APBA 125 Modified Racing with the PRD Fireball

LESSONS LEARNED FROM THE 2018 INAUGURAL SEASON

WITH CONTRIBUTIONS FROM BRIAN MITCHELL, JERRY DAVIDS, JEFF WILLIAMS, GARY MILLER AND STEVE ROSKOWSKI WITH THE GRACIOUS SUPPORT OF THE APBA MODIFIED RACING COMMISSION

APBA
AMERICAN POWER BOAT ASSOCIATION

APBA 125 Modified Racing

Lessons on the PRD Fireball 125

Contents

All photos herein by the authors and/or used with permission.

Please read this guide in its entirety before starting assembly of your powerhead – learn from the lessons of participants from the inaugural year of PRD Fireball outboard racing, and be sure to pass back anything you learn along the way that could help other racers.

Most importantly, have fun!

Overview

The PRD Fireball is two-stroke, single-cylinder, water-cooled, racing motor originally designed for competitive kart racing, and adapted by the APBA Modified Racing Commission as a powerhead for outboard racing. This document is intended to provide information about how to prepare and use this motor, and to share what was learned during the inaugural racing season. All information provided in this document is done without warranty or guarantee, and each mechanic/racer is encouraged to use this thoughtfully in support their own PRD Fireball experience.

General consensus through the 2018 season seems to be that AX/A-size runabouts work well, but you will want a larger A or 15SSH size hydroplane as the speeds are currently running around 60mph in hydroplane class.

Engine Management

A Mychron 5 2T or similar engine management tool is VERY helpful when setting up and managing the PRD Fireball for racing. Like any racing motor, you can tune your setup using information collected in testing and in practice. Monitoring temperature and RPM will go a long way to understanding your setup and how changes in setup are affecting your performance. The PRD Fireball has an integrated port in the side of the water jacket for installation of a water temperature gauge. This, when combined with a Cylinder Head Temperature (CHT) gauge on the spark plug provides great information for tuning. Racers are finding head temps in the 220-240°F range and water temps in the 130-150°F range under racing conditions. RPMs around 12,000-13,000 are common on the best running rigs at this time.

The tachometer/RPM sensor for the MyChron is seen wrapped around the spark plug wire.

The 14mm Cylinder Head Temperature (CHT) sensor is mounted under the spark plug against the head.

The water temperature sensor is seen mounted in the side of the cylinder wall in the factory-provided port.

Powerhead/Tower Assembly Notes

There are many options to mount the powerhead to a midsection/tower for racing. The OMC 15 tower which uses a transom height of about 18". As a result this height is nearly identical to the Mercury 15 used in APBA "AX" and "A" classes allowing boats to be used across categories. Further the OMC tower requires no modification using the PRD with the powerhead adapter available from Brown Tool & Machine (BTM).

The Roskowski tower was designed specifically with the PRD Fireball in mind for shorter Yamato-cut transoms. This all-in-one unit requires no further adapter plate and is prepared to accept the powerhead and pro-style gearfoot. This tower does lower the overall center of gravity for the motor package.

NOTE: Although the crankshaft is balanced in the PRD Fireball, the motor does experience more vibration than a two or four cylinder model. This vibration is completely manageable with proper maintenance. **Loctite thread locker should be used on mounting screws throughout the powerhead, including the carburetor nuts.**

MUFFLER SUPPORT BRACKET

Like other modified engines with a muffler/pipe extending aft of the motor, the muffler support plate designed for the PRD Fireball requires bracing to prevent the muffler from bouncing and placing unnecessary stress on the motor. There are many options for creating a brace and securing it to the motor but many racers are using 1-1 ½" aluminum bar at least ¼" in thickness. This bar is then bent and secured to the muffler support plate and the cavitation plate as shown.

General Electrical Information

The PRD Fireball is powered by a battery ignition system. Unlike many of the other outboard two-stroke racing motors in use today, the PRD does not have a magneto under the flywheel or magnets on the flywheel itself. As a result, the motor requires a solid external 12V power source to operate both the starter and maintain the ignition circuit. Note that a weak or discharged 12V battery may not have adequate power to maintain the ignition circuit during the starting process. If this occurs the motor will crank and may even appear to run momentarily, but not maintain ignition as the starting amperage discharges the battery momentarily below the ignition cut-off. It would be possible to separate these circuits and use separate starting and ignition power sources but you would need to consider implications of the added weight carrying a second battery.

Operating the ignition for racing requires the use of an appropriate kill switch for an electronic ignition system. This circuit is normally closed, meaning the circuit is connected during operation (this is opposite of a magneto ignition system), and activating the kill switch will open the circuit killing power from the battery. Mercury makes an electronic cap style ignition (part # 525-368100) which has worked very well for us. Note also that your wiring must be well maintained because any disconnection of this circuit as a result of frayed wiring or loose connectors will open the circuit and kill the motor as well.

The ignition circuit requires a ground/negative (-) connection to the ignition coil and block, and a power/positive connection to the positive (+) side of the battery.

There are many possibilities for mounting your brain/switch box (PRD calls it the "Modular RPM Control Sensor"), including mounting it to the flat side of the engine where the standard kart mount would typically attach. You may also wish to mount your starting switch on this same plate. It is a good idea to isolate the switch box from the motor using rubber/neoprene washers or bushings.

You will want appropriately sized wiring to operate the starter and the additional power/amperage requirements of the starter circuit and button. 10 gauge silicon-jacket wire commonly used in solar power systems works very well and is available with quick disconnect harnesses. This is quite similar to a trailer wiring solution but much heavier duty and is available through Amazon (search: “10 gauge solar” for wire and pre-built connectors).

NOTE: If you use these connectors, for safety please use the female red/positive connection on your battery side. This protects the positive connection from the battery from accidently making contact with a ground, the motor, or the negative battery post. Take this advice, you have been warned!

REGARDING THE KART KILL SWITCH

Your PRD Fireball kit may include a kart-style kill switch which is used as a pressure switch in a kart and is installed under the seat. You do not need this part, and it confuses the assembly process. Throw it away now or you will carry it for years in your motor box, and wonder later what it was for.

REGARDING LITHIUM BATTERIES

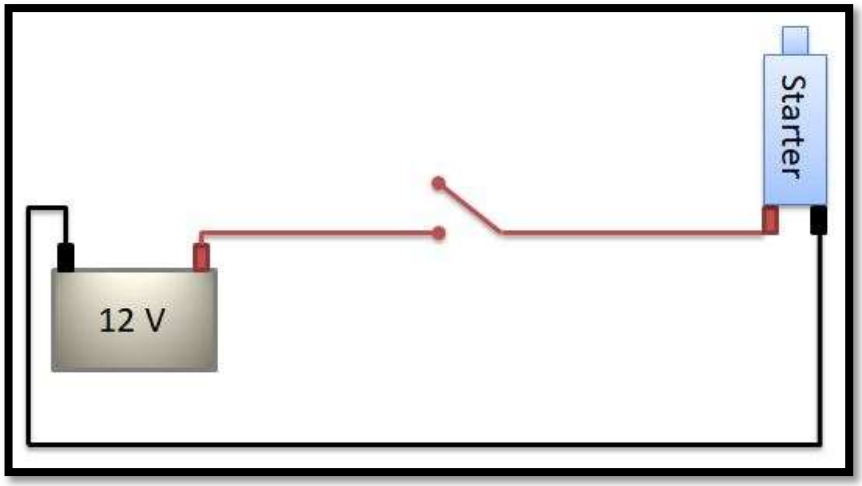
They're so incredibly light, and they often come with a fancy integrated charge-level meter so you can see the charge level. And they also have an integrated automatic cut-off so you don't accidently discharge the battery below the minimum level that will render your lithium batteries into useless bricks. However, as pointed out earlier about the amperage draw of the starting circuit, this automatic cut-off does not care if you are in the middle of turn 2 on your third lap…and it will protect the battery, kill the power (and your motor) if your voltage level falls below the preset cutoff level. Proceed with caution and ensure your lithium battery is adequately sized for a weekend of racing.

ELECTRICAL DIAGRAMS

There are two electrical circuits on the PRD Fireball. One controls the starter and the other the ignition.

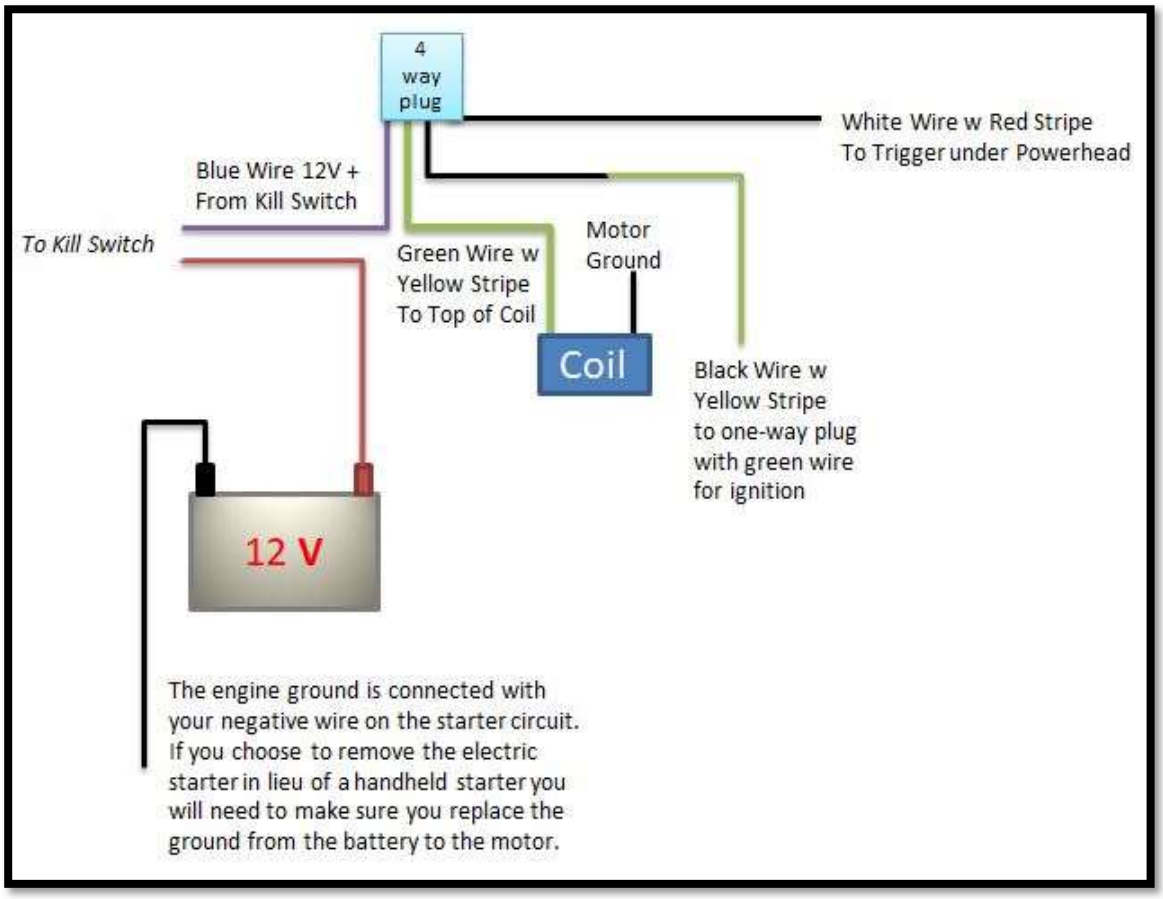
<u>Starter Circuit</u>

The starter is powered by the 12v battery and a button that can be mounted on the engine or on the dash. Be sure to use appropriate wire for this purpose as the momentary amperage draw can be quite high. 10 gauge silicon jacket wiring, such as that used on solar panel installations, is great for this purpose and can be purchased from Amazon. As discussed earlier, please be mindful of where you expose the positive connection from the battery and do not allow it to ground against any part of the motor to prevent accidents.



Ignition Circuit

The ignition circuit is 'live' once the kill switch is connected, and maintaining a continuous 12v ignition circuit is crucial to operation of the PRD Fireball. If the kill switch or any part of the ignition wiring is fraying, worn or loose you may struggle to keep the engine running. If you are having problems starting your engine, start by verifying connectivity throughout the ignition circuit.



Assembly Notes:

1. *Be careful not to crush the white trigger wire under the powerhead when mounting the adapter plate!*
2. *The large gauge 3" black wire in your PRD kit connects between the ignition coil plate and the powerhead to support grounding of the motor and coil.*
3. *Be sure to make solid connections using quality waterproof butt connectors, solder connections and/or heat-shrink tubing. Attention to detail makes a reliable motor!*

Motor Break-In

The break-in process for the PRD Fireball as discussed in the factory manual requires a series of heat cycles under varying loads on the race track. For outboard racing you can emulate this process with a test wheel and using a water/bilge pump adapted to your powerhead at the shoreline or in a test tank. A small (e.g.: 400-600 GPH) bilge pump from your local marine/boat shop powered with a 12V battery can be connected to the water intake on the powerhead to provide cooling during the break-in process. See photograph below. During a cool-down cycle you can run the pump with cool water to accelerate the overall cooling process.

NOTE: Although the gear foot does not contain an impeller there is running friction on the seals and gears in the lower unit, so it is advisable to keep the gear case submerged for adequate cooling during this process.

NOTE: During the running/heat cycle you may find that the water pump cools a little too much so you might find restricting water flow at the outlet improves the ability of the motor to heat sufficiently for break-in.

Break-In Process – Derived from PRD manual:

All sessions using a test wheel or small / low-pitch propeller using a conventional oil (DO NOT use synthetic motor oils for break-in processes)

Sessions 1-4

Length: Varies – usually 3-5 minutes per session

Process: Warm up slowly varying speeds from closed to ½ throttle.
DO NOT EXCEED 11,500rpm in this session.
Do not exceed 150 °F on head temperature – warm it up, once it reaches 150 °F, stop the motor and allow it to cool down completely. You may choose to accelerate the cool down for the next session by keeping your water pump running after the engine is stopped. For reference a hand placed on the side of the cylinder will become uncomfortable to the touch around 145-150 °F. If your motor is struggling to reach this temperature you may need to restrict water flow slightly at the output.

Session 5

Length: 5 minutes

Process: Varying speeds from closed to ¾ throttle

Session 6

Length: 5 minutes

Process: Vary speeds from closed to full throttle. After running up to full throttle, quickly place your hand over the carburetor intake and remove to allow a rich burst of fuel into the cylinder

After break-in, a motor compression check of 180-185psi (cold) is common.

Gasoline / Oil

The PRD manual recommends using 92 octane or greater fuel. Per discussion with kart racers, a quality 110 leaded racing gasoline is common for these motors in kart racing, and is our current outboard racing fuel of choice (e.g. VP 110). Testing this powerhead as an outboard motor has been done with 90 octane non-ethanol "marina" gas with no apparent loss of power or motor issues, but proceed at your own risk. A good quality fully synthetic racing oil or synthetic-castor oil blend is recommended to prevent issues with lubricity if your motor experiences excessive heat.

Recommended Fuel-Oil ratio for racing: At least 8:1. The PRD manual recommends 10:1.

Propellers

From factory specifications, the PRD Fireball is capable of 26hp and redlines at 16,000rpm.

Racers have found the motor makes good power at 12,000-13,000 rpm for outboard racing. You will want a MyChron or some other tachometer to monitor engine RPM and other metrics to maximize the potential of your motor.

We have had good success with 2-blade KG-4 propellers and 3-blade propellers originally made for the PRO 125 class that were designed for 11:15 gear ratios. This motor needs to be able to make sufficient RPM in order to get in the optimum torque range. Propellers in the 5.5-6" diameter with 7-9" pitch work very well.

Muffler Installation

The PRD Fireball muffler is secured to the exhaust header with 5 springs which are readily available from karting supply stores. A spring installation/removal tool such as those used for drum brakes on cars is incredibly useful to prevent springs from flying all over the pits, and is much easier to use than needle nose pliers.

This Klein 6" Spring tool can be purchased from Amazon for about $8.

Starting

Starting the PRD Fireball is usually very easy so long as your battery is charged and your kill switch is working (and supplying power to the ignition). Our starting process is:

First start of the day (after rigging the boat):

1) Connect the battery wiring and kill switch
2) Throttle is completely off
3) One hand completely over the carb air intake
4) Press the starter button
5) This process will turn the motor over, choking it to crank and power the fuel pump diaphragm in the carburetor to draw fuel up the line from the fuel tank. Once fuel reaches the carburetor entrance, let off the power button and remove your hand from the carburetor.

After priming and for starting during a race:

6) Now, give it just the slightest amount of throttle to crack the butterfly, and press the starter button. The motor usually starts pretty quickly at this point.
   DO NOT try to start a cold PRD Fireball with a half or wide-open throttle as this motor likes to be warmed up just a little bit before getting too much throttle. *Otherwise, it will quickly flood, and this is one of the most common problems we learned very early on. As a kart motor and originally designed to be used with a centrifugal clutch, it will happily idle at low RPMs to get a little heat in the powerhead. We found that warming the motor lightly and getting the fuel flowing was essential to consistent prompt starts when the green flag flies.*
7) If you flooded it, remove the spark plug and clean it with starter fluid to dry the plug. Reinstall and go back to step 6.

Launching

When starting for a race – follow step 6 under "Starting" above, once started, rev the motor quickly 2-3 times to ensure throttle response is good and the motor is not flooded, then squeeze to full throttle and slide the boat forward.

> **NOTE:** Due to the powerband of the PRD Fireball, it generally needs to be running at/above 9,000 rpm during the launch in order to keep the motor from dying when it is released. **Do NOT lift and just drop the back of the boat into the water** until you have fully tested your setup. *Lift the back of the boat, start the motor, rev it 2-3x, squeeze the throttle fully and slide the boat forward gently to keep the rpms up during the initial release.*

Troubleshooting a motor that will not start

Think: Heat, fuel and oxygen

- Make sure your battery is adequately charged and plugged in
- Make sure your kill switch is working and supplying power to the ignition circuit.
- Make sure your spark plug wire is securely fastened to the spark plug and did not vibrate loose
- Make sure your positive power lead from the battery to the ignition circuit is connected and not frayed/loose

Carburetion

The Tillotson HL360A carburetor used with the PRD Fireball includes an integrated fuel pump. The metering diaphragm in the carburetor eliminates the need for a float and bowl, and for boat racing this also reduces the amount of liquid area where water might hide during a dunking!

The carburetor includes both a low and high speed adjustable jet. Tiny movements of these settings will make noticeable differences in engine performance.

Recommended Carburetor Base Settings

Tighten/close each jet very gently until you feel firm resistance as the jet closes completely, then open/unscrew according to the table below. Keep notes on your settings using various propellers, setups, altitude and/or weather conditions for maximum performance. Closing the jet will reduce the amount of fuel going to the cylinder and will 'lean' the ratio of fuel to the incoming air. Opening the jet will increase the amount of fuel to air, creating a 'rich' setting. Finding the correct ratio for your setup creates the best performance. If your motor is hard starting or dies when launching, make sure you have adequate low speed needle to keep the engine running when the RPMs are lower.

HIGH SPEED	1 ¼ Turns
LOW SPEED	1 ½ - 2 ½ Turns

NOTE: If you have not tuned a two-stroke racing motor, be very careful not to make your fuel-air mix too lean. Start with a richer fuel setting and carefully back this down during testing while monitoring engine temperatures and plug color. Your motor will likely get faster as you lean out the mixture up until the point it overheats and/or performs some other catastrophic failure if you fail to monitor your setup.

You can use the color of the white ceramic tip of the spark plug to gauge your ratio. A rich mixture will turn chocolate brown while a lean mixture will turn white/cream colored. Here is a photo of a plug tuned light brown and is running just about perfectly:

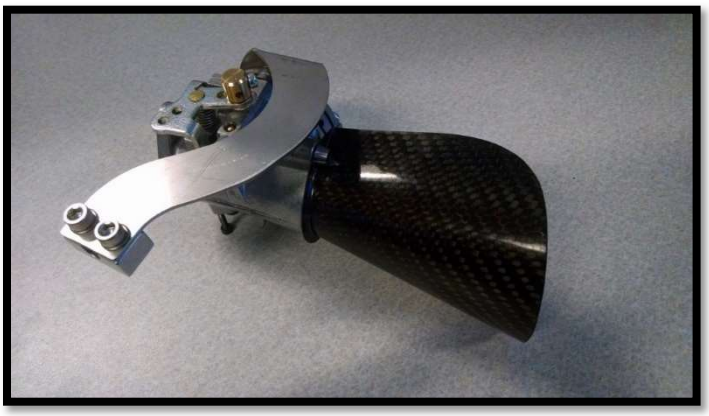
NOTE: The inherent vibration of a single-cylinder motor and the physically aggressive motion of a racing boat may allow the adjustment of the low and high-speed jets to move from vibration unless you take special measures to help lock them into place once you have completed adjustments.

Solutions for securing the carburetor jets:

- Use fine stainless wire through the opening in the center of the "T" screw on the high speed jet and secured around the carburetor

- Place spacer washers under the resistance spring and stretch the resistance spring on the screw to provide additional resistance
- Use a tiny bit of medium strength Loctite on the thread to stiffen the movement. Do NOT allow Loctite on the end of the jet or in the inlet or you will affect your ability to tune the mixture!

Due to the water spray involved in outboard racing you should consider placing some sort of spray shield over the carburetor air-intake. Steve Roskowski makes a fine carbon fiber shield for this purpose, or you can purchase an air-intake mount through a kart shop. If you purchase an air-intake from a kart shop you can use a PVC plumbing 45 degree elbow to make a shield. Gently heat the PVC using a heat gun or stove (do not breath the fumes!) until it softens and you can test the fitting on the air intake mount. Once it cools, you can make relief cutouts in the PVC and secure it with a stainless worm-drive clamp.



The Roskowski spray shield and throttle adapter shown mounted on a Tillotson HL-360A carburetor used on the PRD Fireball:

PVC-style carb spray shield with the Roskowski throttle adapter.

Drying from a Dunking

Due to the single cylinder and the design of the carburetor, the PRD Fireball has proven thus far to be relatively straight-forward to dry out after being submerged. The starter housing is generally water resistant being sealed with a rubber O-ring. After a dunking the starter should be fine for use to help pump water from the wet motor.

Steps for Drying

- Remove the spark plug
- Disconnect the fuel line from the carburetor
- Disconnect the kill switch or unplug the ignition circuit
- Disconnect and remove the muffler – dump any water from the muffler
- Lock the throttle open to provide good fresh air intake
- Press the starter button, activating the starter to pump water from the cylinder and crankcase
- Squirt a generous amount of WD-40 into the carburetor to help displace water from the motor while the motor is being cranked
- Empty the gas tank, dry the tank as necessary, and refill with fresh gas
- Reinstall the spark plug by making it finger tight and then backing out 1 full rotation – this will help allow any excess cylinder pressure from residual water or WD-40 to minimize blowing head gaskets or rings.
- Reconnect the plug wire, reconnect the kill switch or ignition circuit
- Start as you would a cold/unprimed motor
- Once the motor has been started and running for 20-30 seconds you may stop the motor and tighten the spark plug fully
- If you have any problems check the troubleshooting list – pay special attention to connectivity/power from the battery and that your kill switch is working.

NOTE: There is a small bowl formed in the top of the starter housing below the bendix (drive gear) where the shaft exits the starter itself. You will want to remove the 2 screws to drop the starter from the motor to clean any residual water, or you might also tip the motor sideways to dump water from this bowl. Just be careful about making certain this area is dry before storing the motor.

NOTE: If you do decide to disassemble the starter, the brushes/springs are contained in the end-cap with the exit of the drive shaft. After removing the screws that secure the end-cap to the bell-housing, *firmly grip the drive shaft* and pull the bell-housing to separate the end-cap containing the armature, brushes, and springs from the bell-housing. Apply a touch of light grease on the oilite bushing in the bell-housing and a drop of oil on the bearing in the end-cap for maintenance.

Engine Tightening Torque Settings

Copied from the PRD Fireball Manual, available from PRD Racing Engines.

These are recommended measurements that suit most cases. There could be some variation caused by temperature or altitude.

ENGINE REBUILD SPECS

Cylinder head squish clearance 0.8mm (.0314) thick base gasket

Cylinder head squish clearance 0.7mm (.0275) thin base gasket

Piston ring gap 0.3mm Min (.0118)

Piston ring gap 0.45mm Max (.0177)

Piston to cylinder clearance 0.1mm Min (.0397)

Piston to cylinder clearance hot weather 0.125mm (.0492)

NGK B8XX plugs are good for run in and racing

ENGINE TIGHTENING TORQUE SETTINGS

Cylinder head 14 ft/lb (168 in/lb)

Spark plug 12 ft/lb (144 in/lb)

Crankcase bolts 7 ft/lb (84 in/lb)

Rotor mounting nut 15ft/lb (180 in/lb)

Carb nuts 5ft/lb (60 in/lb)

Exhaust nuts 14ft/lb (168 in/lb)

Reed block nuts 5ft/lb (60 in/lb)