The Stream Engine®

Owner's Manual

Please Read Carefully

The Stream Engine is a Trademark of Energy Systems & Design Ltd. | Version 2.11 3 2023

Email: sales@microhydropower.com
Website: www.microhydropower.com

Congratulations on your purchase of a new *Stream Engine*! With a proper installation and a little routine maintenance, your *Stream Engine* will provide you with years of trouble-free operation. This manual will help you to install your *Stream Engine* as well as assist you in troubleshooting and problem solving. Of course, you may contact **Energy Systems & Design Ltd**. if you run into trouble.

May your RE adventures prove successful!

PLEASE READ CAREFULLY

It is very important to keep the alternator rotor from contacting the stator (the stationary part under the rotor). If this occurs, serious damage may result.

Whenever you are operating the machine with a small air gap (distance between alternator rotor and stator) you should check the gap whenever an adjustment is made!

Do this by inserting the supplied thickness gauge which is 0.020" (0.5mm) thick in the gap when the rotor is stationary. Most business cards are 0.010" (0.25mm) thick, therefore, using two business cards or one folded in half could be used to check the air gap. Check all the way around the rotor. This is also a way to check for bearing wear on a monthly basis. If you **cannot** easily insert the gauge into the gap, either all or in part, it is necessary to adjust the rotor upward (see *Output Adjustment* in this manual). DO NOT USE steel feeler gauges as they will be attracted to the magnets.

When making air gap adjustments, make sure the larger bolt is tightened (clockwise) against the shaft and the smaller bolt is also tightened (clockwise); so as to lock both parts in place.

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INTRODUCTION

This manual describes the *Stream Engine*, which is manufactured by **Energy Systems and Design Ltd (**ES&D). The installer must have some knowledge of plumbing and electrical systems, as should the end user of the system. These machines are small, but can generate very high voltages. Even 12-volt machines can produce high voltages under certain conditions. Practice all due safety precautions. Electricity cannot be seen and can be lethal.

It is important to consult with local officials before conducting any watercourse alteration. ES&D advises following all local laws and ordinances regarding watercourses.

Electricity is produced from the potential energy in water moving from a high point to a lower one. This distance is called "head" and is measured in units of distance (feet, meters) or in units of pressure (pounds per square inch, kilo-Pascals). "Flow" is measured in units of volume (gallons per minute - gpm, or liters per second - l/s), and is the second portion of the power equation. The power available is related to the head and the flow.

The *Stream Engine* is available with three different turbine wheels or runners and two types of magnet rotors. One to four nozzles can be used with these machines.

The turgo wheel is available in plastic or stainless steel. Nozzles up to one inch (25 mm) in diameter can be used with this wheel.

For lower flows we offer our “low flow wheel” (LF) in stainless steel. This can use nozzles up to one half inch (13 mm) in diameter. This turbine wheel operates at a higher efficiency than the turgo so that increased output of 10-15% can be realized for the same flow. A machine with the low flow wheel and multiple nozzles could generate more power than a turgo machine that has one or two nozzles and the same flow.

The *Stream Engine* is also available with two types of magnet rotors. There is the standard rotor and the rotor using bigger, more powerful magnets. This is used with the *X-Stream Engine* and doubles the capacity of the machine. That is, one *X-Stream* can generate the power of two standard machines.

The *Stream Engine* uses a permanent magnet type alternator. This design eliminates the need for brushes and the maintenance that accompany them, while increasing efficiency. The *Stream Engine's* output can be optimized by simply adjusting the rotor clearance. This should be done because it will usually increase the output of the machine. This is covered in the section on Output Adjustment.

SITE EVALUATION

Certain information must be determined concerning your site, in order to use its potential for maximum output. Head and flow must first be determined. Other factors are: pipeline length, transmission distance, and the system voltage. These factors determine how much power can be expected.

Power is generated at a constant rate by the *Stream Engine* and stored in batteries as direct current (DC). Power is supplied, as needed, by the batteries, which store energy during periods of low consumption for use in periods where consumption exceeds the generation rate. Appliances can be used that operate directly from batteries, or alternating current (AC) power (at regular domestic specifications) can be supplied through an inverter, converting DC to AC power.

Sites may vary, so carefully consider flow and head when choosing yours. Remember, maximum head can be achieved by placing the *Stream Engine* at as low an elevation as possible, but going too low may cause the machine to become submerged (or washed away!).

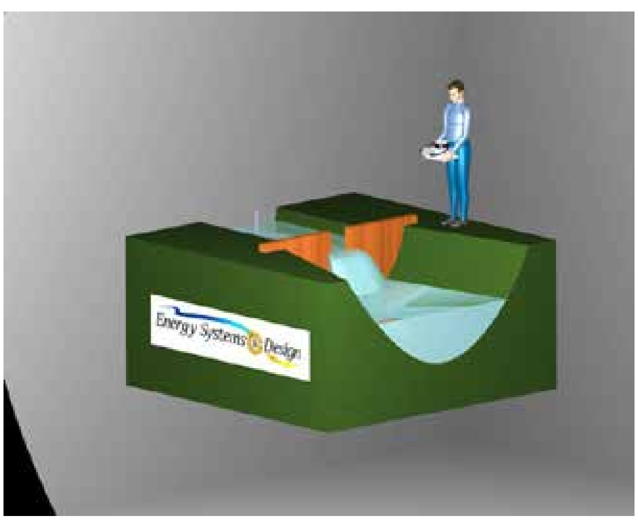
HEAD MEASUREMENT

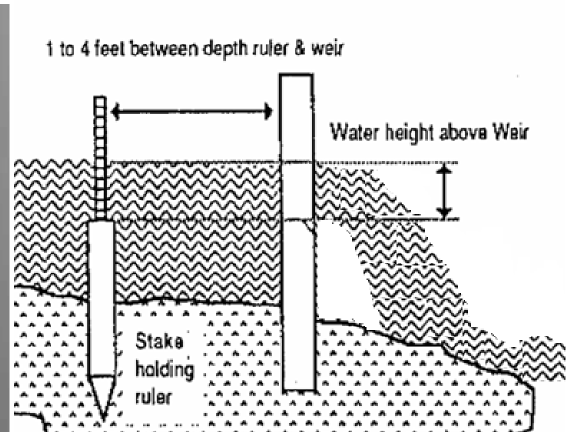
Head may be measured using various techniques. A garden hose or length of pipe can be submerged with one end upstream and the other end downstream. Anchor the upstream end with rocks or have an assistant hold it, water should flow out the low end, especially if the pipeline is pre-filled. Once water is flowing, raise the downstream end until it stops. Do this slowly since the water tends to oscillate. When the flow has stabilized, measure the distance down to the level of water in the stream with a tape measure. This will give a very accurate measurement of that stream section. Mark the spot and then repeat the procedure until the entire distance is covered.

Another technique is to use a surveyor's transit. This method can also be approximated using a carpenter's level, a measuring stick or a "story pole". This technique is also done in a series of steps to arrive at the overall head. A variation on this method is the use of a handheld altimeter. GPS equipment could also be used to measure elevation. Some hikers Apps measure distance and elevation change. Research which is best as some have a noted possible discrepancy in accuracy.

FLOW MEASUREMENT

The easiest method to measure small flows is to channel the water into a pipe using a temporary dam and to fill a container of known volume. Measuring the time to fill the container enables you to calculate the flow rate.





WEIR MEASUREMENT TABLE								
Table shows water flow in gallons/minute (gpm) that will flow over a weir one inch wide and from 1/8 to 10-7/8 inches deep.								
Inches		1/8	1/4	3/8	1/2	5/8	3/4	7/8
0	0.0	0.1	0.4	0.7	1.0	1.4	1.9	2.4
1	3.0	3.5	4.1	4.8	5.5	6.1	6.9	7.6
2	8.5	9.2	10.1	10.9	11.8	12.7	13.6	14.6
3	15.5	16.5	17.5	18.6	19.5	20.6	21.7	22.8
4	23.9	25.1	26.2	27.4	28.5	29.7	31.0	32.2
5	33.4	34.7	36.0	37.3	38.5	39.9	41.2	42.6
6	43.9	45.3	46.8	48.2	49.5	51.0	52.4	53.9
7	55.4	56.8	58.3	59.9	61.4	63.0	64.6	66.0
8	67.7	69.3	70.8	72.5	74.1	75.8	77.4	79.1
9	80.8	82.4	84.2	85.9	87.6	89.3	91.0	92.8
10	94.5	96.3	98.1	99.9	101.7	103.6	105.4	107.3
Example of how to use weir table: Suppose depth of water above stake is 9 3/8 inches. Find 9 in the left-hand column and 3/8 in the top column. The value where they intersect is 85.9 gpm. That's only for a 1-inch weir, however. You multiply this value by the width of your weir in inches to obtain water flow.								

The weir method is more versatile and may prove useful for higher flows. This technique uses a rectangular opening cut in a board or piece of sheet metal, set into the brook like a dam. The water is channeled into the weir and the depth is measured from the top of a stake that is level with the edge of the weir and several feet upstream. Looking at the chart above will enable you to convert the width and depth of flowing water into gallons per minute.

Measuring the flow at different times of the year helps you estimate maximum and minimum usable flows. If the water source is seasonally limited, you may have to depend on some other source of power during dry times (solar, wind). Keep in mind that a reasonable amount of water must be left in the stream (Don't take it all, that water supports life forms).

When head and flow are determined, the expected power output can be determined from the following chart. Keep in mind that chart values represent *generated* output and that actual power delivered to the batteries will be reduced by transmission lines, power converters, and other equipment required by the system. All systems should be carefully planned to maximize power output.

Stream Engine Output in Watts (Continuous)

* In these higher output situations, it may be worthwhile to utilize more than one *Stream Engine*.

Net Head		Flow Rate Liters/sec (Gallons/min)						
		0.67 (10)	1.33 (20)	2.50 (40)	5.00 (75)	6.67 (100)	7.50 (112)	9.50 (150)
Meters	Feet							
3	10	-	20	40	75	100	130	150
6	20	15	40	80	150	200	250	350
15	49	45	100	200	375	500	650	800
30	98	80	200	400	750	1000	*	*
60	197	150	400	800	1500	*	*	*
90	295	200	550	1200	*	*	*	*
120	394	300	700	1500	*	*	*	*
150	492	400	850	1900	*	*	*	*

INTAKE, PIPELINE, AND TAILRACE

Most hydro systems require a pipeline. Even systems operating directly from a dam require at least a short plumbing run. It is important to use the correct type and size of pipe to minimize restrictions in the flow to the nozzle(s). When possible, pipelines should be buried; this stabilizes the line and prevents animals from chewing it.

At the inlet of the pipe, a filter should be installed. A screened box can be used with the pipe entering one side, or add a section of pipe drilled full of holes wrapped with screen, or small holes and used without screen. Make sure that the filter openings are smaller than the smallest nozzle used. Note that particles over about ¼" or 6mm in size may lodge in the turgo runner.

The intake must be above the streambed so as not to suck in silt and should be deep enough so as not to suck in air. The intake structure should be placed to one side of the main flow of the stream so that the force of the flowing water and its debris bypasses it. Routinely clean the intake of any leaves or other debris.

Another option is to use what is called a Coanda intake. These are available from www.hydroscreen.com. These must be placed at the lowest spot the water flows so as to wash the surface of the screen to removed debris.

If the whole pipeline doesn't run continuously downhill, at least the first section should, so the water can begin flowing with the use of a bypass valve. This should be installed at a low point in the pipe.

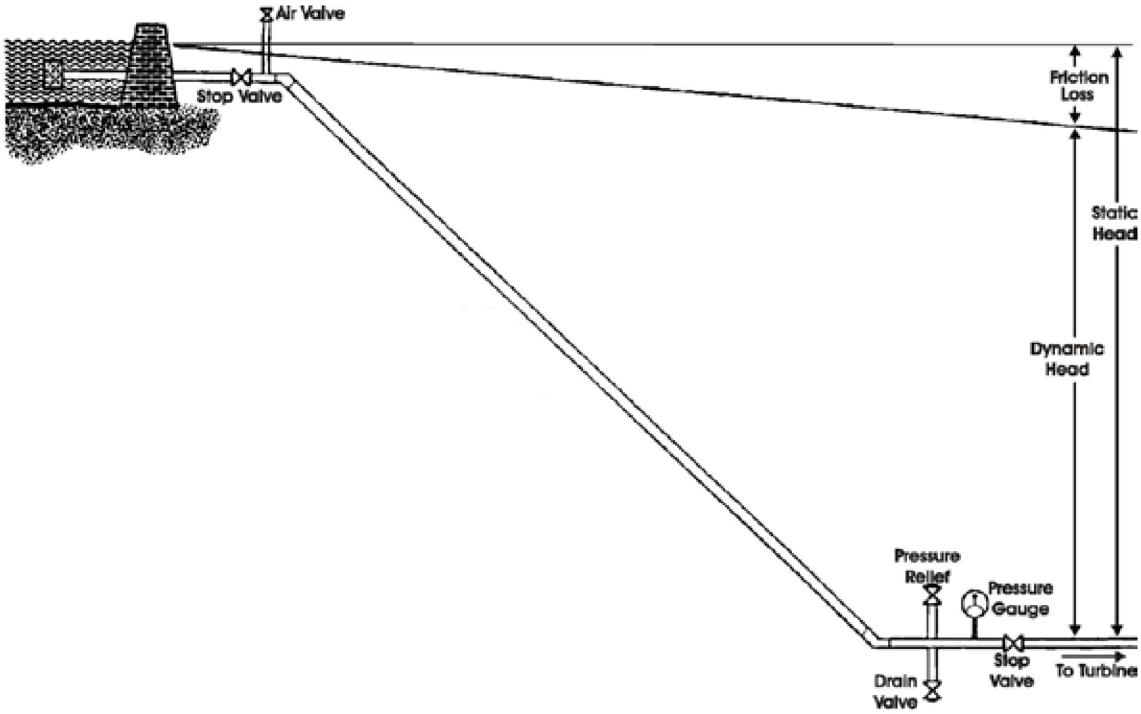
For pipelines running over dams, or in conditions that create a siphon, the downstream side may be filled by hand. Once filled, the stop valve at the turbine can be opened to start the flow. If full pressure is not developed, or air builds up in the line, a vacuum pump can be used to remove air trapped at the high point.

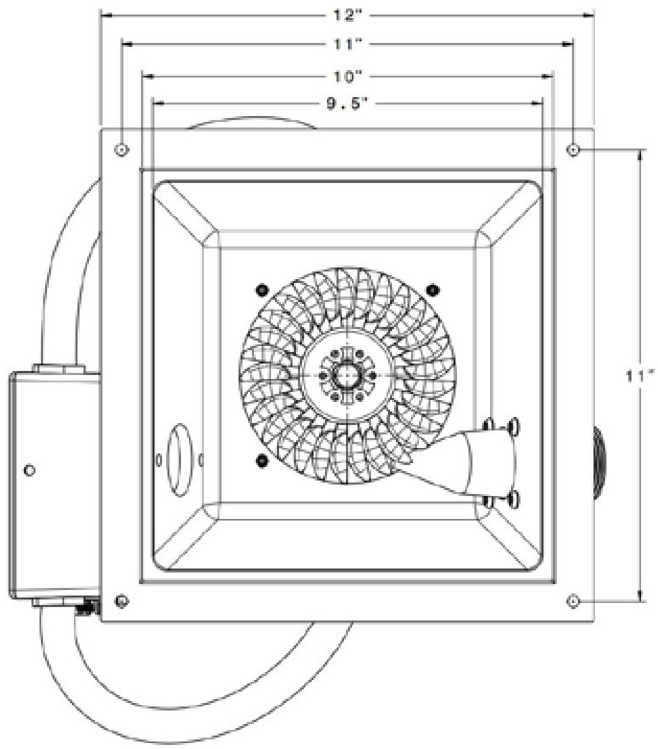
At the turbine end of the pipeline a bypass valve may be necessary to allow water to run through the pipe without affecting the turbine, purging the line of air or increasing flow to prevent freezing.

A stop valve should be installed upstream of the nozzle. A pressure gauge should be installed upstream of the stop valve so both the static head (no water flowing) and the dynamic head (water flowing) can be read.

The stop valve on a pipeline should always be closed slowly to prevent water hammer (the column of water in the pipe coming to an abrupt stop). This can easily destroy your pipeline and for this reason, you may wish to install a pressure relief valve just upstream of the stop valve. This can also occur if debris clogs the nozzle. In a single nozzle machine a nozzle that becomes clogged suddenly may create a water hammer.

Nozzles can be installed or changed by removing the nozzle. The nozzle is removed by unscrewing its four nuts using a 7/16” (11 mm) wrench. The use of flexible pipe makes it easier to remove the plumbing from the nozzles. The low flow wheel uses a separate adapter with threaded brass nozzle inserts that come in different sizes.





- *Now with ¾" (19mm) drip lip.*
- *Nozzle opposite Junction box (J-box) should always be primary nozzle for cooling.*

The turbine housing can be mounted as simply as supporting it on two boards to suspend it above the stream. It is recommended to have the *Stream Engine* in a small enclosure or under some cover to keep it dry and provide a place for auxiliary equipment. Mounting the machine on a concrete base is also possible (you may wish to try a temporary wood mounting first). The housing now has a ¾" (19mm) drip lip and can be mounted in an opening 10 inches (250 mm). Make certain the tailrace (exit channel) provides enough flow for the exiting water. The diameter of the bolt holes is ¼" (6 mm). In cold climates, it may be necessary to build a "trap" into the exit. This prevents outside air from entering the housing and causing freeze-ups.

BATTERIES, INVERTERS & CONTROLLERS

System Voltage

A small system with a short transmission distance can be designed to operate at 12 volts. Larger systems can also be 12 volts, but if higher power is desired or the transmission distance is long, then a system of 24 volts or higher may be preferable. This is especially true if all loads are inverter-powered. In a 12-volt system operating at a low power level, it may be advantageous to operate all loads directly from batteries. Many 12-volt appliances and small inverters are available.
In 24-volt systems, it may also be preferable to operate the loads directly (although not as many appliances are available).

In higher power systems, it is usually better to use an inverter to convert battery voltage to regular 120 volt AC power at 60 Hz (cycles per second), or 240 volt 50Hz in some countries. This has been made feasible with the advent of reliable high power inverters. Thousands if not millions of home power systems are in operation with only AC loads.

Sizing Battery Bank

A typical hydro system should have about one or two days of battery storage capacity. This will generally keep lead-acid cells operating in the middle of their charge range where they are the most efficient and long-lived.

Batteries should be located outside of any living space unless they are the sealed type. Adequate ventilation should be provided for flooded lead acid batteries, as a rising charge level tends to produce both hydrogen gas and corrosive fumes. Also, distilled water should be added as needed to maintain the electrolyte level as water is consumed in flooded batteries.

Charge Control

Unlike solar systems, a hydro system must always be connected to a load even when the batteries are fully charged. If the output power does not have somewhere to go, system voltage can rise to very high levels. This situation provides an opportunity to do something with the excess power like water or space heating.

As the batteries become more fully charged, their voltage rises. At some point, excess power should be diverted to a secondary or dump load. You will need to use a controller that has diversion capability. Most charge controllers permit different charge levels such as bulk, absorption, and float. Literature supplied with the controller should be consulted to determine the set points of the charge controller.

Watt-Hour meters are available that monitor the battery state of charge.

An ammeter that monitors turbine output should always be installed that shows the power going into the batteries. This can be installed in a high traffic or living space so difficulties with the machine can be easily detected. If a drop in output is noticed, the machine should be inspected. This could be caused by air in the pipeline, or a blocked or partially blocked nozzle. More importantly, a drop in output could be the beginning of bearing failure. Bearing failure will cause serious damage to the machine. Early detection of problems with the bearings is vital. ES&D sells a power meter that measures watts output in addition to volts and amps.

WIRING AND LOAD CENTER

Every system requires wiring to connect the various components. Load centers are available as a complete package that easily facilitates the connection of loads and power source(s). All circuits in the system should use wire of adequate size and have fuses or breakers of sufficient capacity to carry the expected load current. The *Stream Engine* must be fused when connected directly to the batteries since it can suffer from a short or similar fault just like anything else in the system.

Inside the junction box on the side of the machine are two terminals for the battery wiring that are mounted to the terminal board. The positive terminal is painted red and the negative is black. Your transmission wire ends are inserted into these two connectors (after being stripped of insulation) and then tightened. Make sure that the battery wiring is correctly connected with respect to polarity or the rectifier will be destroyed. Do not operate the machine without being connected to the batteries as very high voltages may be generated. A grounding terminal on the side of the box is painted green.

The supplied multi-meter can be temporarily connected to the test jacks on the side of the junction box (see *current measurement technique, pg. 20)* which will measure current output and is used when adjusting the output.

DESIGN EXAMPLE

This example shows how to proceed with a complete installation. The parameters of the example site are:

-120 feet of head over a distance of 1000 feet
-30 gpm of flow (most of the time)
-100 feet of distance from the house to the hydro machine
-24 volt system

The first thing to do is determine the pipeline size. Although maximum power is produced from a given size pipe when the flow loss is 1/3 of the static head, more power can be obtained from the same flow with a larger pipe, which has lower losses. Therefore, pipe size must be optimized based on economics.

The pipe flow charts show us that two-inch diameter polyethylene pipe has a head loss of 1.77 feet of head per 100 feet of pipe at a flow rate of 30 gpm. This is 17.7 feet of loss for 1000 feet of pipe.

Using two-inch PVC gives us a loss of 1.17 feet of head per 100 feet of pipe or 11.7 feet for 1000 feet.

Polyethylene comes in continuous coils because it is flexible (and more freeze resistant). PVC comes in shorter lengths and has to be glued together or purchased with gaskets (for larger sizes). Let's say we select polyethylene.

The maximum output occurs with a flow of about 45 gpm since that gives us a head loss of 3.75 feet per 100 feet of pipe, or 37.5 feet of loss for our 1000 feet of pipe. This is 37.5' loss/120' head = 31% loss. This means that if the flow is increased beyond this, the power will actually drop as the losses in the pipe are increasing faster than the flow.

A flow of 30 gpm gives a net head of 102.3 feet (120' - 17.7'). The losses caused by the various pipe fittings and intake screen will further decrease the dynamic head, so 100 feet is a good working figure for the net head. Looking at the nozzle flow chart, we see that a 3/8" nozzle will produce a flow of 27.6 gpm at a head of 100'. This is very close to the design point and the net head will be a bit higher since the flow is less. Looking at the output chart we see that the machine could generate about 300 watts. That is, at a 30 meter head or about 100 feet and halfway between 20 and 40 gpm. A simple rule of thumb to use is: Head (feet) x Flow (gpm) and divide by ten, for metric: Head (m) x Flow (l/s) x five, which will roughly give the output in watts. Our machines can usually do better than this, but this is a starting point.

Since we require 24 volts and the transmission distance is fairly short, we can generate and transmit

24 volts using the *Stream Engine*. This *Stream Engine* could also be used for higher voltages like 48 and 120 or 240. With higher voltages, the power could be transmitted longer distances.

We need to go 100' with 300 watts at our site. This will be about 10 amps at 30 volts at the generator. Note that there will be some voltage drop in the line and batteries require somewhat higher voltages than nominal to become charged. So the 10 amps must pass through 200' of wire for the round trip. Resistance losses should be kept as low as economics permit, just like the pipeline losses.

Let's say we can accept around a 10% loss. This is 30 watts out of the original 300. The formula for resistive loss is I^2R = watts. I = Intensity (current in amps) and R = Resistance (in ohms).

$(10 \text{ amps})^2 \times R \text{ (ohms)} = 30 \text{ watts}$
100 amps x R (ohms) = 30 watts
R = 30 watts/100 amps
R = 0.3 ohms

This is the wire resistance that will produce a 10% loss. The wire loss chart shows loss per 1000', so:

1000'/200' x 0.3 ohms = 1.5 ohms per 1000'.

The chart shows 12 ga. Wire has a resistance of 1.62 ohms per 1000', so:

200'/1000' x 1.62 ohms = 0.32ohms. This is close to the desired level.
10 amps x 10 amps x 0.32 ohms = 32 watts of loss.

Increasing the wire size further would reduce the losses. Voltage drop in the wire is equal to:

IR = 10 amps x 0.32 ohms = 3.2 volts

So if the battery voltage is 26.8 the generator will be operating at 30.0 volts. Keep in mind that it is always the batteries that determine the system voltage. That is, all voltages in the system rise and fall according to the battery's state of charge.

At the site, we would be generating 10 amps continuously. If we use lead acid batteries and wish to have two days of storage capacity, then:

10 amps x 24 hrs x 2 days = 480 amp. hours (Ah) Capacity

We would probably use an inverter and load controller with the system. The diagram for such a system would look like this:

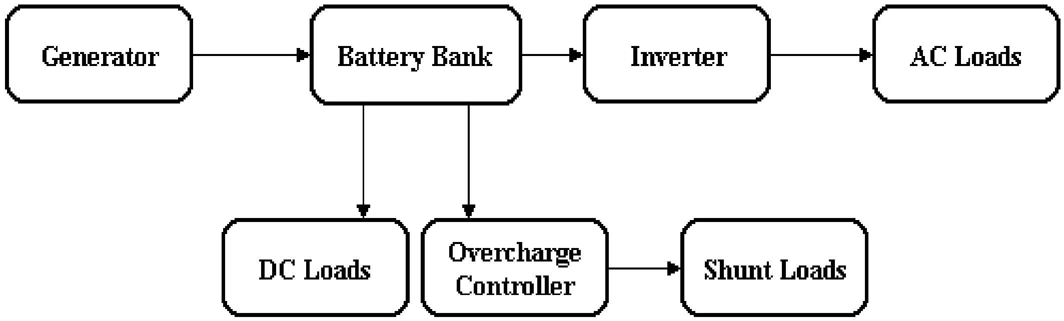


Diagram of a typical battery-based system:

OUTPUT ADJUSTMENT

For the machine to produce the highest output, the rotor height should be adjusted. This involves raising or lowering the rotor to change the magnetic flux level. This is necessary to match the output of the turbine with that of the generator which optimizes output.

After the machine is installed, perform an initial run to establish a power output level. This can be determined using the method described on page 20. After everything is hooked up, start the machine by opening the stop valve. Run it long enough for the output level to stabilize and note the current (or voltage in the case of a long distance transmission AC machine). Then shut the stop valve. Since the machine comes with the rotor set very close to the stator (the stationary part of the machine), you will need to adjust the rotor upwards to see if this gives a power increase. To increase this distance and reduce the magnetic flux level, first insert the 1/4" pin supplied in one of the holes in the edge of the rotor. Then the smaller 7/16"(11 mm) head bolt is loosened while using the pin to keep the rotor from turning. Now you can turn the larger 3/4" head bolt, which will force the rotor up. Each full turn of the bolt will move the rotor vertically 0.050" (1.25 mm). If raising the rotor causes the current (or the voltage) to increase, then continue to do so until there is no longer an increase. If a point is reached where a decrease occurs, then the rotor should be lowered. This is done by loosening the larger bolt and then tightening the smaller one. Turning the smaller bolt causes the rotor to move vertically the same distance per turn as the larger bolt does. When you have found the best position (no increase in current or voltage), make sure the larger bolt is turned until it has contacted the shaft but not enough to change your adjustment. Now the smaller bolt should be tightened securely to lock everything in place. No further adjustments should be required unless nozzle sizes are changed. It will likely take a few tries to get this right.

When adjusting the rotor downward, it may reach the point where it will contact the stator. If this occurs, always adjust it upwards by at least a 1/2 turn of the larger bolt. Operating the machine with the rotor closer than this may damage the machine. Be sure the air gap is at least 0.020" (0.5 mm) as described on page two.

**** Always turn the rotor by hand before starting the machine to check for rubbing**.**
Remove the pin in the rotor edge before starting the machine.

<u>High Voltage models Using Transformers</u>
When operating a *Stream Engine* using transformers, it will require a different technique in order to optimize the output. This can be done at the turbine by adjusting for maximum voltage rather than

maximum current. AC voltage can be measured using any two of the test jacks with the meter set on one of the AC scales. Make rotor air gap adjustments according to the above instructions.

DETERMINING NOZZLE SIZE

Optimum nozzle size can be determined by following the Design Example (page nine) using the Nozzle Flow Chart. It usually works best to use nozzles in the middle of the size range whenever possible. When using two or more nozzles they do not have to be the same diameter.

Two types of turbine runners are offered for the *Stream Engine*.

1- The standard turgo runner can use nozzles of up to one inch in diameter. This turgo wheel is used for higher flow sites which are associated with lower heads. The universal type of nozzle is supplied with the turgo runner. With the universal nozzle, it is possible to create any size nozzle jet that might be required by simply cutting the nozzle to the appropriate length. Cutting can be done with a hacksaw, or any other fine toothed saw. The end of the nozzle should then be finished with a piece of sandpaper. This is best done by placing the sandpaper on a flat surface and moving the nozzle against it. Start at tip and continue until desired size is achieved by measuring across the opening.

LF	A	B	C	D	E	F	G				
mm	3	4.5	6	8	10	11	13	16	19	22	25
inches	1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1

2- The low flow (LF) runner comes with brass nozzle inserts that are supplied in sizes of 1/8” to 1/2” (lettered A-G) in increments of 1/16”. These inserts are screwed into a plastic holder or adapter that mounts to the housing.

Both the standard turgo and the low flow version are supplied with nozzles or adapters which have 1-1/2” male pipe thread that is connected to the incoming plumbing. For lower pressure sites, two inch flexible hose can be used which will fit over the threaded end. The hose can be secured with hose clamps as shown in the pictures on pages 21-22. Using flexible hose simplifies the plumbing and makes nozzle removal easier. At higher heads it is best to use standard barbed fittings and 1-1/2” flex line.

NOZZLE FLOW CHART

Head Feet	Pressure PSI	Nozzle Diameter, inches											Turbine RPM
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1.0	
5	**2.2**					6.18	8.40	11.0	17.1	24.7	33.6	43.9	**460**
10	**4.3**			3.88	6.05	8.75	11.6	15.6	24.2	35.0	47.6	62.1	**650**
15	**6.5**		2.68	4.76	7.40	10.7	14.6	19.0	29.7	42.8	58.2	76.0	**800**
20	**8.7**	1.37	3.09	5.49	8.56	12.4	16.8	22.0	34.3	49.4	67.3	87.8	**925**
30	**13.0**	1.68	3.78	6.72	10.5	15.1	20.6	26.9	42.0	60.5	82.4	107	**1140**
40	**17.3**	1.94	4.37	7.76	12.1	17.5	23.8	31.1	48.5	69.9	95.1	124	**1310**
50	**21.7**	2.17	4.88	8.68	13.6	19.5	26.6	34.7	54.3	78.1	106	139	**1470**
60	**26.0**	2.38	5.35	9.51	14.8	21.4	29.1	38.0	59.4	85.6	117	152	**1600**
80	**34.6**	2.75	6.18	11.0	17.1	24.7	33.6	43.9	68.6	98.8	135	176	**1850**
100	**43.3**	3.07	6.91	12.3	19.2	27.6	37.6	49.1	76.7	111	150	196	**2070**
120	**52.0**	3.36	7.56	13.4	21.0	30.3	41.2	53.8	84.1	121	165	215	**2270**
150	**65.0**	3.76	8.95	15.0	23.5	33.8	46.0	60.1	93.9	135	184	241	**2540**
200	**86.6**	4.34	9.77	17.4	27.1	39.1	53.2	69.4	109	156	213	278	**2930**
250	**108**	4.86	10.9	19.9	30.3	43.6	59.4	77.6	121	175	238	311	**3270**
300	**130**	5.32	12.0	21.3	33.2	47.8	65.1	85.1	133	191	261	340	**3591**
400	**173**	6.14	13.8	24.5	38.3	55.2	75.2	98.2	154	221	301	393	**4140**

Note: Figures are in US gallons per minute and refer to one nozzle. The standard *Stream Engine* can generate about 500 watts per 1000 rpm. The *X-Stream Engine* can generate about 1000 watts per 1000 rpm. These figures are theoretical maximums. Actual flow rates will always be somewhat less—usually by five or ten percent.

METRIC NOZZLE FLOW CHART

NOZZLE FLOW CHART FLOW RATE IN LITRES / SECOND

Meters Head					Nozzle	Diameter	mm					Turbine RPM
	3.2	4.8	6.3	8	9.5	11.1	12.7	16	19	22	25	
2	0	0	0	0	0.39	0.53	0.69	1.08	1.56	2.12	2.77	460
3	0	0	0.24	0.38	0.55	0.73	0.98	1.53	2.21	3.00	3.92	650
5	0	0.17	0.30	0.47	0.68	0.92	1.20	1.87	2.70	3.67	4.79	800
6	0.09	0.19	0.35	0.54	0.78	1.06	1.39	2.16	3.12	4.25	5.54	925
9	0.11	0.24	0.42	0.66	0.95	1.30	1.70	2.65	3.82	5.20	6.75	1140
12	0.12	0.28	0.49	0.76	1.10	1.50	1.96	3.06	4.41	6.00	7.82	1310
15	0.14	0.31	0.55	0.86	1.23	1.68	2.19	3.43	4.93	6.69	8.77	1470
18	0.15	0.34	0.60	0.93	1.35	1.84	2.40	3.75	5.40	7.38	9.59	1600
24	0.17	0.39	0.69	1.08	1.56	2.12	2.77	4.33	6.23	8.52	11.1	1850
30	0.19	0.44	0.78	1.21	1.74	2.37	3.10	4.84	7.00	9.46	12.4	2070
37	0.21	0.48	0.85	1.32	1.91	2.60	3.39	5.31	7.63	10.4	13.5	2270
46	0.24	0.56	0.95	1.48	2.13	2.90	3.79	5.92	8.52	11.6	15.2	2540
61	0.27	0.62	1.10	1.71	2.47	3.36	4.38	6.88	9.84	13.4	17.5	2930
76	0.31	0.69	1.26	1.91	2.75	3.75	4.90	7.63	11.0	15.0	19.6	3270
91	0.34	0.76	1.34	2.09	3.02	4.11	5.37	8.39	12.0	16.5	21.5	3591
122	0.39	0.87	1.55	2.42	3.48	4.74	6.20	9.72	13.9	19.0	24.8	4140

BEARINGS, SERVICE & ASSEMBLY

In order to replace bearings, the turbine wheel must first be removed. Both types of turbine wheel are held in place with a single bolt with a 9/16” (14 mm) head, flat washer and lock-washer. You can remove this by using a wrench on the bolt and keeping the rotor from turning by inserting the ¼” (6 mm) pin that is supplied with the machine into the hole in the edge of the rotor to keep it from turning. Once the turbine wheel has been removed, the four 7/16” (11 mm) nuts that retain the generator can be removed. Now the hub that the wheel mounts to can be removed by unscrewing it from the shaft. To do this, insert a screwdriver into the hole through the hub and the pin into the rotor edge and unscrew the hub. This is a conventional right hand thread so the hub is unscrewed by turning it counter clockwise—looking at the end of the shaft.

Now you can remove the rotor/shaft/hub assembly. This is mostly held by the magnetic attraction of the rotor to the stator—the stationary part of the machine that appears as a big black lump of epoxy. To make it easier to remove the rotor, it will help if it is raised up by turning the larger bolt with the ¾” (19 mm) head clockwise. You will first have to loosen the smaller bolt in the center. At this point, you should be able to pull the rotor and shaft out of the bearings. If this is difficult, you may find it helpful to push down on the stator while holding it in your hands with the end of the shaft on a piece of wood so as not to damage it.

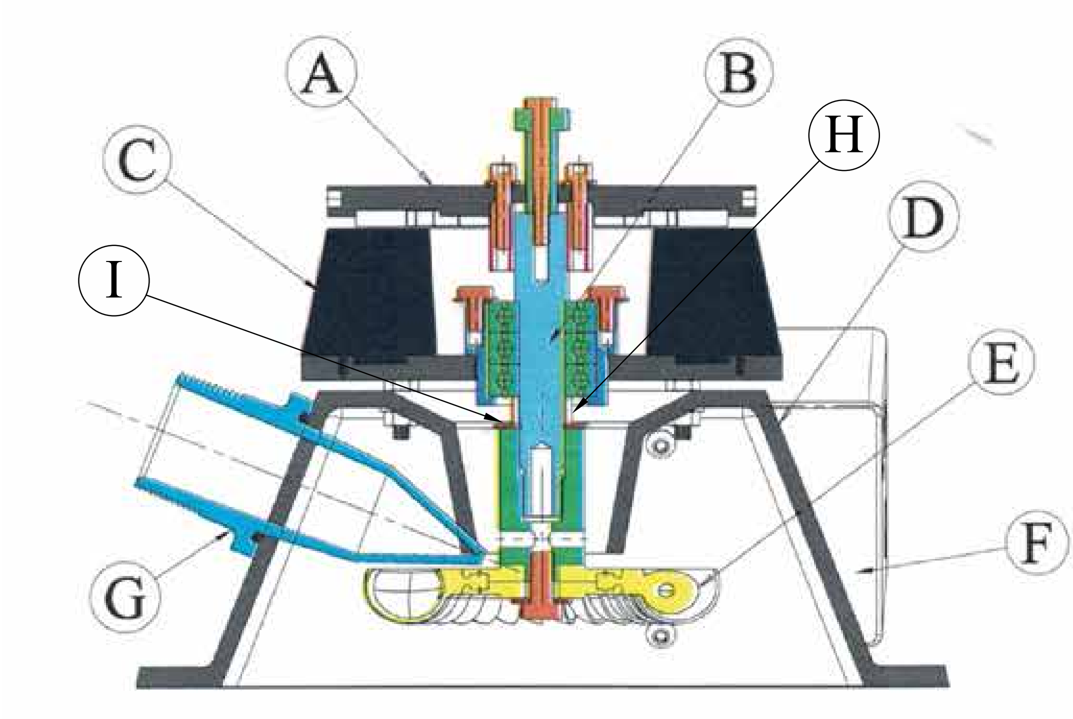
Once the rotor is out, the bearings are retained with two bolts with 7/16" (11 mm) heads. Once these bolts are removed, the bearings can be removed. These are a slip fit and are normally easy to remove. If this is difficult, they can be driven out with a piece of wood or a press may be needed if there is corrosion.

New bearings can now be installed and the two bolts replaced and tightened. Then the rotor can be replaced. Then the generator can be replaced and the shaft and hub reassembled.

IMPORTANT: Bearings are the life of the machine. Replacing them often will not hurt anything and will help keep the area free of corrosion. If you are running the machine with close clearance between the rotor and stator, check the clearance with the gauge provided fairly often as it is easy to do. Sometimes bearings can last for many years, but if you have a high power or high head site, their life will be shorter.

Note: Replace the washer and the spacer above the shaft adapter with the spacer above the washer as shown in the following drawing.

Stream Engine Series Major Component Assembly



A	Rotor Assembly	F	Junction Box
B	Rotot Shaft Assembly	G	Nozzle
C	Stator Base Assembly	H	Spacer
D	Housing	I	Washer
E	Runner/Wheel		

Copper Wire Resistance Chart

Wire Gauge	Diameter Inches	Ohms per 1000'	Ohms per Mile
0000	0.460	0.05	0.26
000	0.410	0.06	0.33
00	0.364	0.08	0.42
0	0.324	0.10	0.52
2	0.258	0.16	0.84
4	0.204	0.25	1.34
6	0.162	0.40	2.13
8	0.128	0.64	3.38
10	0.102	1.02	5.38
12	0.081	1.62	8.56
14	0.064	2.58	13.6
16	0.051	4.10	21.6
18	0.040	6.52	34.4

PIPE FRICTION LOSS - PVC Class 160 PSI Plastic Pipe

Pressure Loss from Friction in Feet of Head per 100 Feet of Pipe

Flow US GPM	Pipe Diameter, Inches										
	1	1.25	1.5	2	2.5	3	4	5	6	8	10
1	0.05	0.02									
2	0.14	0.05	0.02								
3	0.32	0.09	0.04								
4	0.53	0.16	0.09	0.02							
5	0.80	0.25	0.12	0.04							
6	1.13	0.35	0.18	0.07	0.02						
7	1.52	0.46	0.23	0.08	0.02						
8	1.93	0.58	0.30	0.10	0.04						
9	2.42	0.71	0.37	0.12	0.05						
10	2.92	0.87	0.46	0.16	0.07	0.02					
11	3.50	1.04	0.53	0.18	0.07	0.02					
12	4.09	1.22	0.64	0.20	0.09	0.02					
14	5.45	1.63	0.85	0.28	0.12	0.04					
16	7.00	2.09	1.08	0.37	0.14	0.04					
18	8.69	2.60	1.33	0.46	0.18	0.07					
20	10.6	3.15	1.63	0.55	0.21	0.09	0.02				
22	12.6	3.77	1.96	0.67	0.25	0.10	0.02				
24	14.8	4.42	2.32	0.78	0.30	0.12	0.04				
26	17.2	5.13	2.65	0.90	0.35	0.14	0.05				
28	19.7	5.89	3.04	1.04	0.41	0.16	0.05				
30	22.4	6.70	3.45	1.17	0.43	0.18	0.05				
35		8.90	4.64	1.56	0.62	0.23	0.07				
40		11.4	5.89	1.98	0.78	0.30	0.09	0.02			
45		14.2	7.34	2.48	0.97	0.37	0.12	0.04			
50		17.2	8.92	3.01	1.20	0.46	0.14	0.04			
55		20.5	10.6	3.59	1.43	0.55	0.16	0.05			
60		24.1	12.5	4.21	1.66	0.64	0.18	0.07	0.02		
70			16.6	5.61	2.21	0.85	0.25	0.09	0.03		
80			21.3	7.18	2.83	1.08	0.32	0.12	0.04		
90				8.92	3.52	1.36	0.39	0.14	0.07		
100				10.9	4.28	1.66	0.48	0.18	0.07	0.02	
150				23.2	9.06	3.50	1.04	0.37	0.16	0.05	
200					15.5	5.96	1.75	0.62	0.28	0.07	0.02
250					23.4	9.05	2.65	0.94	0.42	0.12	0.05
300						12.6	3.73	1.34	0.58	0.16	0.05
350						16.8	4.95	1.78	0.76	0.21	0.07
400						21.5	6.33	2.25	0.97	0.28	0.10
450							7.87	2.81	1.20	0.32	0.12
500							9.55	3.41	1.45	0.42	0.14
550							11.4	4.07	1.75	0.48	0.16
600							13.4	4.78	2.05	0.58	0.18
650							15.5	5.54	2.37	0.67	0.23
700							17.8	6.37	2.71	0.76	0.25
750							20.3	7.22	3.10	0.86	0.30
800								8.14	3.50	0.97	0.32
850								9.11	3.89	1.08	0.37
900								10.1	4.32	1.20	0.42
950								10.8	4.79	1.34	0.46
1000								12.3	5.27	1.45	0.51

PIPE FRICTION LOSS Polyethylene SDR - Pressure Rated Pipe
Pressure Loss from Friction in Feet of Head per 100 Feet of Pipe

Flow US GPM	Pipe Diameter, Inches							
	0.5	0.75	1	1.25	1.5	2	2.5	3
1	1.13	0.28	0.09	0.02				
2	4.05	1.04	0.32	0.09	0.04			
3	8.60	2.19	0.67	0.19	0.09	0.02		
4	14.6	3.73	1.15	0.30	0.14	0.05		
5	22.1	5.61	1.75	0.46	0.21	0.07		
6	31.0	7.89	2.44	0.65	0.30	0.09	0.05	
7	41.2	10.5	3.24	0.85	0.42	0.12	0.06	
8	53.1	13.4	4.14	1.08	0.51	0.16	0.07	
9		16.7	5.15	1.36	0.65	0.18	0.08	
10		20.3	6.28	1.66	0.78	0.23	0.09	0.02
12		28.5	8.79	2.32	1.11	0.32	0.14	0.05
14		37.9	11.7	3.10	1.45	0.44	0.18	0.07
16			15.0	3.93	1.87	0.55	0.23	0.08
18			18.6	4.90	2.32	0.69	0.30	0.09
20			22.6	5.96	2.81	0.83	0.35	0.12
22			27.0	7.11	3.36	1.00	0.42	0.14
24			31.7	8.35	3.96	1.17	0.49	0.16
26			36.8	9.68	4.58	1.36	0.58	0.21
28				11.1	5.25	1.56	0.67	0.23
30				12.6	5.96	1.77	0.74	0.25
35				16.8	7.94	2.35	1.00	0.35
40				21.5	10.2	3.02	1.27	0.44
45				26.8	12.7	3.75	1.59	0.55
50				32.5	15.4	4.55	1.91	0.67
55					18.3	5.43	1.96	0.81
60					21.5	6.40	2.70	0.94
65					23.8	7.41	3.13	1.08
70					28.7	8.49	3.59	1.24
75					32.6	9.67	4.07	1.40
80						10.9	4.58	1.59
85						12.2	5.13	1.77
90						13.5	5.71	1.98
95						15.0	6.31	2.19
100						16.5	6.92	2.42
150						34.5	14.7	5.11
200							25.0	8.70

Metric Pipe Friction Loss

Pressure Loss from Friction in Meters of Head per 100 meters of pipe

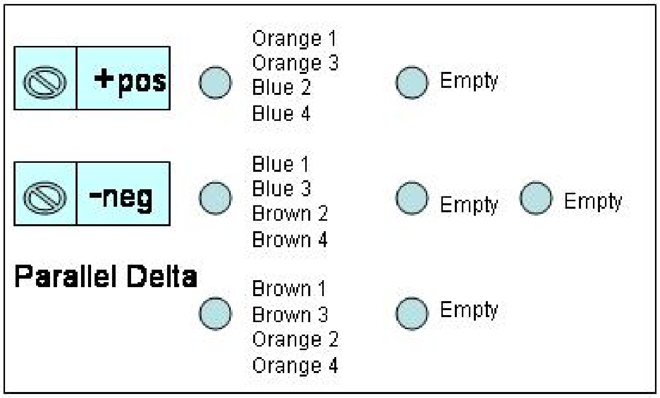
Nominal Pipe Diameter (OD for Metric and ID for Imperial)

Polyethylene Pipe — Type 50 — Class 6 ('B' class)

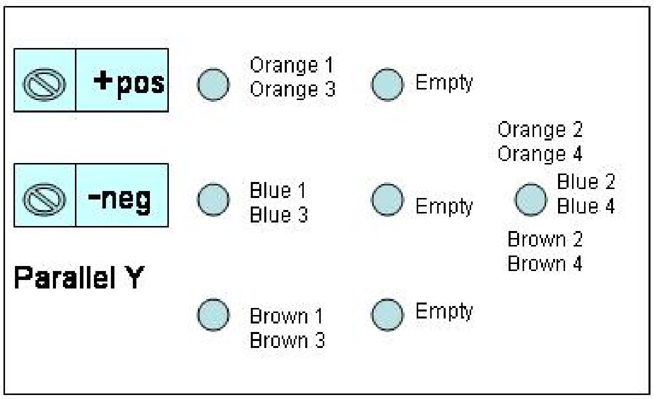
PVC

l/sec	25mm	1"	32mm	1.25""	40mm	1. 5"	50mm	2"	63mm	2.5"	75mm	3"	90mm	100mm	125mm
0.1	0.57	0.28	0.16	0.11	0.05	0.04	0.02	0.01	0	0	0	0	0	0	0
0.2	2.05	1.01	0.6	0.39	0.2	0.14	0.06	0.03	0.02	0.01	0.01	0	0	0	0
0.3	4.34	2.14	1.26	0.83	0.41	0.29	0.14	0.07	0.04	0.02	0.02	0.01	0.01	0	0
0.4	7.39	3.64	2.15	1.41	0.7	0.5	0.23	0.12	0.07	0.04	0.03	0.02	0.01	0.01	0
0.5	11.17	5.5	3.25	2.14	1.07	0.76	0.35	0.18	0.11	0.06	0.05	0.02	0.02	0.01	0
0.6	15.66	7.72	4.56	3	1.49	1.06	0.49	0.26	0.15	0.08	0.06	0.03	0.03	0.02	0.01
0.7	20.83	10.27	6.06	3.99	1.99	1.42	0.65	0.34	0.2	0.11	0.09	0.04	0.03	0.02	0.01
0.8	26.88	13.15	7.76	5.1	2.54	1.81	0.83	0.44	0.26	0.14	0.11	0.06	0.04	0.03	0.01
0.9	33.18	16.35	9.66	6.35	3.16	2.26	1.04	0.55	0.33	0.18	0.14	0.07	0.05	0.03	0.01
1	40.33	19.88	11.74	7.72	3.85	2.74	1.26	0.67	0.4	0.22	0.17	0.08	0.07	0.04	0.01
1.1	48.12	23.72	14	9.21	4.59	3.27	1.5	0.79	0.47	0.26	0.2	0.1	0.08	0.05	0.02
1.2	56.54	27.87	16.45	10.82	5.39	3.84	1.77	0.93	0.56	0.31	0.23	0.12	0.09	0.06	0.02
1.3	65.57	32.32	19.08	12.55	6.25	4.46	2.05	1.08	0.65	0.35	0.27	0.14	0.11	0.06	0.02
1.4	75.22	37.08	21.89	14.39	7.17	5.11	2.35	1.24	0.74	0.41	0.31	0.16	0.12	0.07	0.02
1.5	85.48	42.13	24.88	16.36	8.15	5.81	2.57	1.41	0.84	0.46	0.35	0.18	0.14	0.08	0.03
1.6	96.33	47.48	28.04	18.43	9.19	6.55	3.01	1.59	0.95	0.52	0.4	0.2	0.16	0.09	0.03
1.7		53.12	31.37	20.62	10.28	7.33	3.37	1.78	1.06	0.58	0.44	0.22	0.18	0.11	0.03
1.8		59.06	34.87	22.93	11.43	8.15	3.74	1.98	1.18	0.65	0.49	0.25	0.2	0.12	0.04
1.9		65.28	38.55	25.34	12.63	9.01	4.14	2.15	1.3	0.72	0.55	0.27	0.22	0.13	0.04
2		71.79	42.39	27.87	13.89	9.9	4.55	2.41	1.43	0.79	0.6	0.3	0.24	0.14	0.05
2.1		75.58	46.4	30.5	15.2	10.84	4.98	2.63	1.57	0.86	0.66	0.33	0.26	0.16	0.05
2.2		85.65	50.57	33.25	16.57	11.82	5.43	2.87	1.71	0.94	0.72	0.36	0.29	0.17	0.06
2.3		93	54.92	36.1	17.99	12.83	5.9	3.12	1.86	1.02	0.78	0.39	0.31	0.18	0.06
2.4			59.42	39.07	19.47	13.88	6.38	3.37	2.01	1.11	0.84	0.42	0.34	0.2	0.07
2.5			64.09	42.13	21	14.97	6.88	3.64	2.17	1.19	0.91	0.46	0.36	0.22	0.07
3			89.84	59.06	29.44	20.99	9.65	5.1	3.04	1.67	1.27	0.64	0.51	0.3	0.1
3.5				78.58	39.17	27.93	12.83	6.78	4.04	2.22	1.69	0.85	0.68	0.4	0.13
4					50.16	35.76	16.44	8.69	5.18	2.85	2.16	1.09	0.87	0.51	0.17
4.5					62.39	44.48	20.44	10.81	6.44	3.54	2.69	1.36	1.08	0.64	0.21
5					75.8	54.07	24.85	13.14	7.82	4.3	3.27	1.65	1.32	0.78	0.25
5.5					87.91	64.51	29.65	15.67	9.34	5.14	3.9	1.97	1.57	0.93	0.3
6						75.8	34.84	18.41	10.97	6.03	4.59	2.31	1.84	1.09	0.36
6.5						87.91	40.4	21.36	12.72	7	5.32	2.68	2.14	1.26	0.41
7							46.35	24.5	14.59	8.03	6.1	3.08	2.45	1.45	0.47
7.5							52.67	27.84	16.58	9.12	6.94	3.5	2.79	1.65	0.54
8							59.36	31.37	18.69	16.28	7.82	3.94	3.14	1.85	0.61
8.5							66.41	35.1	20.91	11.5	8.75	4.41	3.51	2.31	0.76
9							73.83	39.02	23.25	12.79	9.72	4.9	3.91	2.31	0.76
9.5							81.61	43.14	25.7	14.13	10.75	5.42	4.32	2.55	0.84
10							89.74	47.44	28.26	15.54	11.82	5.96	4.75	2.8	0.92
11								56.6	33.71	18.55	14.1	7.11	5.67	3.35	1.1
12								66.49	39.61	21.79	16.57	8.36	6.66	3.93	1.29
13								77.12	45.94	25.27	19.21	9.69	7.72	4.56	1.49
14								88.47	52.7	28.99	22.04	11.12	8.86	5.23	1.71

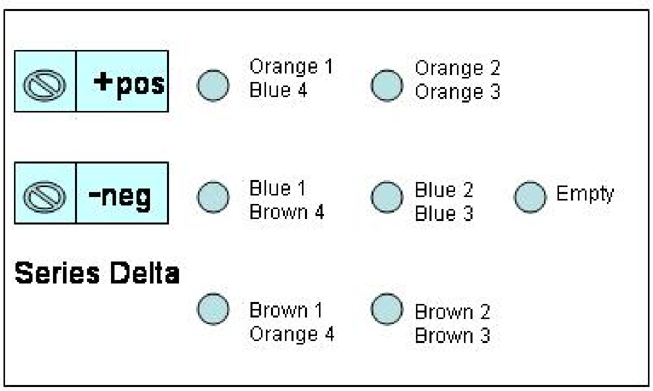
#1 Parallel Delta



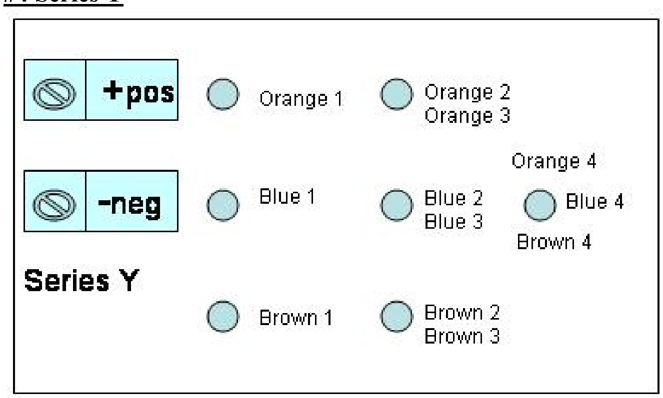
#2 Parallel Y



#3 Series Delta



#4 Series Y



Wiring Diagrams

These diagrams represent the four possible combinations of output wiring.

If you find your air gap adjustment to be at a minimum and wish to try for more power, then try using the next higher combination.

If you find the air gap is very large, try the next lower one.
Note that there is only a small change between #2 (Parallel Y), to #3 (Series Delta).

There is a ground lug on the junction box for grounding the machine.

The negative output is on the terminal block and is isolated.

Example of series delta wiring

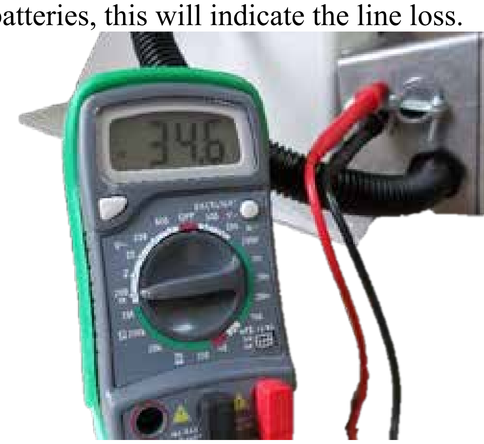
WIRING SCHEMES

12 VOLTS	*24 VOLTS*	*48 VOLTS*
Parallel Delta All Heads	**Series Delta** *up to 60'/18 m*	**Series Y** *up to 60'/ 18m*
	Parallel Delta *30'/ 9m and up*	**Series Delta** *30'/9m to 250'/75m*
		Parallel Delta *140'/43m and up*

Note: At a given site, more than one scheme may work. But one will work best.

Parallel wye configuration is not mentioned because it is very similar to series delta. It differs by about 15%. If you have a site where series delta is used and you think the output could be greater, try it. Remember to adjust the rotor for highest output when changing the wiring.

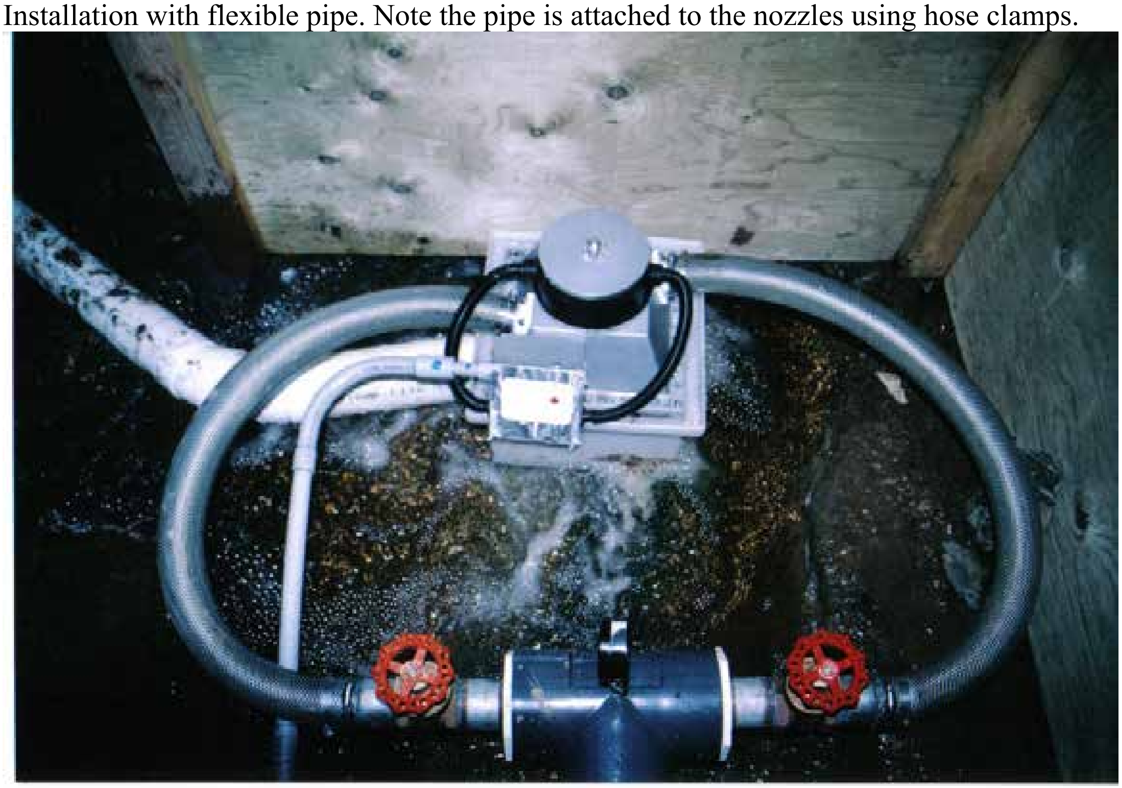
CURRENT MEASUREMENT TECHNIQUE
A built-in shunt is installed in the junction box which allows the current to be measured. This is done with a DMM (digital multi meter). To measure the current produced by the generator, set the DMM scale to "DC milli-volts" or "200 m", which is the nine o'clock position. **<u>Do not use the amps scale.</u>** Plug the leads into their corresponding color-coded jacks on the side of the junction box and the reading will be the generated current. Note also that output voltage can be measured by plugging the red lead into the white jack and using a suitable DC scale on the meter. Compared to the voltage at the batteries, this will indicate the line loss.



INSTALLATION EXAMPLES

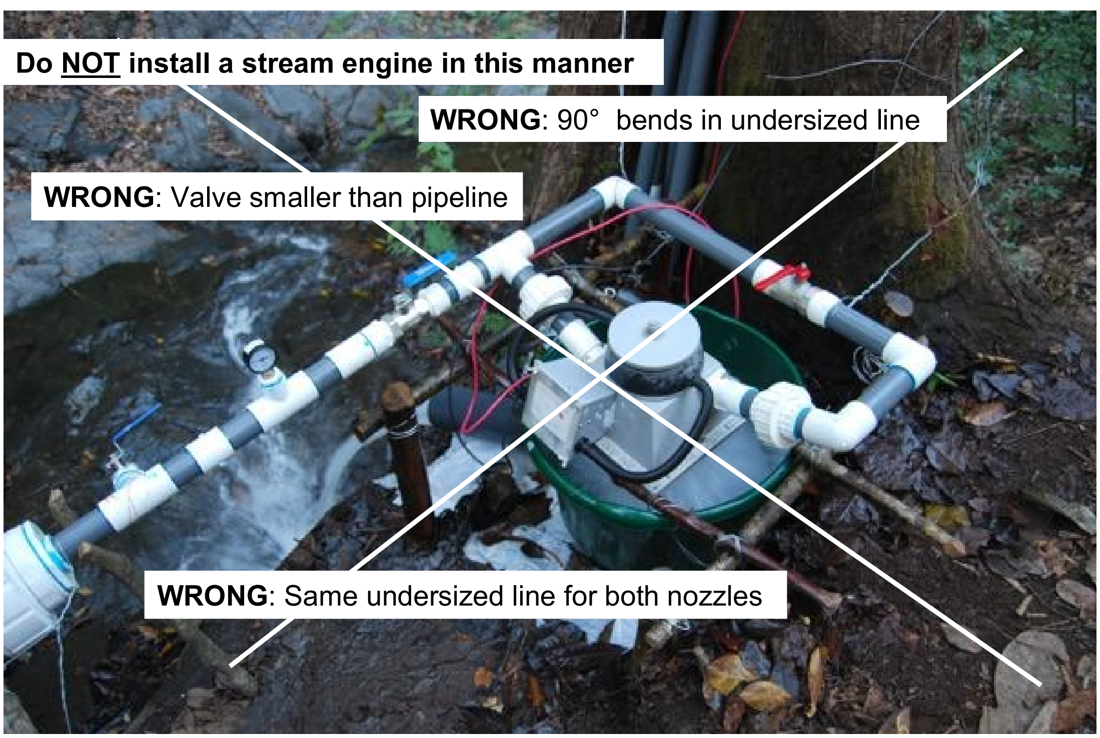
A *Stream Engine* installed using PVC pipe and union valves.

Under construction; a 30’ head site shown before gravel base was added.
Installation with flexible pipe. Note the pipe is attached to the nozzles using hose clamps.



Note pressure gauge installed by drilling and tapping the T fitting and using a small valve. This allows removal of the gauge to prevent freezing damage to the gauge.

Following is an example of what **NOT** to do for a *Stream Engine* installation. An installation of this sort will result in a huge loss of power. To optimize the output of the generator all aspects of installation should be well done. It is important to pay attention to plumbing, nozzle size, intake conditions, siting, electrical components, as well as regular maintenance.



GUARANTEE

This machine is guaranteed to change your life.

The fine print:

This ES&D water powered generator is warranted against defects in workmanship and materials. The period that this covers is one year, starting at the date of shipment to the customer.

In the event that an ES&D machine is found to have defects in material or workmanship, the remedies of repair or replacement of parts shall in each case be at the reasonable discretion of ES&D. Machines that the purchaser claims are defective must be returned at the purchaser's cost.

ES&D will not be responsible for problems caused by improper maintenance, faulty installation, unauthorized modifications or additions, abuse, or any other cause not due to defects in the machine.

ES&D will not be held liable for consequential damages or interruption of service to the buyer. The buyer, furthermore, by acceptance of the equipment assumes all responsibility for the consequences of its use.

After one year from the shipping date, all liability terminates and no action for any breach of any such warranty may be commenced.

Personal Hydropower

Product Information

Model # ____________________ Serial # ___________________
Date Purchased ____
Purchased From ____
Name: ____
Address: ____
City: ____
State/Prov: ________________ Zip/Postal Code: _____________
Telephone: ____
Email: ____
Comments: ____
____
____

Manufactured proudly in North America

by

Energy Systems and Design Ltd.
PO Box 4557
Sussex New Brunswick (NB)
Canada E4E 5L7

Shipping Address:
745 Waterford Road
Waterford, NB E4E 5B4

Phone +1 (506) 433-3151
Fax +1 (506) 433-6151

Email: sales@microhydropower.com
Website: www.microhydropower.com

www.microhydropower.com

PO Box 4557, Sussex NB
Canada E4E 5L7

Phone +1 (506) 433-3151