need to pack it with washers to deliver the correct voltage at lower flow rates (and higher net head).

If your turbine has been designed to use the maximum flow for the pipe then the jet sizes required will have been calculated based on the head, pipe size and flow indicated. Some fine-tuning on-site will still be required.

When operating your Smart Drive generator near the maximum power level for the rpm it is operating at, you will notice that a little more or less Smart Drive rotor packing does not make a significant difference. A 10% reduction in rotor magnetism results in approximately a 10% drop in Smart Drive generator input torque which results in an approximately 5% rise in Pelton wheel rpm which results in a 5% increase in Smart Drive torque. The two 5% rises will be almost as much as the 10% reduction in rotor magnetisation.

This is best illustrated in the Smart Drive test graph (see next page). A 10% reduction in the rotor magnetism to the stator reduces the power line’s height by 10% and the amps / volts lines by 5% approximately.



Simplified Smart Drive test graph

This example assumes that calculations for your site data predicted that you could get 530 W at 1000 rpm (brown line) and 70% generator efficiency (red line) on a fully charged 48 V DC bank at 56 V DC.

At maximum power, increasing or decreasing the rpm of the Smart Drive by packing will make little difference to the output power it can produce, as the gradient of the brown line is shallow.

In summer when a smaller jet is used and generation potential falls to only 200 W, the turbine operates at close to the static pressure of the pipeline and the power curve has a steep gradient. The speed of the turbine will be slow due to an oversized generator combined with poor Pelton runner efficiency (because it is not running at the optimum speed). Packing the magnetic rotor out a small amount will have a dramatic effect. This rotor packing flattens and moves to the right of the brown power line and the red efficiency line; this allows the Pelton rotor to pick up speed and become more efficient at extracting power from the water jet, increasing the rpm even more.

Your PowerSpout will have been shipped with a Smart Drive generator optimised for maximum efficiency at your maximum power level expected. This has the result of reducing the requirement to pack the rotor. However, if you are using your PowerSpout PLT over a wide range of flow rates some rotor packing will be needed. As low flow often coincides with very sunny weather, solar PV can normally make up any shortfall in hydropower during dry periods.

2.4.5. Thermal Checks

A PowerSpout has an enclosed generator. The inside stator core temperature of the generator will depend on:

- Output power of the turbine
- Revolutions (speed) of turbine – higher rpm has more cooling
- Ambient air temperature
- Water temperature
- Voltage of operation (12V turbines have high currents in the rectifier, so it gets hotter)

More cooling may be required for turbines with high outputs (over 1000W) in warmer climates. The ideal stator core temperature should be in the range 40-60°C after 2-3 hours of operation.

The generator core is cooled by air flow across the stator. The warmed air then transfers this heat through the aluminium bulkhead into the exhaust water of the hydro turbine. The air temperature inside the housing is typically 30-40 degrees Celsius. This warm environment ensures a near constant temperature of the Smart Drive bearings thus reducing moisture ingress due to condensation that is common in the damp environments in which hydro turbines are often installed.

Make sure your thermal checks are done on the hottest day of the year. We have seen some industrial applications where the air and water temperatures have exceeded 40°C, resulting in the generator running too hot.

2 x side air vents and 1 x rear lid air vent – Keep them clean.

EcoInnovation will have fitted 3 air vents as shown. If your turbine is running too hot (hot climate, high output and 12 V operation) then even more cooling may be required. Contact EcoInnovation and we will send out extra vents that you can easily install with a hole-saw.

In such cases the person responsible for installing and commissioning the turbine needs to do a thermal check by removing the rotor and testing the stator temperature. If it is too hot to touch then it is above 60C. This needs to be repeated at the hottest time of the year.

At our test site in NZ, the temperature inside the bottom of a PowerSpout PLT (operating at 1.6kW on a 130m running head) reached 36°C. Due to a farm animal breaking the water pipe, the unit was left not operating. The following data was inadvertently collected by a data logger inside the turbine:

Case temperatures rose up to 39°C caused by sunlight heating. Ambient air temperatures were around 25°C. Relative humidity was around 40% during operation and increased to 95% when not operating.

This observation is interesting and shows that a turbine should not be turned off for extended periods of time. If your turbine is only used for winter generation, then the turbine should be greased and removed to a dry indoor storage area with the back rear cover left off while in storage. See section 2.1.10 for details of how to grease the turbine.

2.4.6. Maintenance

The PowerSpout is a durable machine but it runs 24/7 so regular checks and maintenance are advised. A PowerSpout may do more revolutions in one year than a car engine during the life of the car. A car engine has a filtered and pumped oil lubrication system, whereas a small hydro turbine does not. You must pay special attention to the bearings. See section 2.1.10 and our Bearing care guide for details of how to grease them.

To maintain your hydro scheme in a good condition for years to come we recommend you keep a log book and regularly (every week initially, and once you become familiar with your system every 2 weeks) do the following:

- Check the specific gravity of your batteries with a hydrometer and reduce your power usage if battery charge is falling.
- Check the acid level in your batteries and top up with distilled water as required.
- Check PowerSpout air vents are clean
- Check hydro output is normal and has not changed since last checked.
- Check your diversion load is working (if fitted)
- Check you have surplus water at the intake. If not, reduce your jet sizes.
- Check there are no obstructions (twigs and stones) that have got in your pipe and are partially blocking the jets.
- Walk the pipe line each year and check for any damage to the pipe.
- Once a year check termination points on your battery, controller, inverter, fuses and diversion load. Clean and tighten as required. If you observe any heat damage or corrosion at terminations attend to these and repair. Remember to turn off all generation, your inverter and remove battery fuses before cleaning/tightening any termination points. You should pay special attention to your diversion load and battery terminals.

We also suggest you be wary of complacency. Since these systems work and give free power, people tend to keep adding more and more loads until they reach the limit of the system. Hence we recommend you:

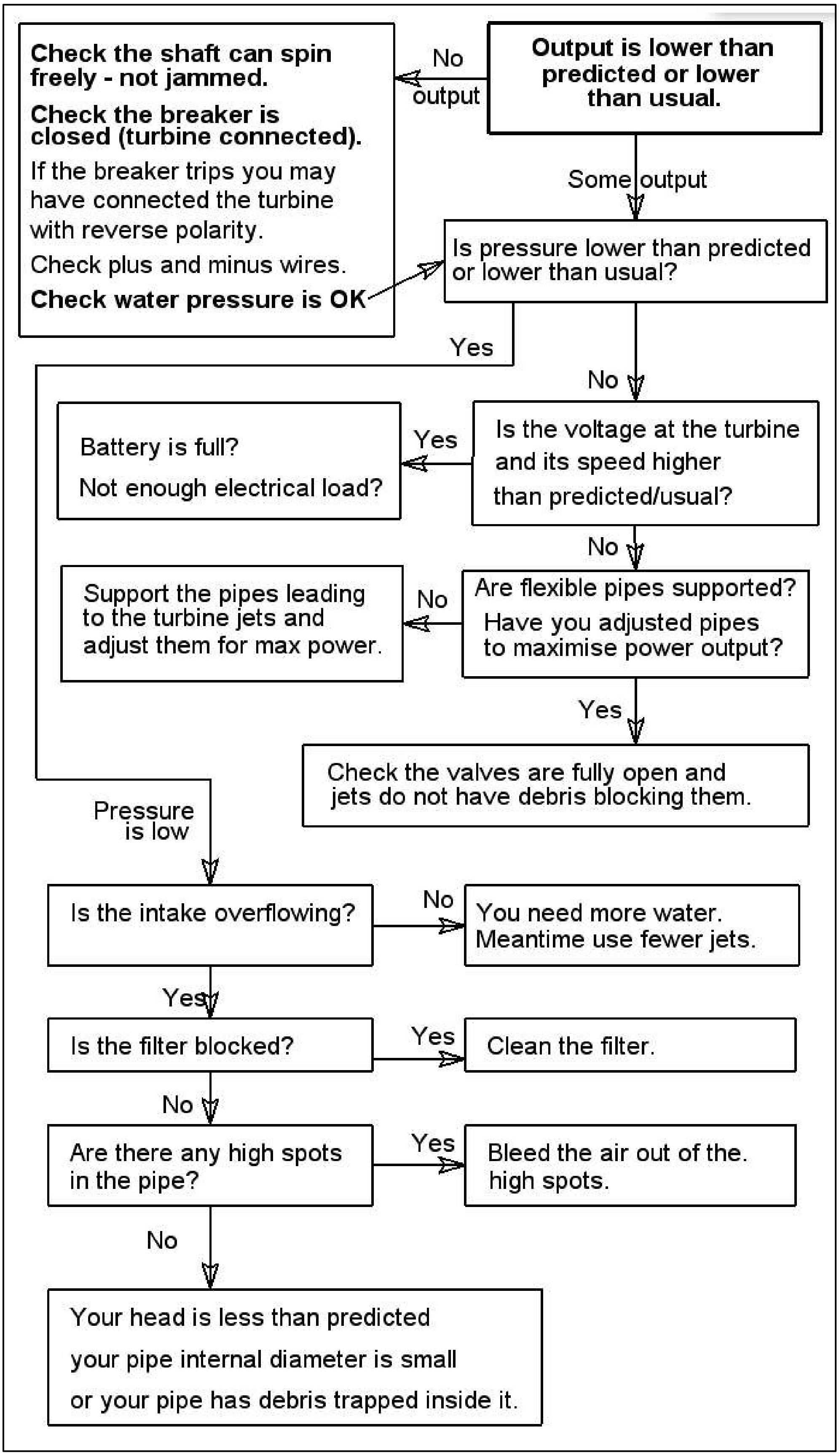
- Fit a remote power meter to your inverter that will alert you if you exceed your peak load and advise you how many kWhrs you are using each day.
- Tell your guests about living off the grid and that they cannot plug in large resistive heaters, as these can knock years off your battery life and overload your inverter system.

Power meter

2.4.7. Spare parts

If you live in a remote part of the world you should consider having a full spare parts kit on the shelf. This will mean that whatever the problem you can get your system going again quickly. At the very least you should hold spare bearings; parts from NZ can take up to 10 working days to arrive to some global destinations.

2.4.8. Troubleshooting



For assistance with your system please contact your equipment installer or provider.

2.4.9. Making the most of your pressure gauge

Your pressure gauge is essential in locating possible problems. In most cases they are pretty accurate. To allow for changes in temperature you should equalise the case pressure by pushing the rubber bung aside with a thumbnail to allow air in or out. If the bung is at the top of the gauge then you can snip off the nipple in the bung to allow it to breathe all the time. If your pressure reading is inexplicable then you should try a new gauge for comparison, as no gauge is infallible.

Check the static pressure with valves closed. If this is less than the predicted value for the site then either the surveyed head (height difference) is incorrect, or there is air in the pipe. Check also for significant leaks that might cause head loss due to their flow in the pipe. Check that the pipe is full. (Overflow is visible at the intake; filter unobstructed, any high spots in the pipe are clear of air pockets).

If the static pressure is higher than predicted then you need to be prepared for higher power than expected or you need to reduce the size of your jets. The turbine will be running a bit faster so there will be more voltage and you may need to add washers behind the magnet rotor to compensate for this higher rpm and obtain the ideal output voltage.

Check the dynamic pressure with valve(s) open and compare with static pressure to obtain pipe "efficiency". This should match your calculated efficiency.

If dynamic pressure is higher than expected whereas power (Watts) is low then you probably have blocked jet(s). If dynamic pressure is lower then check for air in the pipe or leaks. Another reason for lower dynamic pressure (inefficient pipe) is using too small internal diameter. Check that the diameter inside the pipe matches the design calculation.

2.4.10. Turbine case flooding

On low head hydro sites, turbines are more exposed to flooding risk. PLT turbines (up to 120 VDC) can handle submersion on rare occasions.

Immediately following a submersion of the turbine you must:

- Remove the magnetic rotor and clean off any magnetic grit carried by the water.
- Regrease the bearings and run the turbine so that internal generator heat will dry it out.
- Clean out any excess grease from the front of the bearing block and top hat drain hole as this can block with grease preventing water from draining away.

Damage caused by water submersion is not covered under warranty.

3. Reference section

3.1. Examples of good/bad hydro system installations

Taking care in planning and installation, completing all commissioning tests, and observing and documenting correct operation are all the responsibility of the installer. Pictures of various installs follow, in the hope that these assist you in doing a quality job.

3.1.1. Good installations

This turbine install includes:

- Pressure gauge
- Good solid mounting platform
- Good water exhaust system
- Clean and tidy install
- Good all round access for servicing

Note the following in this Outback prewired inverter system:

- Dry and insect/pest free install location
- Clean and tidy
- Smoke alarm
- Dry powder fire extinguisher
- Meter for permanent record of kWh AC supplied
- DC hydro off breaker (left white box)
- Clear labels

Features of this 48 V DC battery room include:

- Well vented, clean and tidy, lockable
- Battery retention strap (earthquake restraint)
- Distilled battery top up water on hand
- Dry powder fire extinguisher
- Emergency eye wash
- Tool box with goggles, gloves and apron
- Smoke alarm
- All battery terminals covered to prevent corrosion and drop hazards
- Safety emergency signs and log book
- Main DC disconnection point and fuse

In this grid tied system note the:

- Tidy installation
- Installer identification label
- Clear labels

6.4kW from 4 x PLT200's (running at 171 VDC) feeding into 2 x 4kW EnaSolar inverters

Features of this PLT install:

- Earthing of all metal parts
- Clearly labelled
- Good solid mounting platform
- Good water exhaust system
- Clean and tidy install
- Good all round access for servicing

3.1.2. Poor quality hydro systems

With a little more effort the installs below could have been made tidy, safe and compliant with wiring codes and recommended install procedures. Your system should be an asset not a liability.

Poor aspects of this hydro install include:

- Turbine is not securely attached
- Main support (old chair) will rust out and the structure will collapse
- Wire path is not clear
- Site is not safe for access and service work

Issues with this inverter/controller install include:

- Untidy install; it might work but is hard for outside help to assist you.
- Almost certainly does not comply with the local wiring rules

Poor features in this battery install include:

- Untidy install
- Different battery types combined
- Unprotected terminals
- Not a secure site - children can get access
- Inverter mounted by batteries is a source of ignition
- Almost certainly does not comply with the local wiring rules

3.1.3. Hydro installations with room for improvement

This example has a few issues that could have been avoided:

- The turbine is difficult to access for servicing
- With the door closed, the humidity in this plastic enclosure can get very high. If you do this ensure good ventilation to outside air.
- Plastic PVC pipe work could be tidier with fewer bends

This example shows the turbine and inverter enclosed in same structure. If you do this you should ensure:

- Ease of removal for servicing
- Good ventilation to limit humidity

Do not confuse AC and DC wiring runs when you order your turbine.

On this site we were advised of a long cable DC run, but it was installed on a long AC cable into the grid.

DC lines can have losses from 0-10% and higher in some cases. AC cables need to be run with much less loss or the inverter may trip, causing a nuisance. Always follow recommended wiring sizes in your inverter installation manual for grid connected inverters.

3.1.4. Poor quality turbine install, maintenance and servicing

With a little more care and more careful attention to the detail in this manual your turbine will last much longer between service intervals.

The pictures opposite show water stains caused by not installing the O-ring seals on the case/valve and then leaving the joints to leak.

Such leaks can result in water spray/mist that is then drawn into the casing via the cooling system. This may result in moisture ingress into the bearings and cause a premature bearing failure.

This turbine had been returned to our factory for service, but it was clear the turbine had not been installed correctly from new.

Examination of the bearings showed that that bearing block had been greased, but not with sufficient quantity to reach the bearings.

The best ways to make sure you have put in sufficient initial grease charge is to remove the magnetic rotor and ensure that grease has exited through dust shields. See section 2.1.10 for details.

This turbine was sold in April 2011 and returned for service in April 2013, so had run for 2 years.
Failure was a due to a seized bearing that could have easily been avoided if:

- Auto grease canisters had been fitted after a manual charge
- Correct manual greasing had been undertaken
- Prevention of water mist due to missing O-ring seals

A picture of the bearings journals cut open shows that dry bearings combined with insufficient lubrication and a moisture rich condensation environment has resulted in the early on-set of corrosion. This bearing would have been noisy in operation indicating there is a problem that needs attention.

3.2. Units and conversions

- An **ampere** (amp, A) is the unit of measurement of electric current produced in a circuit by 1 volt acting through a resistance of 1 ohm.
- A **current** is a flow of electrons in an electrical conductor. The strength or rate of movement of the electricity is measured in amperes.
- An **ohm** is the unit of measurement of electrical resistance. It is the resistance of a circuit in which a potential difference of 1 volt produces a current of 1 ampere.
- A **Watt** is the electrical unit of power: that is, the rate of energy transfer equivalent to 1 ampere flowing under a pressure of 1 volt at unit power factor.
- A **Watthour** (Wh) is an electric energy unit of measure equal to 1 Watt of power supplied to (or taken from) an electric circuit steadily for 1 hour.

Volts x Amps = Watts

To convert	**To**	**Multiply by**
centimeters	inches	0.3937
sq millimeters	sq inches	0.0015
Meters	feet	3.2808
miles per hour	feet per second	1.4667
Litres	gallons	0.2641
litres per second	gallons per minute	15.900
kilowatts	horsepower (electrical)	1.3405
degrees Celsius	degrees Fahrenheit	x 9/5 +32

To convert	**To**	**Multiply by**
Inches	centimeters	2.5400
Feet	meters	0.3048
feet per second	miles per hour	0.6819
Gallons	liters	3.7854
gallons per minute	liters per second	0.0631
horsepower (electrical)	kilowatts	0.7460
degrees Fahrenheit	degrees Celsius	-32 x 5/9

3.3. Annex III Noise measurements

Noise test at PowerSpout on PLT turbine

Test parameters:

Watts:	1000
Flow:	3,05 l/s
Pressure:	95,5 psi
Head:	600 kPa

 In front of running turbine: 93.8 dBA	 On top of running turbine: 81.7 dBA
 1m away from running turbine: 83.3 dBA	 2m away from running turbine: 81.9 dBA
 6m away from running turbine: 73.9 dBA	 12m away from running turbine: 56.7 dBA

3.4. PLT Specifications

Permanent Magnet Alternator	
Generator (PMA)	10.5 in (270mm) 3-phase Smart Drive permanent magnet generator (PMG)
Generator efficiency	> 70% and up to 80% in ideal conditions with MPPT fitted
Wattage single turbine	100 - 1200 W standard. Custom HP version 1600W and up to 2000W in certain cases
Wattage stacked (2-10 units)	0.2-12 kW standard. Custom up to 20 kW
Current rating (each)	Up to 32 amp standard, up to 50 amp surcharge applies
Running speed	200 - 2000 rpm
Watt/rpm	Up to 0.7 W/rpm standard. Up to 1.0 W/rpm high power ("HP") versions with MPPT
Materials	
Case	LDPE plastic case 6mm thick
Drive shaft	stainless steel
All fasteners and fixings	stainless steel
Recycled content	up to 68%
Pelton runner	GF30 Nylon
Runner	Pelton wheel (Impulse turbine)
Jets	1 or 2, range 2-25mm each
Pelton wheel	Number of spoons on rotor: 20 Pelton spoon width: 70 mm Length of spoon: 62 mm Maximum jet diameter: 25 mm Hub thickness: 17 mm Hub fixing hole: 12 mm Outside diameter: 290 mm Running diameter: 230-240 mm
Static head range	3 to 160m (10 – 525 feet)
Dynamic head range	3 to 130m (10 – 430 feet)
Maximum flow/turbine	8 -10 l/s (130 – 160 gpm) (at 8m head)
Minimum flow/turbine	0.05 l/s (0.8 gpm) (special reduced core Smart Drive needed)
Bearings	Front 6205-2Z OD 52mm ID 25mm, and rear 6005-2Z OD 47mm ID 25mm
Rectification	100 amp water cooled rectifier
Dimensions	470 x 400 x 430 mm (18.5 x 15.7 x 17 inches)
Weight	Net Weight 23kg. Up to 25kg packed weight.
Jets supplied	1 set cut to calculated size + 2 spare uncut set