800/900 to 1000cc or 1150cc Big Bore Kit
RACING PERFORMANCE HANDBOOK

This Big Bore Kit was designed to increase displacement on 2001 through 2005 800/900 Arctic Cat engines. CPC Racing Engines are custom high quality cast cylinders with billet heads built to the highest standards of the snowmobile industry. Our twin cylinders can be tuned to over 220 hp and our triple cylinder engines are over 330 hp. As with any high quality engine, a little common sense and good maintenance will keep it running at peek performance for along time.

This handbook has been written as a generic guild . It contains valuable information that will help you tune your engine as well as save you money and time in avoiding potential problems. I would like to address some areas of importance. They are all important and do not appear in any special order.

1. **Assembly** Before assembling the rings on to the piston, it is important that you check piston ring end gap. Proper ring end gap on all CPC engines are .016 to .022. Ring end gap is accomplished by installing the ring into the cylinder and then turning the piston upside down and squaring the ring in the bore of the cylinder. Then take a feeler gauge and measure the distance between the ring ends. If the measurement is less than .016 you will need to file the ring. Be careful not to over file the end gap as this will reduce performance and hurt the compression! The best way of doing this is to clamp a file into a vice and take the ring in your hand and wiggle or stroke it back and forth while applying pressure to the rings on each side with the file sandwiched between. **All 1150 engines (98 mm pistons) may need to have the end gap adjusted by filing. Failure to do so will damage the nikasil coating on the cylinder and will not be cover on warranty! It is the mechanics responsibility to check and adjust the clearance if needed!**

The following instructions are prepared to avoid streaking and scuffing of nikasil plated cylinders. After installing new pistons onto the connecting rod and before sliding the piston into the cylinder we mandatorily recommend using <u>STP Brand Oil Treatment</u> to lubricate the piston as an assembly lube to the piston, rings and cylinder. It is important that the STP be applied in the piston ring land. STP is very sticky and will not run off like 2-Stroke oil. Also you must pour approximately 2 ounces of 2- cycle oil into each crankcase cavity. (Underneath the piston, before installing cylinder.) The oil in the crankcase cavity will allow additional oiling during the first few minutes of startup which is the most critical time of break-in. **It is very important to use Arctic Cat part # 0636-069 high-temp silicon sealant on both sides of the base gasket. Only a small film (about .010 to .015 thick) of sealant is needed on the base gasket. Coating the base gasket will prevent antifreeze from entering the crankcase due to metal expansion caused by extremely cold and hot engine cycles.** After the engine is assembled it is mandatory that you pre-mix a full tank of gas at a 50:1 mixture along with your oil injection. If your oil injection system has been removed you must use a 32:1 mixture for the first tank of fuel after installing the big bore kit.

2. **Break-In** How you break-in your new CPC engine will determine if your engine will be fast or slow. Proper break-in procedure also requires 30 to 60 minutes of break-in time at an idle. Do not rev the engine over 2000 RPM's during the first 30 minutes of idle time. In order to avoid overheating of the engine, you should run the engine three to five minutes at a time and then allow a fifteen minute cool down time.
Make sure that oil injection lines are purged of any air bubbles before start-up . Also the use of high quality synthetic oils greatly increase the success of a proper break-in . Quality synthetic oils include Redline or Amsoil racing oil. After the 30 minutes of idle break-in time we suggest that you vary the running RPM's . Do not hold the throttle at a steady position for more than 15 seconds at a time. Revving the engine up and down with short bursts of full throttle acceleration will improve break-in for the first 60 minutes. If these instructions are not adhered to strictly, streaking and scuffing will appear immediately, causing poor performance and ruining the nikasil in the cylinder. We recommend that you have patience during the jetting and clutching tuning stages of your new CPC engines. Take a day or two of dialing the engine in before competition racing or long rides. Do not make any hard pulls up steep mountain or Dyno pulls at Wide Open Throttle (WOT) for more than 2 to 4 seconds for the 1st tank of fuel. Do not run WOT for more than 4 to 6 seconds the 2nd tank of fuel and 10 second WOT for third tank of fuel. Do not make any hard pulls over 30 seconds long until after 4 full tanks of fuel or piston seizure will result!

3. **Compression** Before running any CPC Racing engine, the correct squish and compression should be decided upon before you can choose the correct fuel. Compression, squish and the quality of fuel are dependent upon one another. If you change one, the other **must** be changed. All CPC Racing engines come in either a low compression or a high compression versions. The compression can be changed by simply changing the head insert. Each insert is marked with a **H** for high or a **L** for low or **P** for pump gas.

The squish must be checked before the engine is run. This test is performed by taking 1/8 inch solder in your hand and bending a arch in the wire at the same time pushing it down the spark plug hole in line (parallel) with the piston pin. The solder must reach the edge of the cylinder wall. Next pull the engine over three or four times while holding the solder at the spark plug location so the solder won't slip to the side. This test will require two people, on to hold the solder and the other to pull the engine over. Preform the same procedure 180 degrees on the same cylinder. This allows you to recheck your measurement. The squish is measured by either using a veneer calipers or micrometer. Your measurement is the average of tests. Repeat the process and check each cylinder. High compression inserts should have a minimum of .060 squish. Low compression inserts should have a minimum of .070 squish. The squish and compression can be adjusted slightly by the use of thicker or thinner base gaskets.

At CPC we calculate compression by the volume of the head, not by taking compression tests with your compression gauge measured in pounds per square inch (psi). The reason for this is simple; if you take a given engine with a set head volume and you run a compression test on it, you will get different readings at different altitudes. For example, a given engine will vary in compression about 3.5 % per 1000 feet in altitude. At sea level you might register 125 to 130 psi. The same engine if tested at 4000 feet may measure approximately 110 psi using a compensation factor of 14% (3.5 times 4=14%). Also each compression gauge registers a different value. We have four different gauges in our shop and everyone of them will register a different psi reading on the same engine by as much as 20 psi. You can use a compression gauge as a comparison tool or barometer to make comparisons as well as a tool to trouble shoot and check for problems especially if you use the same gauge each time. At CPC we use a compression gauge to make comparisons. We also use mathematical formulas to determine compression ratios.

So let me get to the point; you should use your gauge as a tool for comparison and not let the gauge reading over rule common sense and proven compression ratios. And as compression ratios increase so does the need for higher octane. Octane numerical ratings are a guild for how much anti-detonation abilities that the fuel possess. Higher octane fuel burns slower and resists detonation . Sense high octane fuel burns slower it has a cooling effect which allows you to run higher compression and more ignition timing to produce more horsepower. If you increase you compression, you will also need to increase your octane. Engines that are run at low elevations also need higher octane fuel than high elevation engines **if** they are run at the same compression. This is due to the fact that the air is more dense at low elevation. Sense denser air is trapped in the engine, you have an increase in compression even though you didn't increase the compression ratio. Engines that have less squish require higher octane fuel than engines with larger squish. Also larger bore engines require more squish than smaller bore engines. And larger bore race engines need a little more advance on the ignition timing than smaller bore race engines due to the fact that the flame front has a longer distance to travel on bigger bore engines. Engines that run more advance on ignition timing need higher octane fuel requirements. Generally speaking, larger bore engines require higher octane fuel than smaller bore engines. The real question is how high of octane fuel is required for your CPC Racing engine? The answer is, it depends on elevation, timing, squish, engine bore size and compression. Sense each CPC Racing engine is built specifically for each customer needs, then engine octane requirements will vary from customer to customer.

Octane Requirements On 91mm, 91.5 mm And 98mm Bore CPC Racing Engines using a 2 degree timing key.

Elevation	**0' to 4,000'**	**4,000' to 7,000'**	**7,000' to 10,000'**
High Compression Head Insert	**100+ Min.Octane***	**95 + Min.Octane**	**92 + Min.Octane**
Low Compression Head Insert	**95 Min.Octane**	**92 + Min.Octane**	**92 + Min.Octane**

***** 100 Octane can be substituted by using 50 % 110 Octane Racing Fuel with 50% Premium unleaded fuel.

For those of you who will be trail riding CPC Racing engines, we recommend that you use at least 2 gallons of race fuel with 8 gallons of premium unleaded for the above 92 Octane requirements. Aviation fuel (AV Gas) can be substituted for race fuel but still must be blended to achieve octane requirements that the specific engine requires. Be aware that many gas stations dispense low octane fuel out of it's pumps marked premium. It makes no sense to purchase an very expensive engine and ruin it by running junk fuel. If you can't afford the fuel, then you shouldn't be running our engines!

4. **Oil Requirements** There are many good oils out in the market place. CPC recommends the use of quality synthetic oils. Oil brands such as Arctic Cat APV Synthetic, Redline or Amsoil are ideal and can be purchased at CPC. Synthetic oils provide a 2 to 3 % gain in horsepower and torque over petroleum lubrications. CPC recommends the 32:1 fuel/oil mixture on all engines which have the oil pump disconnected. If you are using the oil injection as a source of lubrication, then we recommend mixing oil with the fuel at a 100:1 for additional protection and lubrication with each tank **even after break-in!**

5. **Cooling Information** The ideal running water temperature for most snowmobiles is between 125 and 140 degrees F. CPC has undergone an extensive study on the relationship of water temperature and horsepower output. **FACT #1**: Any CPC Racing performance engine than runs over 155 degrees F. will lose horsepower and will be hard to jet or tune. Further more it tells me that your cooling system is inadequate. Our findings indicate that engines that are run at water temperatures as high as 180 degrees will lose up to 15% horsepower! **FACT#2**: Any snowmobile engine that is consistently run at temperatures over 150 + will experience shorter engine life! This means premature piston failure such as piston skirt collapse and anti-rotation pins falling out of pistons. Sense CPC Racing engines produce 40 to 60% more horsepower than stock engine, the bi-product of power is heat. Most heat exchanger's are inadequate to handle the increased heat that is produced by larger, more powerful engines. And worse yet, some customers want to remove heat exchanger's to make their snowmobiles lighter. The results are slow death to your engine. CPC requires every engine to have a water temp gauge to monitor water temperature. **Solution**: #1. Make sure that you have adequate quantity of heat exchanger. #2. Make sure that heat exchanger's are placed where the maximum amount of snow dust will hit them. If the rear exchanger's are too far forward in the tunnel, over heating will be present. Also the most effective heat exchanger is the one in the rear by the snow flap. Make sure it hangs down from the top of the tunnel above the snow flap. Increasing the volume and size of this heat exchanger will have the most effect on cooling. #3. Using a water wetter agent such as Redline Water Wetter will also cool your engine down aproximately10 plus degrees. **FACT #3**: **If you ignore this section and do nothing, expect major problems!**

CPC engines should be run with a thermostat. Water temperature should reach at least 115 before running engine. Removing thermostat in heavy powder conditions can lower water temperature below 115 and cause a cold seizure due to engine cylinder not being allowed to expand so you have proper cylinder to piston tolerance. Managing water temperature is the most critical element next to proper jetting in a CPC Racing engine. Because we use such large bore's in our engines, there is a lot more thermal expansion and contraction in our engines. If you have too low of water temperature, then the cylinder contracts and the cylinder to piston clearances are reduced and can cause a seizure. If the water temperature is too high, then the piston will over heat and loose the heat treat properties (piston will be annealed) and the anti-rotation pins will loosen and fall out causing the ring to snag on the ports and destroy your engine. If snow conditions are marginal, you can remove the thermostat which will lower your water temperature by about 15 to 20 degrees, however you will need to reinstall it the moment that the snow conditions change to avoid a cold seizure.

6. **Timing Recommendations** After you have a few hours on your engine, power gains can be picked up generally by advancing the timing. We do not recommend checking the timing until after you have broke the engine in. Running the engine at high RPM before the engine is broke in will result in streaking the nikasil cylinders (see break in page 1). We have experienced good power gains by increasing timing 2 to 4 degrees over stock ignition . Increasing the timing can be beneficial on large bore engines due to the fact that you have a large flame front on larger pistons. Increasing ignition timing builds additional heat into your engine. Heat is energy, and energy is horsepower. Additional timing can bring additional horsepower out of your engine, too much timing can add detonation, causing burn downs. Additional timing also means that you need to be using higher octane fuel. Just as higher compression engines require higher octane, increasing your ignition timing also requires using higher octane fuel. Before doing so it is important to have your snowmobile jetted as close as possible. Timing can effect your jetting and effect the readings on your EGT gauges. As ignition timing increases, your EGT gauges will show lower readings. This is due to the fact that the fuel is now burning more completely and also that the heat is being transferred to the piston rather than out the exhaust port. Even though your EGT gauges are showing a lower reading, the fact remains that the fuel mixture will be burning leaner because of additional heat produced by the timing. You now must read piston wash to determine proper jetting and comparing the piston wash to your EGT readings. You now can see that if you are on the ragged edge of jetting, and then advance your timing, the end result will normally end in piston seizure!

After timing has been advanced by installing an advanced timing key. It is critical that you do not cruise at 1/4 to ½ throttle for over 10 seconds at these throttle settings as the timing curve is at its maximum advance. Long durations of cruising at high advance timing will cause detonation and or piston seizure. If you are going to use your CPC Racing engine for transportation and many miles of cruising, you must vary throttle positions from part throttle to full throttle and vise versa, up and down to avoid excessive durations of high advanced timing caused by the timing curve which is pre-programed in the CDI box. When you install a 2 degree or a 4 degree key, you must remember that you advanced the timing from idle all the way to full max RPM's across the board including part throttle RPM areas. Too much timing can cause detonation and not enough timing (especially at max RPM) will not allow the engine to reach full potential and produce max horsepower. The ideal thing would be for someone to custom program a CDI box ignition timing curve will low advance at part throttle and increased timing at high RPM. Since the factory has control of programing the CDI and does not allow after market companies to modify timing curves, the best we can do is install advanced timing key to improve the high RPM's and caution owners to avoid long period of cruising at part throttle to avoid detonation.

Anytime you are assembling your own CPC Racing engine and you are installing a drive clutch or flywheel, remember to use automotive type valve lapping compound to lap your flywheel with the mag end of your crankshaft. Failure to do so will eventually end up in a sheared flywheel key or best scenario a partially sheared flywheel key affecting ignition timing due to a loose flywheel. While you are lapping the flywheel, it is a good idea to lap the drive clutch on the PTO end of your crankshaft. When installing drive clutch, do not tighten with an air impact and do not tighten over 50 foot lbs of torque.

7. **Exhaust Gas Temperature (EGT'S) And Jetting**.

CPC recommends that the EGT probe be placed at 7 inches from the exhaust side of the piston skirt to the center line on the probe (approximately 5 inches from the exhaust gasket). **A perfectly jetted engine will have a 1/2 inch wash on the piston.** Piston wash is the lack (No carbon) of carbon around the outside parameter of the piston. For trail use on CPC Racing engines it is highly recommended that you have about a ½ inch of piston wash. This gives you a small margin of safety to prevent piston seizure. Anything less than a ½ inch of piston wash, you can expect piston seizure. Failure to take time to jet your engine will be a costly mistake. **Jetting is your responsibility!**

After you have about two hours of test time on your engine, then pull your spark plugs and by using a cylinder bore light, inspect the carbon deposits on top of the crown of each piston. This inspection is called reading the "Wash". As air/fuel mixture comes up the transfer ports, this mixture has a tendency to **wash** the carbon off the top of the piston if it is too rich. If the fuel mixture is too lean then the heat of the engine will bake carbon deposits on to the top of each piston. By reading the "wash" expert tuners can determine if the air/fuel mixture is too lean or too rich. Adjustments on jetting should be made according to what air/fuel mixture makes your engine run right and this is determined by reading the wash. If your EGT's readings say that your engine is running too lean, but the wash on your piston says it is too rich, then always use the reading of the wash to determine what the jetting should be. Remember that the EGT's are just a tool to monitor and aid you in your tunning. Don't be so paranoid about reading the EGT's that you fail to truly tune your engine. Reading the wash on the piston is best accomplished by lowering the piston down to bottom dead center, and with a cylinder bore light inspect the outer edge of the piston by looking down the spark plug hole. On a full radius dome piston, there should be about 1/2 of an inch of wash (no carbon) on the top of the piston at the area of the piston in front of each transfer port (see Figure #1). If carbon is burnt to the edge of the piston in this area, then the jetting is too lean. You should then increase your main jets a couple of sizes and/or adjust the E-clip/needle jet settings. If you find that there is no carbon attached to the outer edge of the piston for over an inch, then the jetting is too rich. An adjustment on the main jet and possibly the jet needle/needle jet circuit may need to be leaned.

As a general rule we suggest the following temperature readings. These readings are only starting points. 1/4 throttle position to be at 900 to 1000 degrees F. ½ throttle position to be at 1000 to 1100 degrees F. 3/4 throttle position to be at 1100 degrees F. Full throttle position to be at 1100 to 1200 with stock timing. On **Low** **Compression** engines with stock timing, the above readings are generally spot on. For **High Compression** engines with advanced timing key, the temperature will run a little lower at Wide Open Throttle (WOT) (approximately 100 degrees F. ie 1075 to 1125) due to the fact that on high compression engines and also engines that use a lot of advance timing create more heat and the fuel is burned in the combustion chamber more efficiently as well as heat is absorbed into the piston, rings, and cylinder rather than heat being sent out the exhaust port. Full throttle positions are closer to the 1100 degree F range. This heat is energy, which is torque and horsepower. Therefore you will see lower EGT'S on your gauge even though your engine is jetted lean. **The bottom line is that you need to compare EGT readings along with piston wash to determine the correct jetting (½ inch piston wash).** See last page for piston wash info.

Before running your CPC Racing engine, make sure you have at least 1.8 needle and seat in the carburetor. Anything smaller will lean out in wide open throttle (WOT) positions on long runs. We also encourage you to run two vents in your fuel tank to prevent a air lock which will starve your carb from fuel. **Also make sure that your fuel pump is a high volume version. If you use anything else, expect mechanical or carb problems.**

CPC can not give specific recommendations on jetting because there are too many variables. Some of these include temperature, altitude, barometric pressure, octane, gearing, compression ratio, clutching and the brand and size of carburetor. When jetting, always start rich, then lean out as needed. Patience is the most important tool when jetting your CPC Racing engine. CPC offers a Handbook on Carburetors that goes through Mikuni and CPC "T" Flat slide carburetors tunning procedures for $19.95.

8. **Clutching**. Clutching, gearing and jetting are the big three tuning areas to focus on when prepping a CPC Racing Engine. There isn't enough space here to go over all theories on clutching, but there is additional help. I have recently authored a book on clutching that has over 100 photo's and 100 + pages of information for $19.95.

9. **Power Valves**. CPC engines that use Arctic Power Valves (APV) must be adjusted and maintained properly for maximum performance. This section will cover both areas. The APV system adjusts the size of the exhaust ports to produce maximum horsepower and torque on the top end while providing excellent low end power and increased fuel economy on the low end of the RPM band. The system operates like this: at low RPM's the exhaust valves are held in the low position by the return spring. When the engine reaches higher RPM's, the CDI will send a signal to the servo motor instruction the motor to pull the exhaust valves open via a cable to a high position. This system requires periodic cleaning and cable adjustment. Cleaning is recommended every 1000 miles or every 50 hours of use. Cleaning is accomplished by using a aerosol carb cleaner and a plastic or wooden scraper to remove any carbon on valve or the valve cavity. The use of high quality synthetic oil will minimize cleaning due to lower carbon levels.

Cable adjustment is critical to the operation and performance of your engine. If the APV cables are out of adjustment you will experience lower power levels as well as lower RPM's Make sure the power valves are installed correctly. On 2001-3 style exhaust valves, the cavity of the exhaust valve goes down when you are installing them in the cylinder. **If the Power valve was installed upside down, the piston may come in contact with the exhaust valve and**

damage to the piston and cylinder will result! This will not be covered under warranty! It is the mechanic who is assembling the engine responsibility to make sure that the power valves fit correctly. After assembling the power valves with the piston at bottom dead center, take a straight edge ruler and make sure you have a minimum of .020 to .030 clearance between the piston and the power valve. If needed the mechanic can remove the power valves and grind on it with a die grinder to make sure there is enough clearance.
To adjust or inspect proper cable adjustment, proceed

#1. Remove the two bolts securing the servo motor plastic cover.

#2. Using a small screwdriver, remove the cable retaining clip.

#3. Rotate the servo actuator counterclockwise to loosen the cable, then pull the cable housing out of the holder.

#4. Pull the cable up and out of the cable housing holder, then slide each cable drum to the left and out of the servo actuator.

#5. While holding the cable housing firmly, pull the cable out as far out as it will go, the release. Repeat this three to four times to insure that the valve is free and not hung-up.

#6. While holding the cable housing, lightly pull on one cable end to remove any slack. Measure the amount of exposed cable from the outer cable housing to the end of the cable. When measuring the cables, keep them as close to their installed position as possible. Proper cable adjustment on the 2001 or 2002 800 twin engine should be about 23.5 mm to 27 mm when measuring from the inside of the lead ball to the end of the outer cable housing. 2003 and newer 900 cc engines use different PV cables and the adjustment is different. Generally start at approximately 40mm and adjust as needed. If the cables are not equal or are out of adjustment, then loosen the jam nut on the cable, then using the adjuster nuts in the center of the cable, lengthen or shorten the outer housing as needed, then tighten jam nuts. Generally we suggest that you start on the short side when adjusting.

10. **Troubleshooting the APV system**. The APV system has a self-cleaning and self-testing mode built in. Every time that the engine is started, the servo will cycle **once**, and this will wipe-off the carbon that has accumulated on the exhaust valves. The CDI unit also monitors the voltages at the servo during this cycle to assure they are within operational tolerances. If all the voltages are within tolerance, the system is ready for use. **If the voltages are not within tolerance, the servo will cycle up to two more times. If the voltages remain out of tolerance, the system will not operate.** Troubleshooting is simply accomplished by removing the plastic servo motor cover, then starting the engine and with the engine at a high idle, watch the servo motor to see how many times it cycles. If the servo motor **only cycles 1 (one) time**, then the cables are adjusted correctly and the power valves are clean enough to work properly. If the servo motor cycles 2 or 3 times, then the valves are either dirty or the cables are out of adjustment. Proper adjustment is essential to producing maximum power! A final check should be made by starting the engine, then rev up the motor to 7000 RPM's (after break-in) and hold the motor at this RPM for two seconds. The servo motor should pull on the cable/exhaust valve and keep them open as long as the engine is over the 7000 RPM range. The servo motor should open the power valves up at approximately 6700 RPM's and keep them open as long as the engine RPM's are over 7000. **If the servo motor does not hold the valves open then shorten the cable by one or two mm and try it again.** If the power valves cycle more than one time at a high idle or don't open up at all, then you could loose up to 20+ horsepower! Contact your local Arctic Cat dealer for troubleshooting or for adjustment procedures.

NOTE: It is possible to remove the power valve cable and servo motor from our CPC Racing cylinders. The power valves can be locked in the wide open position by removing the cables from the power valve retainer and installing a spacer between the power valve retainer and the power valve stopper.