PWC Carb Tuning Documents

TABLE OF CONTENTS

Group K, Part I

CARBURETOR FINE TUNING GUIDE by Harry & Gerhard Klemm / GroupK

While there seems to be an abundant number of folks selling high performance carburetors and carb kits, there seems to be a desperate shortage of folks providing "understandable" carburetor tuning information. For the 8 or 9 warmer months out of the year, getting a knowledgeable technician to talk to you on the phone about adjusting "your carb on your boat" is darn near impossible.

For the knowledgeable and experienced (read: very very busy) technician, few things are more frustrating than trying to explain fine tuning procedures, along with the history of carburetors, over the phone. It's even more frustrating if that same technician knows it's a carburetor you bought from somebody else (someone who won't help you tune it).

The following is a guide to help you avert being that unwelcome caller. Good technicians, no matter how busy, are usually glad to help someone who has covered all the basics and just requires detail information. The following guide is an easy to understand outline of "those basics". We hope you find them helpful.

UNDERSTANDING SOME BACKGROUND

The two generations of carbs - Before 1989, virtually all pwc's utilized the "round pump" Mikuni carbs. These carbs came in 38mm and 44 mm sizes only. These "round pump" carbs performed well, but they were somewhat temperamental because the round diaphragm pumps often had difficulty supplying enough fuel to high output racing engines. In 1990, both Mikuni and Keihin introduced "square pump" style carbs. The fuel pumps on these carbs produce more than double the fuel pressure of the earlier "round pump" designs. Among other new design features, the square pump carbs also have changeable high speed and low speed jets. These changeable internal jets allow for very accurate mixture adjustment on a broad range of engine formats.

External adjustments - Virtually all pwc carbs have a high speed and low speed fuel mixture adjustment screws. The adjustment screw positioned closest to the air intake (top) is always the high speed fuel mixture screw (30%-100% throttle range). The adjustment screw closest to the mounting surface (bottom) of the carb is always the low speed fuel mixture adjustment (0-35% throttle range). As these screws are turned out, the fuel mixture is made richer. All adjustment settings are noted as "turns out" from the bottomed out position. That is, "1 turn out" means 1 turn from the bottomed closed position.

Power tuning - Many shops offer "power tuning" as a means of adjusting carburetion. The boat is held stationary in a test tank or on a trailer backed into the water so that adjustments can be made while the engine is running under a load. This type of tuning is adequate for getting carburetion close, however it is by no means an effective way to achieve the ideal mid-range or full throttle carb settings. Power tuning does not simulate the added loads of the water drag on the hull surface, the rider's weight, or high speed water being loaded into the front side of the pump. These collective loads make "riding on the water" the only accurate way of evaluating carburetion settings on a high output watercraft.

Reading spark plugs - Determining proper fuel mixture by inspecting the color and condition of the spark plugs can be very helpful in situations where the engine is being operated constantly at full rpm under full load. "Reading plugs" for perfect fuel mixture is very common in high speed auto and motorcycle racing where the engines are nearly always run at full rpm and full load. Closed course pwc racing, however, requires as much "partial throttle" operation as full throttle. Furthermore a pwc racing engine seldom experiences full steady loads because of the rough water conditions. This means that spark plug readings, done on a pwc that is being ridden on a rough water course, has very questionable accuracy.

To get an accurate plug reading on a pwc, a fresh set of spark plugs should be run in the machine for 3-5 minutes at full throttle/full rpm on relatively smooth water. At the end of the full throttle running, the throttle should be chopped and the kill button pushed simultaneously (called a "plug chop"). If the engine is run at partial throttle for even 3 seconds after the full throttle run, the plug reading will be invalid.

After the full throttle running, and the plug chop, a combination flashlight/magnifying glass must be used to view the carbon deposit at the base of the porcelain (down inside the spark plug where the porcelain insulator and outer steel spark plug casing meet. A ring of dark brown at the base of the porcelain denotes ideal fuel mixture, light brown is lean, and a ring of black is over rich. This is the only area of the spark plug that accurately indicates fuel mixture. Furthermore, this reading only indicates full throttle fuel mixture. No part of the spark plug can indicate low speed or mid range fuel mixture. The upper part of the spark plug porcelain (by the electrodes) is often very light or white in color, however this coloring is mostly affected by additives in the gasoline and oil. The coloring of the end of the porcelain in no way indicates appropriate fuel mixtures of any throttle range. The cosmetic appearance of the spark plugs can defiantly help a pwc mechanic to quickly diagnose the symptoms of a major operational problem. But as far as carb fine tuning for personal water crafts is concerned...reading plugs qualifies as a very questionably accurate way to fine tune the carbs. Very few professional PWC engine builders recommend their customers to do carb fine tuning based on plug readings...and even fewer engine builders do it themselves.

The weather - Weather and altitude can defiantly be a factor during fine tuning. The factors that will require you to go leaner are, higher altitude (changes of 1000 ft. or more), higher temperatures (changes of 20' F or more), and higher humidity (changes of 20% or more). Water temperature itself (55-85'F) seems to have very little effect on fuel mixture. It seems that the big changes in weather that come with very warm water, and very cold water are what actually affect the mixture.

BEFORE YOU ENTER THE WATER

Air leaks - The lower end of a two cycle engine must be air tight to about 10 psi. If there are any minute air leaks at a crank seal or a gasket surface, tiny amounts of air will intermittently leak into the lower end and cause a temporary lean condition. As a matter of reality, about 50% of the engines on an average race lineup have an air leak. Most of those leaks are not big enough to cause chronic hard-starting or piston seizures, however they are usually big enough to cause on-going jetting problems.

As the castings of an engine expand and contract with heat, so too can the air leaks change to admit greater and lesser amounts of outside air during operation.

Group K offers an inexpensive pressure test kit that allows you to quickly check for, and locate, any potential air leaks your engine may have. An engine with a small air leak will never carburate consistently. Remember...air leaks never get smaller.

Reeds - If your reed petals are chipped or frayed in a way that does not permit perfect sealing, the low speed and mid range circuits will be very difficult, if not impossible, to set accurately. Damaged reed petals will cause a false low speed rich condition, not to mention hesitations in mid range that you will not be able to carburate out. Installing aftermarket reeds will often require significant changes in cab adjustment.

Carb gaskets - Confirm that these gaskets have a soft drying sealer (like Gaskacinch or Permatex Hi-Tack or 3Bond 1211)on them, and that the carb mounting bolts are torqued.

Confirm full closing and opening - With the flame arrestor(s) off, be sure that the carb butterfly(s) can close completely with the handle pole all the way down and the handlebars in the full left and right positions.

Pressure test fuel system - All pwc utilize a sealed fuel system that has a check valve on the gas tank vent. This check valve (which permits pressure in the gas tank but not out) causes pressure in the gas tank that helps deliver fuel to the carb(s). Any air leak in the fuel system that permits the leaking off of this pressure, will also affect fuel delivery to the carb(s) at low speeds. To test for leaks, follow this procedure. 1) remove the return line from the fitting on the carb. 2) Blow into the return line while sealing off the return fitting on the carb with your finger. This will pressurize the entire fuel system. In a quiet room you'll be able to hear any remaining leak in the fuel system. When you remove your finger from the fitting on the carb, fuel will eventually drip out indicating that the float chamber is primed full of fuel.

Return line restrictors - The round pump 44 Mikuni carbs were manufactured with an unrestricted return fitting on the carb. This causes them to return so much fuel to the tank that the fuel circuits can get starved for fuel. If you are using a round pump 44 Mikuni, be sure you have a restrictor jet in the return line whose inside diameter is no more than .030" (.75mm) All of the new generation square pump carbs have adequate "built in" return line restrictors.

Spark plugs - Most machines can safely use NGK #8 heat range spark plugs. However, in situations where you're trying to resolve a serious rich condition, it's best to do your preliminary tuning with #7 heat range plugs. After the tuning is done, however, return to the #8 heat range.

Pop off pressure - This term refers to the amount of fuel pressure needed to push the float needle valve away from it's sealing seat. Pop off pressure is checked with a hand pump that is fitted with an in line gage. The pump is connected to the fuel input fitting of the carb. The return line fitting is then sealed off with one finger while the pump pressurizes the float chamber. The pressure reached on the gauge when the needle gives way is called the pop off pressure. "Adjusting" the pop off pressure is discussed below. If you don't have a pop off pressure gauge, you should get one that has a gauge and pump capable of 30 psi. (Most Mikuni distributors carry them) At the beginning, it's only important to check that the needle holds the pressure back with no leaking up to the point where it pops cleanly away from the seat. Perform the pop off test several times to confirm the actual pop off pressure. Initial pop off pressures on round pump carbs should be between 8 - 12 psi. Initial pop off pressures on the square pump Mikuni and Kiehin carbs (unless otherwise specified) should be no less than 25 psi and no greater than 35 psi.

Dual carbs - Racing has certainly popularized dual carburetors. However having dual carbs is not necessarily the passport to big time horsepower. Dual carbs usually require a little more maintenance and on going adjustment. If putting up with that is not your cut of tea, you'll probably get all the performance you need, along with all the simplicity you want, from a good aftermarket single carb upgrade kit. If you've decided that aftermarket "duals" are for you, the pop off pressure between them should not vary more than one psi. Of equal importance, before doing any fine tuning, visually confirm that both throttle butterflies are closing completely and opening at the same instant. When setting the mixture screws, the settings should always be kept identical between the two carbs unless otherwise specified by the carb kit maker or your engine builder.

LOW SPEED ADJUSTMENT 0% to 35% throttle range - In 90% of all cases, the low speed mixture screw can be accurately set without riding the machine. Secure the boat on a submerged trailer or standing in about three feet of water. With the engine completely warmed up, set the carb up to a slightly higher than normal steady idle. Turn the low speed mixture screw in or out in 1/4 turn increments. As you get closer to the ideal setting, the engine rpm's will increase. If the idle speed is increased by this mixture adjustment, turn the idle speed adjustment screw down and continue the same process in 1/8 turn increments. At the ideal mixture setting, 1/8 turn in a richer or leaner direction will cause a very un-steady idle and cause the engine to die. To confirm your perfect low speed mixture setting, touch the kill button during idling...and then touch the start button about ten seconds later. The engine should restart instantly and idle steadily without touching the throttle.

Some race engines with heavy mid range fuel demands may eventually require as much as 1/4 turn richer adjustment from this ideal setting point, however the need for an over rich low speed mixture setting usually indicates an unacceptable lean condition in the mid range. Avoid running an over rich low speed mixture screw setting in an effort to cure a mid range hesitation (lean condition).

If you find that your ideal mixture setting is less than 1/2 turn out from bottoming, you should probably consider going to a slightly leaner (smaller number) internal low speed jet. If you find that your ideal setting is beyond 2 turns out, you should consider a slightly richer (larger number) internal low speed jet.

HIGH SPEED ADJUSTMENT 30% to 100% throttle range - The greatest fear of most racers is that of seizing an expensive engine as a result of running an excessively lean high speed fuel mixture. Some old racers contend that maximum horsepower is attained with a high speed fuel mixture that is at the brink of piston seizure. This fable is not true...and it never has been. Where high output pwc engines are concerned, the ideal high speed mixture is the richest setting that still permits strong acceleration up to peak rpm. With this in mind, it is always wise to start out slightly over rich and slowly lean the mixture out. If the high speed mixture is too rich, the peak rpm's will "sign off" prematurely. If the high speed mixture is too lean, you'll experience weak or "lazy" mid range acceleration.

You'll eventually find a narrow adjustment range where peak rpm operation seems unchanged. However, within this range, there should be a noticeable difference in mid to high range acceleration. Finding the setting, within this range, that gives the best "middle through high range acceleration" usually requires a couple of back to back 10-15 minute evaluation rides.

TRANSITION RANGE ADJUSTMENT 20% to 50% throttle range - The early style "round pump" 44 Mikuni is the only pwc carburetor ever manufactured with an external transition range adjustment screw. On the new generation square pump carbs, the manufacturers have abandoned the idea of this third adjustment screw because it caused so much confusion for the average watercraft owners and mechanics. The transition range of the new generation carbs is adjusted by changing the pop off pressure. These pop off pressure adjustments are made by way of various combinations of needle/seat sizes and float arm spring tensions.

In short terms, the transition circuit is richened by reducing pop off pressure with larger needle/seat sizes, as well as shorter or weaker tension float arm springs. The various combinations of larger needle valves and weaker springs result in a wide range of lower pop off pressures. Measuring the pop off pressure is how you determine whether you have made the transition circuit richer or leaner (higher pressures are leaner, lower pressures are richer) Most racing engines prefer very low pop off pressures because they demand so much fuel in the mid range. Unfortunately these low pop off pressures can often create an undesired (and nonadjustable) rich condition in the 0 - 30% range. This nonadjustable rich condition takes place at about 9 psi on the Mikuni square pump carb and about 13 psi on the Keihin. Running pop of pressures this low is not recommended. Ideally, you want to run the highest possible pop off pressure that permits "hesitation free" mid range throttle response.

AFTER TUNING - After you've found the best settings for your carb, make a record of it. By far the best place for this record is the inside of your hood, written in bold felt pen. Denote the final adjustment settings and the pop off pressure. If space permits, record your high and low speed jet sizes, as well as the day's temperature.

LATENT FUEL PRESSURIZATION - The powerful fuel pumps on the new generation Mikuni and Kiehin carbs has mandated a need for much higher pop off pressures than that of the earlier round pump carbs. Pop off pressures in the 25-35 psi range are very common. Without these high pop off pressures, the powerful fuel pumps would quickly flood the motor. All in all, this combination of a powerful pump working against a high pop off pressure is superior in all functional ways...except one.

When the engine is at rest, the pressure in the fuel system is virtually nil. As the engine is started, there is easily enough fuel delivery and fuel pressure to feed the meager needs of the low speed circuit for idling. However when the throttle of a "just started" engine is drawn slightly, a temporary lean condition of the transition circuit often causes the engine to hesitate badly or even stop altogether. This lean condition takes place because the fuel pump has not yet fully pressurized the float chamber of the carb. The 20% - 50% range transition circuit is solely dependent on full float chamber pressure in order to deliver it's fuel. Full float chamber pressure usually takes place after about 10 or 15 seconds of operation under a load. For a recreational rider who is slowly riding away from the beach , this momentary lack of low speed acceleration is no problem. However for the racer who must start an engine at the line, and operate it at little or no load before the start, this momentary lack of acceleration can be a big problem. If you are running dual carbs, this fuel pressurization problem can become even worse.

Unfortunately the only mechanical ways to reduce this hesitation problem is to reduce the fuel hose length, reduce the internal air volume of the fuel system, or slightly reduce the pop off pressure.

On most stock fuel systems the pump must draw the fuel through about three feet of hose from the gas tank to the fuel valve. After that, through another two feet of hose and a fuel filter. This long length of hose saps off a significant amount of fuel pressure and increases fuel pressurization times. To help resolve this on race boats, a direct line should be run from the reserve pickup on the gas tank to the carb. Along with this, it should be understood that the air space in the fuel system is the area that must be pressurized. If the air space is reduced by filling the gas tank, pressurization takes less time. Unfortunately many racers don't like the "nose heavy" handling that a full gas tank yields. For them a smaller gas tank is a wise solution.

The risk of inducing an over rich transition circuit mixture makes "pop off pressure reduction" an absolute last resort choice for solving the latent fuel pressurization that takes place in the starting area of a race.

Group K, Part II

CARBURETOR FINE TUNING GUIDE 1998 by Group K

The technicians of Group K intend this document will provide the most current possible fine tuning information for the Mikuni "Super BN" and "I" series, as well as the Keihin CDK II series carbs as they are applied to personal watercraft. This document is an update of our first carb tuning document. We strongly recommend the reading of that document before reading this one.

Happy Reading, The Technicians of Group K

The Goal - "Seamless" Metering

Everyone wants to have a machine with perfectly tuned carburetion, but not everyone knows what that means. Technicians describe perfect carburetion as being "seamless" throughout all throttle settings. That means you can hold the throttle at any setting without experiencing any sputtering (from being rich) or any hesitations (from being lean). Furthermore you should be able to move swiftly from any throttle speed to another, without experiencing any "stumbling" or "surging". Starting should always be instant, idling should always be smooth and steady, and acceleration characteristics should always be consistent and predictable.

In the real world, all this doesn't happen too often…even on stock boats. The skilled carb specialists that work for the boat manufactures have a tough time meeting all these goals on stock boats for two basic reasons. First, and foremost, there is a wide variation in air density due to variations in altitude, air temperatures, and weather conditions. Setting up one carb that can work perfectly under all these various conditions is impossible. Secondly, as engines become more "high breed" (i.e. produce more horsepower per cc) they become much less tolerant of "less than ideal" calibration settings. If you modify your pwc for higher performance, you increase this intolerance for settings that are not "close". Along that same line, high output race machines have a very narrow tolerance for settings that are not "right on the mark".

While you may never achieve absolutely perfect calibration of your carb(s), you can still make big strides toward better reliability and "predictable" operation of your high performance pwc by performing some basic fine-tuning. If you can't get "seamless" metering…"predictable" metering is the next best thing. The purpose of this document is to help you get as close as possible to that point. We will also attempt to dispel many of the myths and "old wives tales" that makes carb tuning appear to be some kind of black magic. No wand is required.

Carb Choices - If your machine has stock carburetors (along with some other mild modifications), the job of fine tuning will not be too difficult. If you are installing an aftermarket carb of some kind (that has not been pre-set for your engine arrangement)...you have your work cut out for you. In particular, if you are applying a carburetor that does not employ the use of a "bombsight" type fuel atomizer in the carb throat (Buckshot, RedTop, BlackJack, etc.), it's unlikely that you will ever attain seamless overall carburetion. The design of these "non bomb-sight" carbs inherently flows very well at full throttle, however they meter fuel very erratically at low and partial throttle settings. This erratic low speed metering can be minimized if you choose a throat size that is not much larger than stock. However few buyers of aftermarket carbs seem to make that choice. The result of choosing oversized, non bomb-sight carbs is that you may encounter on going difficulties achieving "predictable" metering, especially at low speeds. This is no big deal for pro racers, but it can be a very big deal for just about everyone else.

Piece-meal Carb Sets - Lots of enterprising back yard mechanics enjoy constructing, and dialing in, their own carb setups. These setups are often a collection of a carb from this buddy along with another carb from that buddy, and a manifold from yet another pal. The biggest risk involved with this kind of piece-mealing is variations in the carburetors themselves. An example is a customer who used a 44 Mikuni off his Blaster, and another 44 Mikuni off his buddy's 650 Super Jet to make a dual 44 carb kit. While the two 44 carbs looked identical externally, the internal circuitry drilled into the carb bodies (from the factory) was very different. This hidden variation between the two carbs made it impossible to get them to meter the same in this dual carb application. The carb manufactures have numerous internal "blueprint" variations of each particular carb body. All these variations are designated at the factory as different "blueprint numbers". Over 2 dozen different "blueprint number" variations of the Mikuni 44mm Super BN have been brought into the USA by different oem and aftermarket suppliers. If you intend to piece-meal together a carb kit for your machine, do whatever you can to assure that the carbs your starting out with are as identical as possible.

Along this same line, do not assume that the "jetting" in the large carbs of a new model will work the same in the piece-meal set you are trying to tune in. Each new boat has it's own exclusive internal circuitry that will cause it to meter differently (and require different jetting) from any other "blueprint number" carbs.

Tools of Tuning - For many years, the standard way to confirm good carburetion was via "reading" spark plugs. While that procedure wasn't perfect, it was a good as any other procedure. Today, reading plugs is a very vague (and risky) way to confirm carburetion. Because of all the solvents present in the additives of today's new reformulated fuels, a clear "reading" takes much longer (in operating minutes) to get. By then you can have already seized a piston.

By far the most accurate and effective tool for carb tuning is a good digital tachometer. The digital tachometers found on Sea Doo and Polaris pwcs have excellent accuracy and update times. We highly recommend that owners depend on them. As for aftermarket tachometers, the two most popular types are the "Tiny-Tach" (about $50), and the PET2000/2500 (about $180). The Tiny Tach updates the rpm about every 2.5 seconds. This means that the Tiny tach must see the same sustained rpm for 2.5 seconds to yield an accurate number. While that can be suitable for general recreational use, we consider 2.5 seconds to be too long for effective carb tuning. The PET tachometers update twice a second (like the stock Sea Doo and Polaris tachs). This quick update is an essential feature for safe high speed tuning…particularly on race engines.

Before Testing Begins - You may want to review our other carb tuning document for "before tuning" information. Here, we will add a couple of additional inspections.

In-Carb Fuel Filters - Both Mikuni and Kiehin carbs have internal fuel screen filters that must be clean before tuning. The Mikuni filter is a black plastic "bucket" that is fitted underneath the fuel pump side of the carb. In the Kiehin, the filter screen clips directly onto the bottom of the brass fuel needle and seat.

Needle and Seat condition -- Virtually all pwcs now come with float needles that are fitted with rubber tips that seal against the brass fuel inlet seat. These rubber tips offer much better sealing than the metal tips used only a few years ago. However these rubber tips are not "forever", and they often develop slight leaks when exposed to excessive high frequency vibration. Revving a pwc engine into a higher rpm range contributes to this kind of vibration. When a float needle becomes damaged, it will usually begin to leak a small stream of excess fuel into the carb throat at idle speeds, and during throttle release from high rpms. This leakage can easily be seen while looking down the throat of the carb at idle speeds. We have dubbed the faulty needles that cause this leakage as "dribblers" because of the fuel that visibly dribbles out of the center atomizer at idle speeds. It is impossible to attain seamless or predictable metering with a dribbler in a carb. We have seen countless owners spend all day trying to tune away a low speed rich condition caused by a dribbler…you will never do it. Keep in mind that many heavily modified IJSBA tour machines vibrate so intensely that tuners will change the float needles in between races to avoid the risk of a poor start caused by a dribbler.

Don'ts - DO NOT attempt any kind of carb fine tuning in rough water conditions … it's a waste of time. Smooth water allows you to feel (with great accuracy) when you have made metering better or worse. Smooth water also allows your tachometer to yield the most accurate readings.

DO NOT change any engine parts, exhaust system adjustments, fuel mixes, or octane levels during the course of a test. All these factors can cause significant changes in metering.

DO NOT attempt carb fine tuning on a machine that is over propped. The excessive load of an over-pitched prop will make it impossible to feel subtle changes in throttle response and acceleration.

Jetting With ECWI - Electronically Controlled Water Injection (ECWI) systems are becoming more and more popular in high performance pwc exhaust systems. These aftermarket systems offer huge increases in power between 3500-6500 rpm by injecting additional water into the interior of the headpipe during those rpms. While these systems are very effective in improving low-end power, they can also "very effectively" mask a low range metering difficulty. This masking becomes so profound that low speed fine-tuning becomes almost impossible to confirm. To avoid this masking, we recommend that you do as much low range jetting as possible with the ECWI system disconnected. This is easily done by disconnecting the wires between the solenoid and the driver. The rest of the ECWI plumbing can remain in place without creating any problems. Once your jetting is completed, re-connecting the wires will restore the full function of the ECWI.

Seizures - Perhaps the greatest fear that most folks have, related to carb tuning, is the risk of accidentally inducing piston seizure. This fear is well founded, but the true nature of the seizures is usually misunderstood. The sophisticated ignition curve of modern pwc reduces the likely-hood of piston seizure related to slightly lean high speed mixtures, but seizures that are a direct result of detonation have become much more commonplace.

Power Peak Seizures - This is the failure that used to be most common. However for modern pwcs to experience "lean mixture" seizures at full throttle, the mixture has to be "very" lean. The digital tachometer can easily show a rapidly decreasing rpm trend that tells the operator that full throttle seizure may be eminent. However, of equal occurrence on modern pwcs, is 7/8-throttle seizure. This "7/8-seizure" takes place on arrangements that rely on large high speed screw openings (2 turns or greater) to operate. While this subject is covered later in this document, we would recommend that any machine with high speed screws set beyond 2 turns out be fitted with a richer main jet (5 - 10 numbers richer).

Mid Range "Torque Peak" Seizure - This type of seizure is becoming much more common on modern pwcs. The newer boats have ignitions that are very retarded at idle speeds, then reach their advance peak around 6000-6200 rpm. After the peak advance, the timing retards slightly as rpms escalate. The rpm where ignition timing reaches maximum advance is usually the "torque peak" of the power band. That means that the engine is generating more sheer torque, per revolution, than at any other engine rpm. If your carburetion has an extreme lean condition in the mid-range, you can ride full throttle all day long. However the first time you release the throttle into that lean middle range, the combination of the lean mixture, and the heavy timing advance, can create detonation that will result in a swift piston seizure. The rider seldom suspects a lean mid range, and begins looking for other gremlins (air leaks, etc). It bears noting that a prop with too much pitch can cause exactly the same problem. The higher pitch will cause the rpms to be significantly lower (closer to the torque peak) at full throttle. The lower rpm number means more advanced timing, at full throttle, that can (once again) result in detonation ... and seizure. At Group K we recommend against aftermarket ignition components that have more "advanced" timing curves, because this added advance compounds this same "torque peak" seizure problem. We seriously question the benefits of any additional ignition advance (over stock) on modern pwcs, particularly in cases where pump gasoline is being used.

Fuel Metering vs Fuel Delivery - We think it's very important to distinguish between fuel metering and fuel delivery so that their symptoms are not confused. Fuel delivery is the function of the fuel tank and fuel pump that refers to the adequate supply of fuel (and fuel pressure) to allow for precise metering by the carb(s). Fuel metering refers to the function of the jet circuits in the carburetor accurately delivering the correct amount of fuel for good operation. It often happens that a fuel pump, or fuel system, does not provide enough fuel delivery to allow for correct metering. A perfect example is 1100 Yamahas that have been fitted with big-bore top end kits, and 44mm carbs. The pumps on the 44 carbs can meet the demands of the larger displacement cylinders, but the flow capability of the fuel petcock (on/off/reserve) valve, and the stock 1100 fuel pick-up tube cannot pass enough fuel to serve this modified motor.

Another common example is the 785cc Sea Doo models. The stock fuel pump on these models is rated for 10 gallons per hour of output. This is plenty of fuel for moderately modified machines. However if you install an exhaust system that increases rpms beyond 7200, the stock pump will be at (or beyond) it's ability to deliver enough fuel for the engine to operate at peak rpm. The result can be intermittent fuel starvation at peak rpm (a very difficult problem to diagnose). To assure that you are not creating a fuel delivery problem, seek the advice of your engine builder and/or carb supplier.

Mikuni Pumps - The Mikuni fuel pumps (both remote and carb mounted) are very efficient units. However they can be susceptible to damage by engines whose lower ends have been filled by fluid (fuel or water). A machine that has been sunk will usually have the entire lower end of the motor filled with water. If the start button is pressed on such an engine, the pistons will hydraulically lock against fluid in the lower end.

In the Mikuni fuel pumps, there are two small, round siphon diaphragms made of a clear plastic. When the force of a hydraulic lock from the lower end makes it's way up the pulse line to the fuel pump, these two diaphragms take a heavy sudden impact. This impact can buckle (or crease) these diaphragms in the pump. If these diaphragms are damaged, in any way that compromises a perfect seal against the aluminum pump surface, the pump's efficiency can be seriously compromised. In other words, if your lower end has ever been filled with liquid, these diaphragms in the fuel pump must be closely inspected.

Air Conditions - The prevailing air density of the moment plays heavily into the performance ability of a high output pwc engine. Heavy air density is offered by low altitudes, low air temperatures, low humidity, and high barometric pressures. Of these, the variable that changes performance (and carb settings) most is air temperature. It often happens that a machine, that got it's last fine tuning session in the heat of late summer, is run for it's first annual outing in the frigid (and very oxygen rich) air of early spring. The relatively lean settings that were ideal for last summer are usually much too lean for safe operation in the oxygen rich air of early spring. Add to this the low specific gravity of heavily oxygenated winter fuels (which further leans out mixtures) and you have an ideal recipe for a pre-season piston seizure. If you plan to operate a high output pwc in a wide range of air temperatures (or air densities), be wary of the fuel demands that will accompany those weather conditions.

The Circuits - Since the writing of our last carb tuning document, much new specification information and test data has caused us to re-examine the range of effect of the various circuits. Some of the following information, as it reads, conflicts slightly with our previous carb tuning document. We have no interest in describing the differences, we will only intend to draft the best current tuning information that we can, based on the information we have to date…that's just the way R&D work goes sometimes.

Pop Off Pressure - The pop off pressure is not an adjustment that exists on the carb, but rather a specification that is a combined function of the needle valve size, and the spring rate of the float arm spring. This specification has a wholesale effect on the fuel metering in the 0 - 40% fuel range. Because the pop off pressure has this far reaching range that overlaps with several other metering ranges, we consider it a fundamental starting point.

The term "pop off pressure" refers to the amount of fuel pressure needed to push the float needle valve away from it's sealing seat. Pop off pressure is checked with a hand pump that is fitted with an in line gage. The pump is connected to the fuel input fitting of the carb. The return line fitting is then sealed off with one finger while the pump pressurizes the float chamber. The pressure reached on the gauge when the needle gives way is called the pop off pressure. "Adjusting" the pop off pressure is discussed below. If you don't have a pop off pressure gauge, you should get one that has a gauge and pump capable of 30 psi. (Most Mikuni distributors carry them) At the beginning, it's only important to check that the needle holds the pressure back with no leaking up to the point where it pops cleanly away from the seat. Perform the pop off test several times to confirm the actual pop off pressure. Initial pop off pressures on the Mikuni and Kiehin carbs (unless otherwise specified) should be no less than 25 psi and no greater than 35 psi.

We will address pop-off adjustment again later in this document, but the pre-existing effect of the pop-off on other ranges must always be kept in the fore. There is no specific "ideal" pop-off pressure for all engines. But when the pop-off is far off of "ideal spec" for a particular engine format, it can cause the other circuits to not come into adjustment or not function properly.

In short, the pop-off pressure should be changed if a collection of low range circuits cannot accommodate the current pop-off specification. The best indicator of this is the setting of the low speed adjustment screw.

Low Speed Screw - Theoretically, "every" pwc engine (no matter how radically modified) should be able to start with the touch of the button (no throttle required) and then maintain a reasonably steady idle. Even engines with enlarged and modified throats should be able to deliver this type of operation.

The low speed screw should be adjusted to the setting that offers the highest "sustainable" idling rpm. This setting is easiest found by viewing a digital tachometer with a warmed up machine running in the water (tied to a trailer is fine). As richer and leaner settings are tried, you will quickly see the trend toward higher idle rpms. In truth, you will see the highest rpm when the low speed screws are slightly too lean. However you will notice on the tachometer that those high rpms will waver up and down, not steady and sustained. You will eventually find a range of about ¼ turn that offers this good idle (about 1300-1400). Within this adjustment range, find the setting that allows the engine to come down to the same steady idle rpm after you snap the throttle open momentarily. An additional test of the perfect setting is to stop the engine (about 30 seconds), then restart without touching the throttle. In this test the engine should come back to it's normal steady rpm number.

The low speed adjustment screw carries it's greatest impact in the 0 - 20% throttle opening range. It continues to have a lesser impact up to 40% opening. The low speed screw setting is almost wholly responsible for allowing easy starting and steady idling. We say "almost" because the pop-off pressure can affect the setting of the low speed screw that will finally offer the ideal starting and idling that you want. As an example, an engine with dual 38 carbs may have a pop off pressure of 35 psi, and offer perfect starting and idling with the low speed screws set at 2 ½ turns out. In a perfect world, it's desirable to have the low speed screws end up "in the vicinity of" 1 turn out. The 2 ½ turns of our example is actually an excessively rich compensation for a pop-off pressure that is too high. By reducing the pop off pressure, with a lighter pressure float arm spring, the entire 0 - 40% range is slightly richened. This additional richness will allow for a much leaner (closer to 1 turn out) screw setting that will offer perfect starting and idling. It has been our experience that the pop-off pressure that allows for this "close to 1 turn out setting" will also usually yield the best overall low speed response. If you find your best operation at a setting of less than ½ turn out, the pop-off pressure should be raised slightly. If you find your best operation at a setting above 2 turns out, the pop-off should be lowered slightly.

Needle Valve and Seat - The popular size Mikuni needle valves are 1.5, 2.0, 2.3, and 2.5 (these numbers designate the orifice size in mm. Some stock boats come with other sizes as well: 1.2 in the GP 1200, 1.8 in the 950 Sea Doo. The larger seat diameters will yield lower pop-off pressures. As a rule of thumb, we recommend to use the smallest diameter needle valve/seat that allows the pop-off pressure you are seeking. We recommend this because the smaller diameter seats are less susceptible to vibration leakage/damage, and therefore far less likely to turn into "dribblers". Always use the same size seats in multi-carb arrangements.

Float Arm Spring - These small springs are the preferred way to adjust pop-off pressure because they are inexpensive and easy to change. Lighter weight springs will yield lower pop-off pressures. The standard weights are 65 gm (silver), 80 gm (black), 95 gm (silver but wound the reverse of all the others), and 115 gm (gold). Here too, the springs (along with the pop-off pressure) should not be varied in multi-carb arrangements.

Low Speed Jet - Unlike the low speed jet in many motorcycle carbs, this low speed jet actually has the bulk of it's affect in the mid-range (30-60% throttle). It is common to make significant increases in low speed jet size without having to re-adjust the low speed screw at all (to compensate). The same cannot be said for the pop-off. Changes in the low speed jet will overlap into the pop-off circuit, thus requiring a slight adjustment to the pop-off to attain seamless metering. Unfortunately, even small adjustments to the pop-off (at this time) will require a slight re-adjustment of the low speed screws to regain perfect idling and starting.

The low speed jet is the primary range of affect in situations of "torque peak" seizures. That's because, the low speed jet is the primary circuit of feed when you release to a half throttle "cruise". It often happens that an engine will run reasonably well with a slightly lean low speed jet. This is why torque peak seizures have become much more common. That's also why we recommend to step up on pilot jet size until you experience an apparent mid-range richness that the adjustment screws cannot clear up. If your pop-off/low speed screw combination is well set, you will easily feel the over richness of a lightly oversized low speed jet.

Accelerator-Pump Carbs - Many late model pwcs are coming, from the factory, with accelerator-pump carbs. These carbs have an injector nozzle (fed from the float chamber) that delivers a small spray of raw fuel into the carb throat(s) when the throttle is applied quickly. When the throttle is applied slowly, this system injects little or no fuel. The advantages of this system are many. First and foremost, it allows for a big improvement of low range throttle response on engines that have relatively mild compression ratios. Another big advantage is the reduced sensitivity to slight lean conditions throughout the low speed ranges. The low speed adjustment screws on these accelerator-pump carbs can be set at a slightly leaner setting that permits for very clean and smooth "5 mph zone" operation. Settings this lean (on a non accelerator-pump carb) would likely exhibit a bottom end hesitation when the throttle was applied quickly from idle. When adjusting the low speed screw on these accelerator-pump carbs, we recommend to avoid settings that offer even the slightest rich condition during idling rpms.

High Speed Jet / High Speed Adjustment Screw - While the main jet does effect metering up to 100% throttle, it's primary feed range is the 60-90% range. It can easily happen that a high speed jet can be slightly too lean, yet safe 100% throttle operation can be had by putting the high speed screw to an over rich setting (over 2 turns out). The high risk of this situation is a swift piston seizure if the throttle is relaxed to 80% after a long full throttle pass. At 80% throttle, the high speed screw is not very effective, and it's piston-saving fuel supply is greatly diminished. With the engine still running within 90% of peak rpm, yet the fuel supply cut by much more than that, a piston seizure is not far away.

One method the boat manufactures have used to avoid this risk, is to use a high speed jet so large that the high speed screws must be set at 0 turns out (completely closed that is). This arrangement also eliminates the risk of a customer setting his high-speed screws any leaner than stock. While it sounds a bit unusual, the idea of running closed high-speed adjustment screws has some very sound technical merits (besides the protection against accidental lean settings). Many technicians feel that doing all the high speed metering with the high-speed jet (alone) offers for much more accurate metering of fuel in multi-cylinder applications. While we tend to agree with that concept, making high speed fuel adjustments with the internal jet only is a major pain in the rear. We prefer to make a compromise between these concepts by using main jet sizes that allow for high speed adjustment settings of less than one turn out. We have found that this approach virtually eliminates the occurrence of 7/8 throttle seizures.

Setting The High Speed Adjustment Screw - Few carb adjustments get more attention than the high speed screws. As previously mentioned, we are not big fans of spark plug "reading" as a fine tuning procedure. "Reading" plugs is still a great way to monitor the long term operation of your pwc engine. However, given the high solvent additive content of today's pump gas, plug reading is among the most risky and inaccurate ways to fine-tune the high-speed circuit.

The most accurate means of setting the high-speed circuit is by peak rpm numbers, as indicated by a good digital tachometer. This testing "must" be done on (a large area of) smooth or glass water conditions. With the engine well warmed up, bring the boat quickly up to peak rpm and observe the peak rpm numbers. With a perfectly set high-speed screw, the tach numbers will peak out, then fluctuate up and down within a 30-rpm range. If the mixture is lean, the engine will accelerate strongly up to peak rpm, and then begin to descend steadily without ever stabilizing or raising back up. This situation requires some judgement with respect to the rate of rpm decline. If the rpms decline at the rate of 10 rpm every 5 seconds or longer, the lean condition is slight. If the rpms decline at a rate of 10 rpm every 2 seconds or faster, you have a severe lean condition that can result in seizure if the run is sustained. No matter what the rate of descending rpms, after a loss of 50 rpm or more, the risk of seizure becomes very real. The full throttle pass should be stopped, and a richer setting should be tested.

It bears noting that poor octane fuels (for the compression or rpm range you are running) can also cause a constant trend of declining rpm (a result of the build up of excessive heat). If this happens, and you insist on using the insufficient octane fuel, you will have difficulty stabilizing peak rpm. To avoid the non-stop loss of peak rpm, you will need to set the high-speed screws so over-rich that you will not be able to attain the true rpm peak. This is the performance compromise of low octane gasoline's.

Low-Speed Jet / High Speed Jet Combination - While these two jets (the smaller is the low speed, the larger is the high speed) in the internal chamber of the carb body cover different throttle ranges, those ranges are directly next to one another (along with a certain amount of range overlap). While these jets operate in the same chamber, they have very different operational characteristics. The low speed jet has the brunt of it's impact in the mid range, and delivers fuel all the way to 100% throttle. If you increase a low speed jet from a #70 to a #80, that additional increment of 10 is also present at 100% (full) throttle. This means that if you wanted to increase the fuel delivery though the entire middle and upper throttle range (all the way to 100%), it can be done solely with a low speed jet change. This also means that an increase in low speed jet size would require an equal decrease in main jet size if you wanted to retain the same mixture, as before, in the high range.

Uneven Jet Sizes - Before you embark on re-jetting your pwc, you would be wise to disassemble the carbs to determine the exact jetting of each individual carb. Most of the new pwcs are coming from the factory with different size high and low speed jetting for different cylinders. The term for this is "staggered", or un-even, jetting. Our web document "Rear cylinder Piston Seizures" covers the reasoning behind this in detail. As a rule, we recommend to maintain the "stagger" of the factory jetting when increasing high or low speed jets.

About Take-Offs - Perhaps the biggest area of difficulty, with respect to jetting, is accommodating the different kind of take-off styles of recreational riders. Keep in mind that most professional tour racers perform relatively high rpm starts with two powerful holders controlling the machine. For them, seamless low speed metering that can cleanly and instantly accelerate away from idle or 5 mph zones is a total non-issue. As a result few modified racing carbs, and few tuners hold these abilities as a high priority. In the "real world", those are very big priorities.

While seamless carburetion is certainly supposed to result in instant acceleration under any conditions…that cannot always happen. The most difficult scenario is what we call the "Saturday-Nite" take-off. As it infers, the operator wants to position next to his buddy while setting still in the water, then bolt away by instantly grabbing the throttle to 100%. This may have worked out well for 60's musclecars, but it seldom works out well for recreationally modified pwcs. When a pwc accelerates casually away (instead of bolting) from a Saturday-Nite start, the first thing the owner thinks is that he is under powered or his carb adjustments are off. While one of these may be true, there are many other contributing factors as well.

For many of the new larger and heavier pwcs, there is a tremendous amount of wetted hull surface when the engine is at idle. When the hull is on plane, a big percentage of that wetted surface no longer has contact with the water. This additional water contact surface area (at idle) adds a lot of surface drag that significantly slows down the rate of acceleration in those first few moments of the SN start. This same

heavy machine, just barely up on plane, will accelerate away with all the authority that the owner is looking for.
An additional factor for many machines is the lack of water pressure to the headpipe during a "SN" take-off. Most high performance pwc owners are aware of ECWI systems (electronically controlled water injection). As previously mentioned, these aftermarket systems offer huge increases in power between 3500-6500 rpm by injecting additional water into the interior of the headpipe during those rpms. This water is injected to supplement the (low-end assisting) water already being supplied to the headpipe by the stock cooling system. However when a rider positions in the water (at idle speeds) next to his buddy, the water pressure being delivered into the headpipe is very low to non-existent. As a result, there is no "low end" enhancing water pressure in the headpipe when the throttle is instantly applied. The result is very weak low range acceleration when the throttle is suddenly snapped full open. Here again, having the machine just barely up on plane assures that there is an adequate supply of water in the headpipe to offer the bolting take-off that the rider was looking for.
Even with all this, there are some situations where a "planing" low speed start can still yield a take-off that is "mediocre". In many of these cases, the problem can easily be resolved by grabbing only partial throttle on the initial take-off, then drawing to full throttle once on plane. This effective tip works so well because, at partial throttle (50-70%), the carb butterfly position allows for strong inlet tract vacuum that picks up fuel very efficiently under heavy loads. The sudden low inlet tract vacuum, caused by an instant opening to 100% throttle, does not pick up fuel from the fuel circuits very efficiently, therefore does not offer very strong initial acceleration.
Modified Throat Carburetors - Many shops, Group K included, offer modifications to the throat diameters of various models. Of these modifications, we categorize them in to two basic groups, "bomb-sight atomizer" and "non bomb-sight atomizer". There is little doubt that Non-bsa designs (BuckShot, RedTop, BlackJack, etc.) have better cfm (cubic feet per minute) flow "at full throttle" than the bsa designs. Unfortunately, all this flow typically comes with very significant compromises and difficulties in seamless low and middle range operation. Furthermore, because the non-bsa designs do a very poor job of directing the partial throttle air directly over the low speed transition circuits, they are notorious for requiring constant adjustment for subtle changes in air conditions. We have yet to see any non-bsa design (of same diameter) that can match the overall performance and user friendliness of the bsa designs. For detail on this subject, see our Sea Doo 785 Updates document for the entry titled "Large Carbs Pt 2".
Of all the aftermarket carb modifications, we consider the latest designs from Novi (in North Carolina) to be the top of the heap. The thing that sets the Novis apart from the others, is the intent to improve overall performance by improving overall metering and mixing. The accent is on the maximum efficient overall operation, not on "maximum cfm no matter how big the compromises are". The Novi design uses their own patent pending bomb-sight (they use the automotive term "booster venturi") design that is intended to dampen the reverse waves from the lower end that cause an uneven delivery of fuel at various rpms. It also makes for increased signal strength at the main jet. The net result of this dampening is much cleaner overall carburetion, as well as a higher peak rpm ability. The higher rpm comes from the reduced tendency for the carb to "go rich" at high rpms. "Going rich" is the term for a carb that is losing it's ability to precisely meter fuel in the very high rpm range (largely due to those strong reverse inlet tract pulses).
Overall, these carbs will be far less vulnerable to changes in air density than the non-bsa carbs. The will also rpm as well as the larger throat non-bsa designs, without taking on the low inlet tract airspeeds that hamper low rpm response. As an added benefit, the Novi design will get considerably better overall fuel consumption (than the non-bsa's) because of the much better atomization at all the partial throttle settings.

Tau-Ceti Group

Accurately tuning a PWC carburetor requires a basic understanding of its functions and adhering to a few basic rules. Most importantly, you can only expect the carb to work as well as your engine does; the performance of your carb cannot make up for a weak or worn out engine. Another point to stress here is that you may not be able to achieve maximum performance from your watercraft simply by changing jets in the carb. A mismatch of engine components and or porting may create a carburetion nightmare. The best advise is to use quality parts and service from reputable dealers. To achieve an accurate calibration with a carb you should adjust the tuneable circuits in the following order:

1. LOW SPEED ADJUSTER -To adjust a smooth idle
2. POP-OFF PRESSURE -Just off idle to 1/4 throttle in conjunction with the low speed jet.
3. LOW SPEED JET -Just off idle to 1/3 throttle.
4. HIGH SPEED JET - 1/3 to 3/4 throttle.
5. HIGH SPEED ADJUSTER -3/4 to wide open throttle.

The reason for adjusting the circuits in this order is because several circuits contribute to the total fuel delivery of the carb. Changing the low speed jet for example, affects wide open throttle fuel delivery to some degree The exceptions to the rule are the low speed adjuster and the regulator portion: the low speed
adjuster has no effect past 1/3 throttle. The regulator portion has no tuning effect past 1/4 throttle, although it continues to control the fuel supply.

IDLE STOP SCREW
The idle stop screw is used to adjust the idle speed (rpm) by opening or closing the throttle valve. Refer to your watercraft owners manual for the correct idle speed. As a rule of thumb, adjust the idle speed to approximately 1100 rpm.

LOW SPEED ADJUSTER
The low speed adjuster is used in conjunction with the idle stop screw to adjust and maintain idle speed and smoothness. Experiment turning the low speed adjuster in and out in small increments until a smooth idle is obtained. As the idle stop screw is turned in our out to raise or lower idle speed the low speed mixture is also affected. For clarification, if the idle stop screw is turned out to lower idle speed, this action increases manifold pressure slightly and richens the low speed mixture so that a mixture adjustment may be required. The low speed adjuster is very sensitive and adjustments should be made in small increments only.

Note: Remember, the low speed adjuster is only for adjusting the idle mixture. If you use the adjuster to help get rid of a low speed hesitation, you will probably find that your engine will load up in no wake zones, or after extended idling.

POP-OFF PRESSURE AND LOW SPEED JET

How do pop-off pressure and the low speed jet work together?

These two circuits overlap, although the low speed jet continues past 1/4 throttle where pop-off pressure has little to no effect. In general, if your pop-off is slightly too high, you can compensate by increasing the size of the low speed jet. The opposite is also true; if the low speed jet is slightly too small, you can compensate with less pop-off pressure. Once you get to the point where you think each is adjusted correctly, it's best to try varying the two to make certain you have the best combination. For example: If you have pop-off pressure of 30 psi and a 67.5 low speed jet, you should also try a pop-off of say 35 psi and a 70 low speed jet. To verify that you have the correct combination there are two things to test:

1. Throttle response should be crisp, with no hesitation.

2. Ride the boat at a constant 1/4 throttle opening for about 1 minute and then quickly open the throttle fully, there should be no hesitation and the engine should not show signs of being loaded up. If it hesitates, it's lean; if it's loaded up, it's rich. The first test is to check pop-off pressure, the second test is checking the correctness of the low speed jet size. Take the time to ride the boat slowly and thoroughly test your jetting changes. After a jet change, it takes the engine a few minutes of use to completely respond to the change.

When does it become necessary to adjust pop-off?

When personal watercraft come from the factory they have fairly high pop-off due to the fact that they also have somewhat restrictive air intake systems that cause the engine to generate very high manifold pressures; the higher the manifold pressures, the higher the pop-off pressure required to properly regulate the fuel delivery to the engine. As you modify or change your watercraft's flame arrestor to a less restrictive type you will most likely start to experience a lean hesitation caused by a decrease in manifold pressure. This change will require an adjustment in pop-off pressure to regain crisp throttle response. Because most
aftermarket flame arrestors are less restrictive than stock, you will need to decrease pop-off to compensate.

The Super BN carbs that come from Mikuni America are already set up for performance applications, and come with pop-off settings lower than the carbs that come as original equipment. Pop-off pressure, (the regulator portion of the Super BN) is a tuneable component of the Super BN and works in conjunction with the low speed jet for good initial throttle response. The components that make up the regulator portion of the Super BN are:

1. Needle Valve, available in 4 sizes, 1.5, 2.0, 2.3 and 2.5 (Note: Some OEM carbs have 1.2)
2. Arm Spring, available in 4 sizes, 115gr., 95gr., 80gr. And 65 gr.
3. Arm

4. Regulator Diaphragm

The arm has a limited range of adjustment; from the arm being level with the adjacent carb surface to being bent upwards no more than .040" (1mm) above that surface. If the arm is bent upwards too much, it can cause the needle valve to be held open when the diaphragm and cover are installed. If the arm is bent down, its movement becomes limited and may not be enough to allow the needle valve to open fully.

ADJUSTING POP-OFF PRESSURE

Pop-off pressure is adjusted by replacing the arm spring with one of a different gram rating. Sometimes, in order to achieve the desired pop-off pressure, it is also necessary to change the needle valve size; keep in mind that it's always best to use the smallest needle valve size to obtain the correct pop-off pressure.

MEASURING POP-OFF PRESSURE

You can measure pop-off pressure with a "pop-off" pump, available from Mikuni through your dealer.

CHECKING POP-OFF WITH A POP-OFF PUMP

1. Attach the pump to the fuel inlet nipple.
2. Cover, or in some way plug the fuel return nipple.
3. Remove the regulator diaphragm to observe the needle valve.
4. During testing, it is important to obtain consistent readings. To accomplish this, it is necessary to keep the needle valve wet. Use WD-40 or something similar to wet the needle valve. Note: Don't use gasoline because of the fire hazard. Protect your eyes from the spray when the needle pops open.
5. Pressurize the carb with the pump until the needle valve pops open, being careful to note the indicated pressure. Test the valve 3 times to assure an accurate reading.

An indication that your pop-off needs to be adjusted is a lean hesitation when you open the throttle from idle; in the extreme, the engine may even die. It is much easier to detect a lean pop-off than it is a rich one, so it is wise to adjust your pop-off until you get it too lean and then back up until the lean hesitation disappears.

Note: It is recommended that you do not use too large a needle valve for your application. Many tuners recommend using 2.3 or 2.5 needle valve in all cases. Actually, we recommend using the smallest needle valve that gives you the correct pop-off pressure for your engine. A 1.5 needle valve can flow the maximum amount of fuel that the Super BN can pump, so the only reason to use a larger needle valve is to obtain the correct needle valve and arm spring combination (pop-off) for your watercraft.

HIGH SPEED JET/THROTTLE POSITION AND JETTING

The high speed jet begins contributing fuel at about 3/8 throttle, overlapping the low speed jet. The high speed jet is the primary tuning component from ½ to 3/4 throttle. As you have probably noticed, tuning circuit operations are denoted in fractions of throttle openings.. the reason for this is simple: Carb jetting does not relate to engine rpm or the boat's speed, it only recognizes how far the throttle has been opened; each circuit of the carb responds in turn. This is why it's very important, when trying to diagnose a carb problem, that you identify at which throttle opening the problem occurs, in order to adjust the appropriate circuit.

The procedure for testing for the correct high speed jet size is the same as for the low speed, except that you should now hold the throttle at a constant ½ open for one minute, then quickly open the throttle fully to check engine response. If the engine hesitates, the carb is lean. If the engine takes a second or two to clear out and then accelerate, the carb is too rich. In either case, make the appropriate jet change and do the complete test again.

HIGH SPEED ADJUSTER

The high speed adjuster is the last circuit to adjust. It primarily controls fuel delivery from 3/4 throttle to wide open throttle. Turning the screw clockwise reduces fuel flow, counter clockwise increases fuel flow. The maximum fuel flow is achieved at three turns out from closed. To test the high speed adjuster it is recommended that you start with a fresh set of spark plugs to get quicker plug readings. Unless you have an exhaust gas temperature gauge, you will have to rely on plug readings. You will need to be in an area where you can hold the throttle wide open for several minutes (Factory Pipe suggests that you only do this for about 30 seconds, longer times with a lean setting could cause engine damage) then chop the throttle and stop the engine just prior to removing the plugs to read them. Ideally, you're looking for a nice brown color on the electrode

Another indicator of proper adjustment is a maximum rpm reading on a tachometer. If the carb is lean or rich, it won't pull as high an rpm reading as when it's right on.

PERFORMANCE TIPS

The "Left Turn Syndrome"

You will find in all instances that your watercraft will turn more easily to the right than to the left. The reasons are basically simple. First, engine torque constantly places pressure on the hull to turn right. If your engine's performance is marginal, you can notice a dramatic fall-off in power in a hard turn. This power fall-off can't always be blamed on the engine, being over-propped can also cause the engine to slow enough to fall off its power peak. An engine with a peaky power curve is especially susceptible to a very dramatic power loss in a hard left turn. Most recently, with the increase of Sport and Runabout racing, there has been a marked improvement in hull design with a dramatic increase in "G" forces encountered while turning: over 2.5 G's. In some instances such a hard turn can cause momentary loss of power due to fuel starvation in the carbs. Jetting changes cannot correct this situation, the best solution is to rotate the mounting of the carbs 90 deg, so that their throttle shafts are perpendicular to the crankshaft axis rather that parallel. To date, this solution to the problem has been 100% successful.

Fuel Dripping From The Inner Venturi At Idle

This situation occurs periodically and is easy to cure. What causes this problem is a combination of two things. First, low pop-off pressure (due to installation of a 2.5 needle valve with a light spring pressure) together with an engine that has substantial vibration at idle. The engine vibration causes the needle valve to leak, which causes the engine to run even rougher. You can view this occurrence by carefully looking into the throat of the carb at idle, you will be able to see fuel dripping from the inner venturi. In this same way you can also check to see that the problem is corrected. The cure for the problem is to increase pop-off pressure until the dripping stops.

Engine Hesitation When Accelerating After a High Speed Deceleration

You may find it desirable to increase the number of anti-siphon valves (part# BN34/107), If you ride very fast and find that you have a noticeable stumble when reopening the throttle after a long, high speed deceleration. This is caused by excess fuel in the carb. The engine revs fairly high while decelerating, but it uses very little fuel. The fuel pump still pulses hard, but there is no demand for the fuel. A small amount of fuel will overfill the fuel chamber, leak through the high speed circuit and get deposited on top of the closed throttle valve. This fuel causes a momentary rich condition when the throttle is reopened. The solution is to use one or two additional anti-siphon valves. Never use more than two extra, and recheck your calibration after installing any extra valves; in some cases extra valves can adversely affect throttle response.

SBT – General Tuning

In order for your new engine to run correctly, you must adjust the carburetor(s). First you must be sure that the carburetor(s) are clean. You should disassemble the carbs, clean them, and install a new carb kit. This is called rebuilding the carb(s). We have provided step-by-step guides for doing this here.

To disassemble the carbs, you need to have a clean work area. A muffin tin or egg carton will come in handy for those small parts. To clean the carbs you can cold dip them, however since most people don't have a cold dip tank in their garage, you could take the carb to someone who does, or you can try another method. Go to your local auto parts store and buy a can of carb cleaner. Disassemble the carbs. Place all the little parts in the muffin tin or egg carton. The can of carb cleaner should have a straw that attaches to the nozzle. With the carb cleaner spray through each passageway (wear safety glasses). You should see fluid come out of the other end of the passageway. If nothing is coming out the other end, then get a piece of wire (about the size of one strand from a throttle cable) and run that through the passageway, until you can spray all the way through the passageway. Repeat this procedure until all the passageways are clear. Also remove any corrosion and loose paint from the carb, inside and out.

Next, you need to have a rebuild kit. Reassembling the carb is straight forward, just the reverse of disassembly plus there should be instructions in the kit. Two things you may need to do while reassembling the carb is adjust the control arm level and the pop-off pressure. The control arm level is different for each type of carb, but flush with carb body will usually work. To adjust the pop-off pressure you must have a pop-off pressure gauge. You can order these where you got the carb kit or you can take it to a shop and have them adjust it. Pop-off pressure is different for each carb, but 20 psi will work on most Mikuni square bodies and 23 psi will work on most Keihins. Once those two jobs are done all you have to do is reassemble the carbs.

Once the carbs are reassembled and installed (always use new carb base gaskets), the carbs have to be adjusted. The proper way to adjust the carbs is to take the craft to a body of water, but before you do that you can make some pre-adjustments. Find your low and high speed screws (the low speed is lower on the carb and the high speed is higher). The low speed screw is easy to find and may have a t-handle for ease in turning. The high speed screw may have a plastic cap on it. You will have to remove the cap in order to adjust the carbs (it just pulls off). If you have a manual the carb settings should be in it or while you disassemble them you could turn both screws in, counting the number of turns until they lightly seat then just reset the screws when you are done.

Even if you set the screws back where they came from, the adjustments may still not be correct since no two engines are identical. If you don't know what the screw settings should be, put them at 2 ½ turns out. Once you have the screws set you can take it to the water. You will need a few things like a screwdriver, spark plug wrench, plug gapper, and a new set of plugs.

With the old plugs in the craft, start the engine and warm it up in the water for about 5 minutes at an idle. Once the craft is up to running temperature, remove the old plugs and install a set of new plugs that are gapped correctly (0.024" works if you don't have your exact spec.). Take the craft for a low speed ride, no more than 20% throttle, for 15 minutes. Remove the plugs and inspect them. You are looking for a chocolate brown color on the rim of the plug (the end of the metal threaded part that is exposed to combustion). If the color is tan or nonexistent, the fuel air mixture is too lean. If the color is black the mixture is too rich. Turn the screws in (clockwise) to lean the mixture and out (counterclockwise) to richen the mixture. Do this in 1/8 turn increments. You may have to run the craft and check the plugs several times to get the carbs adjusted correctly. It is the same procedure for high speed except you run the craft at ½ throttle or greater for 5 minutes.

There is a third screw on you carbs, this is the idle speed adjustment. It doesn't have anything to do with fuel air mixture, it only adjusts the RPM that the craft idles at, and this has to be adjusted too. It is the only screw that is attached to the throttle linkage. Turning the screw in will increase rpm, turning out will decrease rpm. With the craft in the water, turn the idle speed screw until the craft idles smoothly but doesn't want to take off. You should be able to stand and hold the craft stationary while idling. If you have a tachometer, it should read 1500 RPM in the water. NOTE: out-of-water idle will be significantly higher, some as high as 3000 RPM. If you don't have a tach but have a speedo, your craft should idle at 2-3 MPH in the water.

SBT - Pop-off Adjustment

Pop-off is the measurement of the point where atmospheric pressure overcomes the fuel draw vacuum of the carb. The entire regulator chamber is nothing more than a big check valve. It is the step between the fuel pump, which is providing more pressure than the carb needs to deliver, and the jets, which meter a fixed amount, within a certain pressure range. The regulator chamber is in place to maintain that pressure range.

The whole regulator chamber gets filled with fuel. The fuel is coming from the pump, sits under the diaphragm, and is flowing through the jets. If it was just an open flow, with no needle and seat, the jets would be supplied with too much pressure from the pump. As the fuel is sucked out the jets, the fuel supply in there’s drawn out, and the diaphragm goes down with it. As it gets to it's low point, it contacts the lever arm, and lifts the needle from the seat. That allows more fuel into the chamber, pushing the diaphragm back up, re-seating the needle and shutting off the flow from the pumps, so the jets aren't over-pressured. This happens many, many times every minute as fuel is consumed.

If the pop-off point is set too low, there isn't enough resistance on the needle to stop the fuel pump flow, and the jets are over-pressurized, giving you a rich condition you will never tune out. The same goes for leaking needles.

If the pop-off is too high, there isn't enough fuel pressure to overcome the vacuum and spring pressure, and you will have hard starts, as the engine is not spinning fast enough o produce enough pulse, to make the pump supply enough pressure to flow the fuel into the regulator chamber.

It is adjusted by changing the size of the N&S, and the spring tension. There are 4 general strengths of springs - the less the spring is rated the lower the pop-off pressure will need to be to unseat the needle. For example, a 65 gram spring may give you a pressure of 15 psi, where a 115 gram spring may give you 50 (not actual numbers).

You test the pressure with a pop-off pressure gauge. With the regulator chamber open, wet the N&S with WD-40 or gas. With the pump body removed, attach the gauge to the fuel inlet fitting on the body. Pump the gauge until it 'pops' noting the pressure gauge. Repeat this 3 times to get a nominal reading. Installing a heavier spring will raise the pressure. To adjust in small increments lower, cut coils 1/2 coil maximum and re-test.

NOTE: You cannot accurately test with the pump body and fuel filter still attached to the carb - you MUST disassemble it and test directly into the fuel inlet orifice, where the fuel filter sets. Otherwise you are testing through the pump check valves, throwing your readings off, too high. If you have an external fuel pump, this does not apply.

SBT - Stock Mixture Settings

M=MAG, Front
C=Center
P=PTO, Rear

Stock Carb Settings, all listed as turns out from seated:

Sea-Doo

1988-1990
All - Low Speed – 1 ½
High Speed – 0

1991
SP - Low Speed – 1 ½
High Speed – 0

GT - Low Speed – 1 1/8
High Speed – 1/4

XP - Low Speed – 1 1/4
High Speed – 1/4

1992
SP - Low Speed – 1 +/- 1/4
High Speed – 0

XP/GTS/GTX - Low Speed – 1 1/4 +/- 1/4
High Speed – 0

1993
SP/SPi - Low Speed – 1 +/- 1/4
High Speed – 0

SPX/XP - Low Speed – 1 1/4 +/- 1/4
High Speed – 0

GTS/GTX - Low Speed – 1 +/- 1/4
High Speed – 0

1994
SP/SPi/GTS - Low Speed – 1 +/- 1/4

High Speed – 0

SPX/XP/GTX - Low Speed – 1 1/4 +/- 1/4
High Speed – 0

1995
SP/SPi/GTS/GTX - Low Speed – 1 1/4 +/- 1/4
High Speed – 0

SPX - Low Speed – 1 1/8 +/- 1/8
High Speed – 0

XP/HX - Low Speed – 1 3/4 +/- 1/4
High Speed – 0

XP800 - Low Speed – 1 +/- 1/8
High Speed – 0

1996
SP/SPi/SPX/GTS/GTi - Low Speed – 1 1/4 +/- 1/4
High Speed – 0

XP/GSX/GTX - Low Speed – 1 +/- 1/4
High Speed – 0

HX - Low Speed – 1 1/2 +/- 1/4
High Speed – 0

1997
SP/XP - Low Speed – 1 3/4 +/- 1/4
High Speed – 0

SPX/GS/GSi/GTS/GTi - Low Speed – 1 +/- 1/4
High Speed – MAG 0 PTO 1/4

XP - Low Speed – 1 3/4 +/- 1/4
High Speed – 0

HX - Low Speed – 1 1/2 +/- 1/4
High Speed – 0

GTX - Low Speed – 1 +/- 1/4
High Speed – MAG 0 PTO 1/4

1998
SPX/GSX - Low Speed – 1 1/2 +/- 1/4

High Speed – 0

XP/GSX Limited - Low Speed – 1 1/4 +/- 1/4
High Speed – MAG 0 PTO 1/4

1997.5 GSX Limited (White) - Low Speed – 1 3/4 +/- 1/4
High Speed – 0

GTS - Low Speed – 1 1/4 +/- 1/4
High Speed – 0

GTI - Low Speed – 1 1/2 +/- 1/4
High Speed – 0

GTX Limited - Low Speed – 1 1/4 +/- 1/4
High Speed – MAG 0 PTO 1/4

1999
SPX/GSX-L/XP-L/GTX-L - Low Speed – 1 1/2 +/- 1/4
High Speed – 0

GS/GTS/GTi - Low Speed – 1
High Speed – 0

2000
GS/GTS/GTi - Low Speed – 1
High Speed – 0

/GTX/LRV/XP/RX - Low Speed – 1-1/2
High Speed – 0

2001
GS/GTS/GTi - Low Speed – 1
High Speed – 0

XP/RX/GTX/LRV - Low Speed – 1-1/2
High Speed – 0

Yamaha

500 - Low Speed – 1-1/4 +/- ¼
High Speed – ¾ +/- ¼

650 - Low Speed – 1-1/8 +/- ¼
High Speed – 1 – 1/8+/- ¼

700 - Low Speed – 5/8 +/- ¼
High Speed – 5/8(M), 1-1/8(P) +/- ¼

760 - Low Speed – 1-5/8 +/- ¼
High Speed – 3/8 +/- ¼

800 - Low Speed – 2-1/4 +/- ¼ (M),1-7/8 +/- ¼ (P)
High Speed – 1/2 +/- ¼

1100 - Low Speed – 1-1/8 +/- ¼
High Speed – 7/8 +/- ¼

1200 - Low Speed – 1-1/4 (M, C), 1-1/8 (P) +/- 1/4
High Speed – ½ (M, P), 7/8 (C) +/- ¼

1200R - not adjustable stock, Low: 1-1/8 All
High: MAG 1-1/4, CTR 1-1/4, PTO 1-1/2

Kawasaki

440 - Low Speed – 1
High Speed – 5/8

550 - Low Speed – 1-1/16 (M), 1 (P)
High Speed – 7/8 (M), 5/8 (P)

650 - Low Speed – 1
High Speed – 5/8

750 - Low Speed – ¾ +/- 1/4
High Speed – 1 ¼ +/- 1/4

900 - Low Speed – 1-1/4 +/- ¼
High Speed – ¾ +/- ¼

1100 - Low Speed – 1-1/8 +/- ¼
High Speed – 1 +/- ¼

1200 - not adjustable

Polaris

1994
650 - Low Speed – 1-1/4
High Speed – 1

750 - Low Speed – 1/2
High Speed – 1 – ¼m, 3/8c, 7/8p

1995
650 - Low Speed – 1
High Speed – 1-1/8m, 1/4c, 7/8p

750 - Low Speed – 1/2
High Speed – 1m, 1/2c, 3/4p

780 - Low Speed – 1/2
High Speed – 7/8m, 3/4c, 1-1/8p

1996
700 - Low Speed – 5/8
High Speed – 1-1/2

Hurricane - Low Speed – 5/8
High Speed – not adjustable

SL780 - Low Speed – 5/8
High Speed – ¾m, 3/4c, 1p

SLT780 - Low Speed – 1-3/8
High Speed – 1-1/8m, 7/8c, 1-1/4p

SLX780 - Low Speed – 1-3/8
High Speed – 1-1/8m, 7/8c, 1-1/4p

900 - Low Speed – 5/8
High Speed – not adjustable

1050 - Low Speed – 1
High Speed – not adjustable

1997
SL700 - Low Speed – 7/8
High Speed – not adjustable

SLT700/Deluxe - Low Speed – 5/8
High Speed – 1-5/8 +/- 1/8

Hurricane - Low Speed – 5/8
High Speed – not adjustable

780 - Low Speed – 1-1/4

High Speed – 1/8

900 - Low Speed – 5/8
High Speed – not adjustable

SL1050 - Low Speed – 7/8
High Speed – not adjustable

SLTX - Low Speed – 1
High Speed – not adjustable

1998
700 - Low Speed – 1-7/8
High Speed – not adjustable

1200 - Low Speed – 1-3/4
High Speed – not adjustable

2000
SLX/Pro 1200/Virage TX - Low speed - 1 1/8
High Speed – not adjustable

Genesis - Low speed - 1 1/4
High Speed - not adjustable

Tigershark

640 - Low Speed – 7/8
High Speed – no adjustment

770 - Low Speed – 1-1/8
High Speed – 5/8

900 - Low Speed – 1
High Speed – 1

1000 - Low Speed – 3/4
High Speed – no adjustment