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fantom
FR21/27
FR21/27 ENGINE MANUAL

FANTOM® FR21 / FR27

Thank you for purchasing a **Fantom® FR21 or FR27 Racing Engine**. Your new engine has been developed to provide superior performance and longevity for both racing and sport applications. To attain the maximum enjoyment from your new engine, even if you have prior experience with engines, please review the following information – you won't be sorry – knowledge is power!

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TOOLS & SUPPLIES REQUIRED FOR EASY INSTALLATION

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- 2.5mm Hex Wrench
- Needle Nose Pliers
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- Throttle Return Spring
- Small Nylon Tie Straps (air filter)
- 5/64 Hex Wrench
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- Piston Stop (Clutch Tool)
- Hobby Knife
- Filter Oil
- Air Filter
- Large Nylon Tie Straps (manifold)
- 1.5mm Hex Wrench
- 5.5mm Nut Driver
- Phillips Screwdriver
- Thread Lock
- After-Run Oil
- Manifold
- Pipe Wire Mount

REMOVING THE OLD ENGINE (If Applicable)

1. If your new Fantom engine is replacing an existing engine, you will need to remove your old engine from the vehicle, following your vehicle's instruction manual. If this is a new installation, please refer to this manual for installation instructions. You may also want to refer to your vehicle's instruction manual for any special instructions not covered in this manual.

2. If applicable, remove your old engine from the original engine mount and set it aside to use with your new Fantom engine.

3. If applicable, disassemble the stock clutch parts from your original engine, noting the order of their removal, as you will need to install them on your new Fantom engine in the exact reverse order that you removed them from your original engine. Clutch removal and installation is best accomplished by using a clutch tool (piston stop tool); this can be obtained at a quality hobby shop. This tool allows you to fully tighten or loosen the clutch nut by keeping the piston from moving up and down or allowing the crankshaft to turn. Never wedge anything inside your engine's exhaust or attempt to grip the shaft with pliers as these techniques will permanently damage internal and external parts.

INSTALLING THE FANTOM® FR21 OR FR27

1. Remove the glow plug and install the piston stop (clutch) tool.
2. Install your clutch parts onto your Fantom engine in the reverse order of their removal from the stock engine. If you are installing a new clutch, follow the instructions that came with the clutch. Before installing the clutch nut, apply a small drop of thread lock to the clean shaft threads; this will prevent the nut from coming loose. Because clutch shoes are important for good engine performance – and are relatively inexpensive – replace them with a new stock set (if you are installing the original clutch).
3. Remove the clutch tool and reinstall the glow plug.
4. Loosen the 5.5mm carburetor-securing nut and position (angle) the carburetor in the same position as your original carburetor was set at, or as your vehicle's instruction manual suggests. While pressing the carburetor firmly to the crankcase, retighten the securing nut. Make certain that the throttle ring ball mount is properly positioned like your original carburetor, or as instructed in your vehicle's instruction manual; if it isn't, loosen the small setscrew on the throttle ring and rotate the ring to the desired location; retighten the setscrew.
5. A leaking fuel tank can cause severe problems with your engine's performance. Therefore, inspect the tank for leaks and replace it, if needed. Install a new fuel-line, leaving plenty of extra length; it will be cut to the proper length once the engine is installed in the chassis.
6. Install the manifold seal to the exhaust port at the rear of the engine – making sure it's fully seated. Follow this by fully seating the manifold (sold separately) over the seal. Because there are so many applications for this engine, please consult your vehicle's manual for manifold recommendations. More than likely you will be able to use your stock manifold if this is a replacement application.
7. Secure engine to the stock engine mount(s), using the original four bolts … add a drop of thread lock to all four bolts at this time (clean them first).
8. Position the engine within the chassis and secure it from the underside with the four original bolts. Add a drop of thread lock to all four bolts at this time (clean them first). Lightly tighten the bolts prior to checking the gear mesh. While holding the clutch bell gear in place, rock the spur gear back and forth; it should measure between 0.003 and 0.005 inch of endplay. Slide the engine back and forth in its mounted position until you achieve the proper gear mesh. DO NOT adjust the gear mesh too tight or too loose – the gears, clutch, and engine can be severely damaged.

Once the proper gear mesh is obtained, fully tighten the four engine mount bolts (under the chassis) and recheck the gear mesh … one more time.

9. Snap the throttle ball cup to carburetor using needle nose pliers.
   I**MPORTANT:** At this point, we recommend installing a throttle return spring (available at any quality hobby dealer). This is a safety precaution, to prevent the engine from running past the idle position, in the event that you lose radio contact with the vehicle, or have any type of radio failure. This situation could cause dangerous uncontrolled wide-open operation, resulting in injury to person(s) and/or property damage. Install the return spring in a manner in which the throttle returns to idle position, when the radio is off.
10. Cut the fuel tubing to the proper length and attach to carburetor inlet nipple. If possible, route the fuel line away from sources of high temperature (e.g., tuned pipe, manifold, and cylinder head). Heated fuel may vaporize in the fuel tubing causing erratic engine operation – cool fuel runs better.
11. Should you use a stock or aftermarket tuned pipe? We recommend using a Fantom WORKS tuned pipe. Our WORKS PIPES produce much better performance than a stock pipe. Besides, they sound “killer” – a much raspier tone – not to mention the cool appearance. Your Fantom dealer has these in stock or they can order one for you from one of our distributors. They are available in natural team finish (part #FAN20014 single stage or FAN20016 dual stage) or shiny nickel finish (part #FAN20015 single stage or FAN20017 dual stage). You can find more details on our pipes by visiting our web site www.fantomracing.com. If you decide to use the stock pipe, attach it to the manifold using the stock silicone coupler and new tie straps. If you use an aftermarket pipe, follow the installation instructions included with the pipe. After completing the connection between the manifold and pipe, secure the pipe to the chassis with a standard wire mount. Finish the tuned pipe installation by connecting the fuel tank pressure line to the pipe’s pressure fitting.
12. With the radio turned on, adjust the throttle and brake trim settings (refer to your radio manual for details):
    - Set the radio trims so the throttle closes and opens fully – take your time with this procedure.
    - Make sure that the transmitter throttle trigger is in the fully pulled back position at the same time the carburetor opens completely (100%); when the throttle trigger reaches its neutral position, the carb must be simultaneously closed (0%). In other words, you don’t want the carburetor fully open when your throttle trigger is only partially back; likewise, you don’t want the carburetor fully closed before the trigger is in the neutral position. Faulty adjustments can damage the throttle servo and/or make the engine act like it isn’t running properly.

13. Install the air filter (sold separately). Make sure to oil the air filter. Use quality air filter treatment oil such as our Fantom Filter Fluid™ / Filter Wash™ kit (part # FAN20111). Use a small tie strap to hold the air filter housing to the carburetor; these are available from your local dealer or hardware store.
    CAUTION: Never run your engine without an air filter. Rapid and permanent damage will result – which is NOT covered by warranty.
    Check all of your work, and read the rest of this manual (twice) to ensure that you completely understand the operational characteristics of your new FR21 or FR27 Racing Engine.

ENGINE OPTIONS

Your FR21 / FR27 can be modified to work in optional configurations, by referring to the following information and part numbers.

1. Your FR21 or FR27 was built with a standard glow plug head button, which is best suited for off-road and/or high torque applications. For on-road and/or high RPM applications we offer an optional turbo style head button, as well as a turbo glow plug. The following optional head buttons and glow plug are available:
    - FAN10422 .21/.27 Turbo Glow Plug
    - FAN10440 .21 Turbo Head Button
    - FAN10442 .27 Turbo Head Button
2. To modify the FR21 or FR27 (non-pull start models) for pull start operation, the following parts are available:
    - FAN10404 Standard Crank with Pull Start Stub
    - FAN10406 Pull Start Assembly
    - FAN10407 Pull Start One-Way Bearing
    - FAN10408 Pull Start One-Way Bearing Shaft
    - FAN10409 Rear Plate for Pull Start
    - FAN10417 Rear Plate Screws for Pull Start
    - FAN10420 Pull Start Assembly Screws

3. To modify the FR21 or FR27 (pull start models) for non-pull start operation, the following parts are available:
   - FAN10410 Rear Plate for Non-Pull Start
   - FAN10414 Gasket Set
   - FAN10419 Rear Plate Bolts for Non-Pull Start

ENGINE OPERATIONAL GUIDELINES

This section covers important information useful in understanding the what, how and why of your new engine.

To get a full understanding of the remainder of this manual, it is important that we cover some basic principles first. Please make sure you fully understand this section of the manual before proceeding.

Your new Fantom engine is built using the latest ABC technology (aluminum, brass, chrome). Expansion of the piston is controlled by the percentage of silicon in the aluminum alloy; by matching the piston expansion to the expansion of the chrome-plated brass cylinder-sleeve… both at normal operating temperatures (220º-290º F), the best running-fit can be obtained. (This subject will be covered in more detail, later in the manual, in the “Break-In” section.) The cooling fin area of the cylinder head regulates the temperature.

When a carburetor mixture is set properly, the temperature of the engine should be of little concern. The flash point of certain modern lubricants found in high quality fuels is generally a minimum of 700º F; meaning as long as you are using high quality fuel, your engine is protected even in extreme temperature conditions… IF THE AIR-FUEL MIXTURE IS NOT SET LEAN.

Unfortunately, over the years it has become customary to set the main needle valve by engine cylinder head temperature (usually called temperature tuning); however, this is a bad practice. Temperature tuning can lead to overly rich or overly lean needle settings – both can damage an ABC-type engine. Depending on the operating conditions (e.g., weather conditions, altitude, surface you are running on, fuel type, etc.), we have found that the FR21 and FR27 cylinder head temperatures (taken with a temperature gun; aiming down inside at the glow plug area of the cylinder head) will generally range between 220º and 290º F; however, do not “temperature tune” to these temperatures.

Tune the engine following the guidelines set forth in the “Setting The Needle Valves For Optimum Performance” section of this manual, and consider the engine temperature a secondary issue. It is OK to check your engine’s temperature, as a reference point, but do not “temperature tune” your FR21 or FR27.

IMPORTANT: Just because the engine is designed to run up to 290º F, do not lean the primary (main) needle valve to achieve this head temperature, unless your operating conditions dictate it! It’s OK to run the engine this temperature ONLY if the air-fuel mixture is properly set for the operating conditions that YOU are running in. Also, don’t allow your engine to run too cool – you’re not protecting its longevity! Operating the engine “blubbering rich” will cool the cylinder-sleeve to the point where the piston will begin to rub excessively in the pinch-zone, because the cylinder-sleeve is not hot enough to expand to its intended designed operating size. The pinch-zone is that necessary area around the top of the tapered cylinder-sleeve, where the piston comes in contact, creating the necessary seal for proper combustion chamber compression. Excessive rubbing due to under-expansion of the cylinder-sleeve produces pinch-zone wear. Pinch-zone wear produces combustion gas blow-by when the engine is up to normal temperature. Combustion gas blow-by produces loss of power…the number one reason that piston and cylinder-sleeve assemblies must be replaced.

IMPORTANT: Pinch-zone wear, resulting in loss of compression, is NOT covered by warranty.
We have no control over what brand of fuel you use, and/or the way you operate your engine. Your FR21 or FR27 is built using the latest ABC technology, and will last just as long as any other brand of ABC type engine, as long as it is used in accordance with this instruction manual, therefore it is your responsibility to operate your engine properly, to obtain the longest usable life possible.

The Effect of Fuel
Different fuels drastically affect the way your engine will run. One manufacturer’s 30% nitro blend isn’t necessarily the same as another’s – there are many variables: the type of oil (synthetic or castor), the amount of oil (% in the fuel blend), the oil blend (% synthetic, %castor), and oil quality will require a different needle valve setting for any engine. With this in mind, here are some rules to follow when fuel-tuning your engine:

- Lower oil content and/or lower nitro content require leaner needle settings.
- Higher oil content and/or higher nitro content require richer needle settings.
- High oil content and/or low nitro content fuels are generally better for engine longevity.
- Low oil content and/or high nitro content fuels provide better engine performance, but reduce its longevity.
- By reducing the oil content in the fuel blend many properly tuned nitro engines will operate at a slightly reduced cylinder head temperature. Don't misinterpret reduced cylinder head temperature as protection against engine damage; to the contrary, less oil content will not protect the engine as well as higher oil content. The less-oil/cooler engine temperature phenomena is beyond the scope of this manual, however, the fact remains: Reduced oil content (10%, 9%, 8%, etc.) can lead to premature engine failure … if the air/fuel mixture becomes lean.

Although not all are directly related to fuel, the following list includes the most common causes for lean mixtures:

1. The primary needle valve is set too lean.
2. Incorrect gearing - placing too much load on the engine leads to increased head temperature, producing a lean setting.
3. A leak in the fuel system can produce a lean run from an otherwise correct needle setting.
4. Hot, humid weather conditions can produce a lean mixture setting as head temperatures rise from an otherwise correct needle setting.

In the final analysis, if you choose to use lower oil content fuel, you may gain performance advantages, but longevity will be sacrificed. Also, in low oil content fuel, there simply isn't enough lubricant present in the fuel-blend to defend against rapid temperature rise (due to out-of-control friction) from a lean mixture...you have sacrificed your margin for error against massive engine damage by running less oil.

The Effect of the Weather

Weather conditions also have an effect on how well your engine performs:

- High air temperature
- High humidity
- Low barometric pressure

These conditions contribute to low oxygen density within a given volume of air; low oxygen density demands that the engine's needle valve be set leaner to ensure the correct air/fuel mixture ratio.

- Low air temperature
- Low humidity
- High barometric pressure

These conditions produce a higher oxygen density within a given volume of air; high oxygen density requires that the engine's needle valve be set richer to ensure the correct air/fuel mixture ratio. Needle valves must always be properly adjusted for the engine to realize peak performance. Too little fuel for the amount of inducted oxygen and the engine will run lean; it will also be starved of the lubricant's protective qualities – lubrication and cooling. Too much fuel for the amount of inducted oxygen and the engine will run rich; with excess fuel and lubricant, the engine will lack power.

Increased oxygen density allows more fuel to be run through the engine, producing greater horsepower. Therefore, any engine will produce more horsepower with oxygen dense air conditions; this is why you will usually notice better engine performance in the spring and fall months.

IMPORTANT: In cold weather conditions (e.g., winter months and/or certain regions in the world) the outdoor temperature may make your engine run too cool. Remember, your FR21 or FR27 is designed to run best between 220º and 290º F, however, DO NOT lean the main needle to achieve these temperatures. The engine's design is such that the engine will run at these temperatures in typical weather conditions that R/C vehicles are operated in (e.g., 55º to 90º). In colder weather conditions, to attain these temperatures, we recommend wrapping the cylinder head with aluminum tape (found at hardware stores), which insulates the cylinder head, helping the engine to run within its designed temperature range, without having to lean the needles to achieve this. REMEMBER: High temperatures produced by the engine design are good, but high temperatures produced by a lean needle setting are bad.
IMPORTANT: In hot weather conditions (e.g., summer months and/or certain regions in the world) the outdoor temperature may make your engine run hotter than the typical operating temperatures between 220º and 290º F.

DO NOT overly richen the main needle to reduce you engine's temperature in these conditions. The engine's design is such that the engine will run at these temperatures in typical weather conditions that R/C vehicles are operated in (e.g., 55º to 90º). In hotter weather conditions you may see higher than typical engine temperatures, but don't be alarmed, as long as your engine is tuned properly. Because of the engine's design, we are more concerned with the engine running too cool, rather than too hot (when the engine is tuned properly), so most importantly make sure to follow the cold weather instructions (pg. 9). In testing, we have operated our engines in excess of 350º F with no negative effects. For proper cooling you should cut a hole in the front windshield and for extra cooling you can enlarge the cut out area of the body around the engine. Also, limiting the amount of time running the engine wide open will help maintain lower engine temperatures. REMEMBER: High temperatures produced by the engine design are good, but high temperatures produced by a lean needle setting are bad.

Although not related to the weather, elevation above sea level also has an effect on engine horsepower; higher altitudes produce lower barometric pressure and reduced oxygen density. The opposite is true of low elevations. The higher you are above sea level, the more you must lean the needle valve, and vice versa.

The Effect of Operating Conditions

Depending on your particular operating conditions, your engine and vehicle will need to be set up properly to maximize their potential. This mainly has to do with the surface you are running on. For example, if you are running on grass, your engine, clutch, and shift points (if applicable) will need to be tuned differently than if you were running on pavement or dirt. Different dirt conditions require specific tuning (e.g., loamy dirt puts a greater load on the engine compared to hard packed dirt). We have found that with high load conditions (grass and loamy dirt), the engine runs best tuned slightly leaner, and the shift point (if applicable) set slightly later. In low load conditions (pavement or hard packed dirt), the engine runs best tuned slightly richer and the shift points (if applicable) set slightly early. Refer to your vehicle's instruction manual for details regarding clutch set-up, gearing options & recommendations, and transmission shift points (if applicable).

IMPORTANT: No matter how you prefer to tune your vehicle (shift points, clutch set up, slipper, etc.), always make sure that the needle valves are set properly, for ideal engine operation, for the conditions that you are operating in. Don't call your buddy, who lives across the state or country, and expect to use his settings – every operating condition is unique.

STARTING YOUR ENGINE FOR THE FIRST TIME

First, fill your fuel tank with a high quality hobby fuel, such as Fantom SC20 / SC30 Performance Blend or SC20R / SC30R Racing Blend Fuel. Typically, most people use 30% nitro content fuel in .21-.27 size engines to gain extra horsepower for the heavier vehicles that these size engines are commonly installed in.

IMPORTANT: Our research has shown that fuel quality plays a very important part in how long your engine will last and perform. There are many inferior fuels on the market – and they can cause premature wear and/or engine failure. We recommend that you use only Fantom Fuels for the best performance and longest engine life. Fantom also suggests Trinity® Monster Horsepower™ blended fuels as the only other recommended fuel.

Before starting your engine for the first time, make sure your carburetor is set to the baseline settings outlined on page 17 of this manual. At any time, if you experience difficulty starting your engine, please refer to the "ENGINE OPERATIONAL GUIDELINES" section of this manual for helpful information. Once the fuel tank is filled and the radio gear is turned-on, proceed by priming the engine by placing your finger over the exhaust outlet for a few seconds, while turning the engine over with either a starter box or pull start depending on your engine model; this will pressurize the fuel tank, moving fuel into the carburetor and engine. NOTE: This technique is also helpful in starting your engine any time it won't start within the first couple of seconds that you turn over the engine. By placing and removing your finger over the exhaust outlet, in two-second intervals, while turning over the engine, this maintains fuel pressure to the carburetor, which aids in starting the engine. Be careful not to overdo it though, as flooding can occur, making the engine difficult to start. With a little practice, you will learn the technique, and should find it very useful.

NOTE TO PULL START ENGINE OWNERS – It is very important that you DO NOT pull the starter rope out to its full length, as permanent damage could result, which is not covered by warranty. Use short, quick pulls, only pulling the rope out about 10 inches.

IMPORTANT: Make sure your glow plug igniter is fully charged. Insufficient power to the glow plug will result in poor starting or complete failure to start. Just because your glow plug glows (while checking it) does not mean that the glow plug is OK and/or that the glow igniter is charged enough.

A low charged igniter will make a glow plug glow, and a bad glow plug will still glow sometimes, but this does not guarantee that either is operating at 100%. We have found that the most common reasons for engine starting failures are due to bad glow plugs and/or igniter problems. A glow plug can go bad in less than one tank of fuel, so it is always wise to check this first if you are having difficulty starting your engine.

When starting your engine, a small amount of throttle may be needed; usually "blipping" the throttle on and off in small amounts (1/4 throttle or less) is recommended. Some of the more expensive radios are equipped with a push button feature that moves the throttle to a pre-set opening; this is especially helpful when trying to start an engine by yourself. Once fuel reaches the carburetor, the engine should start immediately. If it doesn't, look at the fuel line to see if it contains fuel, check the needle valve settings, and glow plug and/or glow plug igniter. Because of the high compression of your new engine, it is sometimes necessary to loosen the glow plug 1/2 to 1 turn to relieve some of the engine's compression; this will make it easier for the starter box or pull start to crank over your engine. Only perform this procedure if you experience difficulty starting your engine during the initial start up and first 2-3 tanks of fuel. After the first few tanks of fuel, the engine should be broken in sufficiently and will not require this tactic again. Once the engine starts, make sure to tighten the glow plug quickly – within the first 10 seconds of running.

BREAK-IN (HEAT CYCLING)

As your engine starts for the first time – the break-in process begins. For most ABC-type engines it's the most critical period of their useful lives … but few operators pay much attention to the details.

In the old days, engine break-in consisted of running the iron or aluminum piston (ringed or lapped) within a steel cylinder-sleeve, very rich with lots of lube for hours and hours. This was intended to wear-in the engine's rough spots, reduce friction, and improve power and longevity. Owners of modern ABC-type engines also demand peak power and longevity; fortunately, break-in is now an abbreviated process, requiring much less time with our method. Improvements are largely the result of CNC (computer numerical control) production machinery. These programmed robots make individual engine components that fit together almost perfectly – every time! This results in very little if any rough spots to smooth out. Despite such accuracy, metal components (primarily the piston and cylinder-sleeve) require heat-cycling to relieve the internal stresses due to their fabrication.

Therefore, heat-cycling (break-in) can be described as the process of heating and cooling the engine from its normal operating temperature, at WOT (wide open throttle), to ambient temperature – time after time – until it holds a peaked setting. Break-in (heat cycling) SHOULD NOT be considered the "wearing-in" of the internal parts as many manufacturers would like you to believe. Our heat cycling method only relieves the internal stresses of the metal parts that occur during the manufacturing process.

Here's how to perform the job correctly:

1. Decide on a fuel (nitro and oil content). Your Fantom engine is designed to run best with at least 20% nitro, but no more than 30% nitro content. If you like a more "drivable" engine, choose 20%; if you like a lot of horsepower choose 30%. As previously mentioned, most people choose 30% nitro with .21-.27 size engines. Whichever type you choose, use the same fuel for break-in and everyday operation – for the life of the engine. Don't indulge in the "fuel of the day" game – it only hastens the day when you will need a new piston and cylinder-sleeve set. Here's why:

   Increased nitromethane content in the fuel causes combustion chamber temperatures to rise. This is normal since nitro is the primary power-producing ingredient in the fuel's chemistry. As the temperature increases, so does the expansion of the piston and cylinder-sleeve. As described previously, the chrome-plated sleeve is engineered to expand more than the aluminum alloy piston – as controlled by the cooling ability of the cylinder head fins. With higher nitro content fuels (e.g., 30%), the piston to cylinder-sleeve running-fit (clearance) is a bit larger than with lower nitro fuel blends, because of higher combustion chamber temperatures produced with higher nitro content. Therefore, if you start by using 30% nitro fuel at the beginning of your engine's life – with its tight pinch fit when cold – It will produce the best possible WOT performance characteristics if you continue to use the same fuel for the life of the piston and sleeve. If you change fuel – reduce the nitro content to say 20% - the engine will run good, but a bit of the pinch will wear away from the top of the piston because lower cylinder temperatures equate to less expansion of the cylinder-sleeve. If you then decide to switch back to the higher nitro fuel, the elevated temperature and expansion will produce greater piston clearance (due to its previous wear using 20%); the elevated quantities of blow-by combustion gas will cause the engine to lose power.

These principles also hold true for oil content. By changing oil content, you may affect the temperature that the engine will run at, which in turn will affect the piston / cylinder-sleeve clearance, as described on previous page. The moral of the story is: It's best not to change fuel, once the break-in process has begun.

2. Start your engine following the starting procedures previously covered.

3. **IMPORTANT:** Once started, begin running your vehicle around immediately, as described in step 4 below.

IMPORTANT: In the following break-in steps you may find what we explain to be different than what you are normally used to, but it is very important that you follow our instructions to obtain the best performance and longest engine life. This paragraph covers information that is very important in understanding the reasons for our break-in method, so please read it carefully. Our principles are based on common laws of physics, so our break-in process should make more sense once you read the rest of this paragraph. In simple terms, your Fantom engine is a true ABC type engine, which means that there is a high silicon content aluminum alloy piston running inside of a brass sleeve that is plated with hard chrome plating. All ABC engines are designed with an interference fit, or in other words, the sleeve is actually tapered so that the piston is pinched at TDC (top dead center), when the piston reaches the top of its stroke. Since ABC engines don't have piston rings, this "pinch" is required, in place of the rings, to create the necessary compression needed to burn the fuel efficiently, ultimately producing maximum horsepower, however, this "pinch" is actually designed to be too tight when the engine is cold, but there is a reason for this. When heat is applied to metal it expands, and different metals expand at different rates. Brass expands more than aluminum, thus the reason for the aluminum/brass combination, the intention being for the brass to expand more than the aluminum. The chrome plating serves as a very slippery and wear resistant surface for the piston to efficiently operate against. With that in mind, your engine is designed so that the top of the cylinder (sleeve) expands more than the piston itself, so that the fit between the piston and sleeve is optimal once the engine reaches the proper operating temperature. For proper break-in and normal operation, your engine ALWAYS needs to come up to the proper temperature as quickly as possible, in order for the sleeve to expand enough to achieve optimal fit, otherwise the piston will scrub the sleeve too much causing premature wear, loss of compression, and ultimately the performance of your engine will diminish.

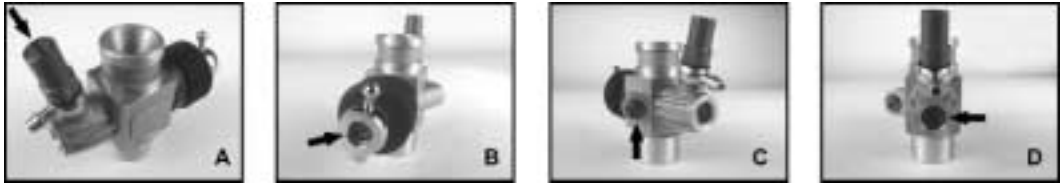
The sleeve will start expanding to the proper design parameters at approximately 205 degrees F., however, this does not mean that this is the normal operating temperature; it only means that you need to always get your engine up to at least this temperature as quickly as possible after the engine is started. Surprisingly, many companies today still recommend the old-fashioned way of breaking in an engine, as described earlier in this manual, but we have found that our method not only makes more common sense, but helps your engine run much better and with more longevity. The old-fashioned method of break-in; running the engine at low temperatures and very rich for several tanks, destroys the piston prematurely. By breaking in your engine the old-fashioned way, the piston actually "wears in" to the cool and under expanded sleeve size. Once the break-in process is complete and you start running the engine up to normal temperatures, the sleeve expands further, but the piston is already "worn in" to the smaller sleeve size. Obviously this will cause lower compression, less power, and shorter piston and sleeve life. In contrast, using our method the piston and sleeve heat up quickly and to the designed size parameters immediately, eliminating the constant wearing of the piston against the sleeve.

4. Here's the tricky part: to the best of your ability, immediately begin dialing-in the high speed needle valve for maximum RPM performance during the first tank of fuel (see more detailed information on setting the needles in the "SETTING THE NEEDLE VALVES FOR OPTIMUM PERFORMANCE" section further in this manual). During the break-in period make sure to keep your engine temperature at least 205º as previously mentioned by making 5 second (WOT) high speed passes back and forth, on the type surface you prefer to operate on – this will keep the piston and sleeve hot enough while the operator tweaks the needle during quick pit stops. A helper is very handy for this critical operation! Ideally, get the needle valves set for maximum performance and a reliable idle as quickly as possible; generally within 5 WOT passes you should try to have it set. If performed correctly, the engine should be running near normal operating temperatures for the entire break-in process. Depending on the operating surface, outdoor temperature, etc., your break-in temperature will range between 205º and 260º F., but this is on average, so don't be alarmed if the temperature is higher. For the most part, you will see that the main difference between our break-in method and normal operation is that during break-in there is a cool down period required between each tank of fuel. Once the break-in period is finished, you will see normal temperatures range between 220º and 290º F. Following the above procedures, run the engine for a complete tank of fuel – then shut it down. Allow the engine to cool down COMPLETELY before re-starting.

5. Continue this process for 4 tanks of fuel; this heat-cycles all the metal parts inside your engine.

   IMPORTANT: Do not let the engine sit and idle for its break-in. The piston and cylinder-sleeve will not get hot enough to expand properly, and the critical pinch-fit will disappear before you know it. In fact, we are more concerned about running an engine too cool, rather than too hot!

SETTING THE NEEDLE VALVES FOR OPTIMUM PERFORMANCE



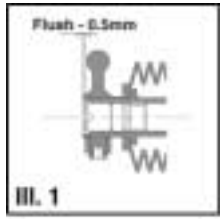
Carburetor settings should always be made after the engine has been brought up to normal operating temperature; this is accomplished by running the vehicle for a minute or so.

IMPORTANT: The needle valve settings will vary from day to day depending on outside weather conditions. Don't expect your engine to run correctly over a period of time without adjusting the needle valves. Slight changes in weather conditions will require needle valve adjustments.

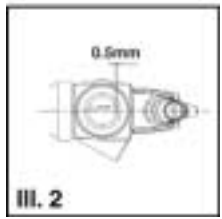
Weather conditions can change during the same day. For example, in a race situation, if you run a qualifier in the morning and another one in the afternoon, chances are the temperature will change, which means your carburetor will need to be readjusted.

There are 3 settings that can be adjusted:

1. The high-speed (main) needle valve (see: Figure A).
2. The low-speed needle valve (see: Figure B).
3. The idle adjustment screw (see: Figure C).
4. WARNING: DO NOT adjust the screw in figure D. This is not an adjustment screw.



Ill. 1



Ill. 2

IMPORTANT: Carburetors are very sensitive to minor adjustments. Any adjustments should be made in increments of 1/16th to 1/8th of-a-turn, at a time. New carburetors should be set to the following guidelines and are not considered pre-set from the factory. The following settings are good baseline settings but are not considered optimum. Use these settings as a starting point as optimum settings will depend on your conditions:

- High-speed needle: 3-1/4 to 3-1/2 turns counter clockwise (CCW), out from closed.
- Low-speed needle: (see illustration 1 - approximately 2-1/4 to 2-1/2 turns CCW)
- Idle adjustment (throttle stop): should be set so that the throttle is open approximately .5mm from the “just-closed” position (see illustration 2).

Baseline settings were obtained in the following operating conditions:

- Hard packed dirt.
- 80º F (air temperature).
- Low humidity (60%)
- Using Fantom SC30 Fuel (30% nitro / 12% oil)
  NOTE: Your baseline settings may differ slightly from ours.

High-Speed Needle Valve

1. Start with the high-speed (main) needle valve. This needle controls the amount of fuel allowed to pass through the carburetor at all times. Turning the screw clockwise (CW) makes the engine run leaner; CCW makes it run richer. Continue making small adjustments to this screw until maximum RPM and power is obtained.

IMPORTANT: Leaning the main needle too much may result in higher obtained RPM and power, but may starve the engine of lubrication. Be careful not to over-lean the engine, once you get close to optimal performance. A step too lean can result in permanent piston and cylinder-sleeve damage very quickly.

2. For maximum life, it is always best to run your engine slightly on the rich side, rather than too lean. When the engine is tuned for maximum performance, you should still be able to see light smoke coming from the pipe at full throttle.
3. Signs of overly rich mixture:
   - Sputtering and/or bogging at mid to full-throttle.
   - Sluggish acceleration with excessive blue smoke coming from the exhaust.
   - Excessive unburned fuel exiting exhaust.

4. Signs of overly lean mixture:
   - Sagging and/or erratic engine response.
   - Sudden loss of power and/or engine cuts out during mid to full-throttle.
   - Over-heating (not due to engine design, but rather by over-lean needle settings).
   - No smoke coming from exhaust.
   - Distorted, broken and/or white glow plug coil.

Both needle valve settings (too lean and too rich) can produce similar symptoms; be observant and careful when trying to determine what the engine is actually doing. If you get lost, refer to the factory needle settings.

WARNING: Prolonged too-lean operation of the engine produces a hot, lubrication-starved condition resulting in permanent damage, which is not covered by warranty.

Low-Speed Needle Valve (see illustration 1 for initial setting)

1. Next, adjust the low speed needle. This adjustment should always be made after the high-speed needle is set. This needle controls the low RPM throttle response, from approximately 0 to 1/4 throttle. Like the high-speed needle, turning the screw CW leans the mixture, while turning the screw CCW richens the mixture.
2. When properly set, the engine should not hesitate when throttle is applied; throttle response should be crisp.
3. The pinch test: by pinching the fuel line closed (at a point just before the fuel inlet of the carburetor), the engine should momentarily speed up and then quit; if it quits immediately – the needle is set too lean.

Setting the Idle-Speed (see illustration 2 for initial setting)

1. Turning the idle-speed screw CW increases engine rpm.
2. Turning the idle-screw CCW reduces engine rpm.
   This setting is a personal preference adjustment; we like to set ours so that the engine idles just below clutch engagement.

ENGINE MAINTENANCE

Proper care is necessary for maintaining engine longevity, reliability, and maximum performance. We have no control over how you operate your engine, so it is your responsibility to maintain the proper care for your engine. Fantom is not responsible for engine problems related to improper use or care of your engine. Most engine problems are due to user error, so it is very important that you maintain your engine on a daily use basis to avoid preventable problems.

ENGINE BOLTS

Because of the extreme conditions that model engines are exposed to (e.g. heat, vibration, etc.), all the screws and bolts on your engine must be regularly checked to avoid having them come loose, as air leaks from loose parts will cause damage to your engine that is NOT covered under warranty. For preventative maintenance, we recommend using a mild Locktite® compound on all the screws and bolts on your engine.

Air Filter

Never run your engine without an air filter (sold separately). An air filter prevents dirt, dust, and debris from entering the engine, which can cause quick and permanent damage that is not covered by warranty. It is extremely important to keep the air filter clean; a clean air filter allows the engine to "breathe" properly for maximum performance. As described earlier, increased airflow (oxygen) allows more fuel flow; in the proper proportion with air, increased fuel flow equals more horsepower. We recommend using high quality air filter oil, such as our Fantom Filter Fluid™ / Filter Wash™ maintenance kit (part # F20111) for the ultimate air filter care. Whichever air filter oil you select, make sure to follow the manufacturer's instructions carefully.

Glow Plug

In the process of break-in and normal operation, you will periodically need to replace the glow plug. The frequency of plug changes will vary depending on products and operating conditions. Some of these include:

- Glow plug brand
- Needle valve settings
- Weather conditions

Checking the Glow Plug's Condition

Under racing conditions, we generally replace the glow plug before the Main, as preventative maintenance. In general use conditions – change as needed. A simple way of checking the glow plug's condition:

1. Start the engine.
2 For a few moments, while the engine is idling, leave the glow plug igniter on the glow plug and note the sound and/or rpm of the engine.
3. Next, remove the glow plug igniter and note the sound and/or rpm again.
4. After removing the igniter, if you notice a drop in RPM, or the engine sounds as if it is loading up with fuel, the glow plug should be replaced.
5. If the engine won't start at all, this is also a good sign that the glow plug needs replacing, especially if the engine was running fine the last time you used it.
   Alternative glow plugs to the stock Fantom F029 glow plug (part # FAN10421) include the McCoy MC59 or OS8 glow plugs.

After Running

After each day's use, it's important to run out any remaining fuel from the engine, fuel line and tank. Model car fuel contains methanol, which attracts moisture; if left inside your engine, this moisture will cause rust and corrosion – especially on ball bearings. After purging the engine of left over fuel, remove the glow plug and squirt a liberal amount of after run oil into the cylinder – through the glow plug hole; also squirt a liberal amount into the carburetor intake, making sure to use a needle applicator to get the after run oil down onto the crankshaft. For superior after-run protection, we recommend our Fantom Rip Saver after-run lubricant (part # FAN20110). After applying the lubricant, turn the engine over a few times with a starter box or pull start, depending on your engine model; this helps to circulate the oil.

Cleaning

Keeping the outside of the engine clean will allow it to run cooler. Never allow heavy dirt deposits to accumulate on the outside of the crankcase or in between the heat sink head fins – overheating will occur. We recommend using a high quality spray cleaner to clean the outside of the engine and heat sink head; we discourage the use of denatured alcohol for this purpose – it's a hygroscopic agent – it attracts rust producing moisture. For stubborn dirt and grime, an old toothbrush will help. Be careful not to allow any dirt or grime to be washed into the engine, through any of its orifices. If you plan on using a large quantity of cleaning agent, again – make certain there is a glow plug installed and the carburetor opening is covered. Never use water to clean your engine because of the metal parts that will rust and corrode.

Rebuilding

All engines have a life span, no matter what brand. Your Fantom engine is constructed using the latest ABC type technology, and will last just as long as any other ABC-type engine – as long as the proper care is taken. When the time comes to rebuild your engine, this manual provides exploded views of the engine and carburetor, as well as a part number list for all the available replacement parts; this will aid you in disassembling and reassembling your engine, and ordering replacement parts. For additional help, our tech support line is also available at 1-(269)-649-9583. Replacement parts are available wherever Fantom engines are sold. Fantom also offers a professional rebuild service for those customers who prefer not to service their engines themselves. This service is available at current shop rates and parts prices. Please call our tech support line for more details, or visit our web site at www.fantomracing.com

Storage

For extended periods of storage, we recommend disassembling the engine and generously coating all the internal parts of the engine with a high quality lubricant. Again, our Fantom Rip Saver lubricant (part # FAN20110) works great for this. After coating all the internal parts, reassemble the engine. A light mist of WD-40™ on the outside of the engine will also prevent any corrosion of external parts.

CAUTION STATEMENT

- Use common sense when operating your vehicle. No engine, no matter what brand, can withstand the abuses of continuous wide-open operation, severe crashes, neglect, or improper use.
- You are responsible for the maintenance of your equipment from the aspect of safety, performance, and longevity.
- Nitro powered vehicles can reach very high speeds; they can cause severe damage and injury to persons and property if not handled properly. Use caution and exercise courtesy when operating your vehicle around people and property.
- Children should ALWAYS be under adult supervision when operating nitro-powered vehicles.
- Model engines operate at high temperatures, which can cause severe burns. Always be careful when handling your vehicle to avoid touching hot components.
- Use caution when handling a vehicle with the engine running; moving parts such as the clutch and gears can cause severe injury.
- Use caution when handling model car fuel. Model car fuel can be a very hazardous material if used improperly; always follow the manufacturer's safety warnings and instructions.
- Run your vehicle in well-ventilated areas – never indoors – exhaust fumes can be very dangerous.
- Fantom has no control over the use of this product, and therefore accepts no responsibility and cannot be held responsible for any damage or injury caused by its use or misuse.
- The user accepts all responsibility for the use of this product.

NEWS

Please check out our web site at www.fantomracing.com for the latest news, tips, and high performance parts and products.

WARRANTY

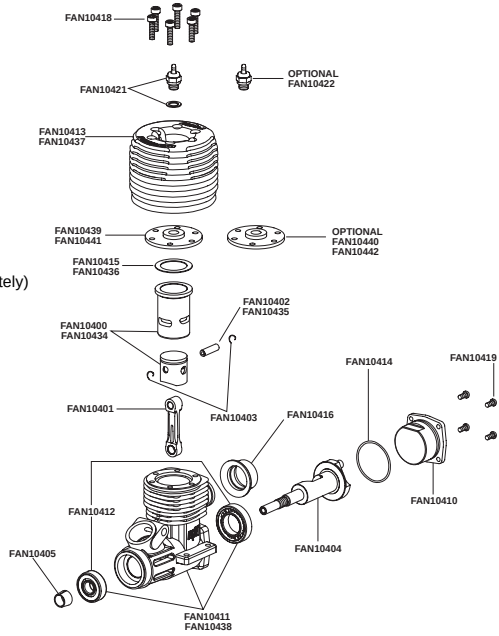
Because Fantom does not control the use of this engine, we offer the following limited warranty:

- The engine is free of manufacturing defects, and it meets all factory specifications at the time of purchase.
- Parts that are defective at the time of purchase will be repaired or replaced free of charge; all other repairs or parts will be charged to the customer.
- This warranty will not exceed 30 days from the date of purchase.
- Proof of purchase is required for any warranty service.
- Engine failure due to misuse, abuse, improper adjustment, incorrect fuel, and normal wear are not covered under warranty.
- Any warranty repairs will be at the discretion of Fantom upon inspection of the engine.
- Any modifications to the engine will void all of this warranty.
- If it is necessary to return your engine for service or warranty repair, please call: 1-(269)-649-9583 for a return authorization number and instructions for returning the engine.
- The cost of shipping the engine to Fantom, and shipping charges back to the customer from Fantom for non-warranty repairs are the responsibility of the customer. Fantom will cover only shipping charges back to the customer for warranty repair returns.

All prices, products, specifications, availability, and policies are subject to change without prior notification. Fantom is not responsible for any unintentional misprints or errors in this manual.

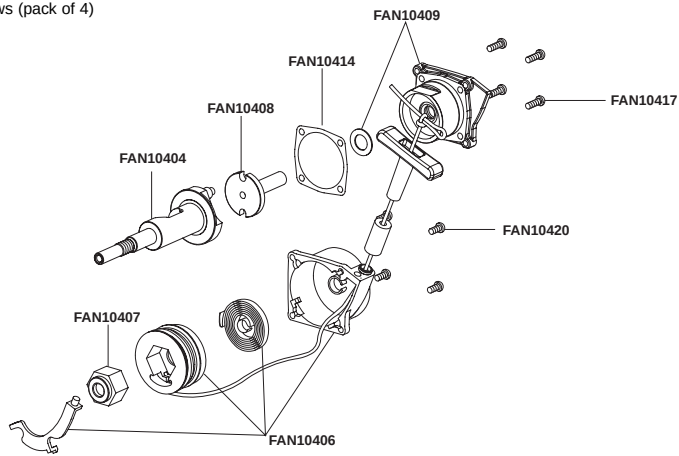
FR 21/27 REPLACEMENT PARTS LIST

FAN01030 FR21 - .21 Rear Exhaust , Slide Carburetor, SG Crank
FAN01031 FR21 - .21 Rear Exhaust , Slide Carburetor, SG Crank, Pull Start
FAN01040 FR27 - .27 Rear Exhaust , Slide Carburetor, SG Crank
FAN01041 FR27 - .27 Rear Exhaust , Slide Carburetor, SG Crank, Pull Start
FAN10400 .21 ABC Piston and Sleeve Set
FAN10401 .21 / .27 Knife-Edge Performance Connecting Rod
FAN10402 .21 Performance Wrist Pin
FAN10403 .21 / .27 Wrist Pin Clips (pack of 8)
FAN10404 .21 / .27 SG Turbo Crank w/ Pull Start Stub (removeable)
FAN10405 .21 / .27 Cone Collet for Crankshaft
FAN10410 .21 / .27 Rear Plate for Non-Pull Start
FAN10411 .21 Crankcase with Bearings
FAN10412 .21 / .27 Crankcase Bearing Set (2)
FAN10413 .21 Machined Heat Sink Head (combustion chamber sold separately)
FAN10414 .21 / .27 Gasket Set
FAN10415 .21 Head Shim (pack of 3)
FAN10416 .21 / .27 Exhaust Header Seal (pack of 2)
FAN10418 .21 / .27 Replacement Head Bolts (pack of 6)
FAN10419 .21 / .27 Rear Plate SHC Screws for Non-Pull Start (pack of 4)
FAN10421 .21 / .27 Standard Glow Plug
FAN10422 .21 / .27 Turbo Glow Plug
FAN10434 .27 ABC Piston and Sleeve Set
FAN10435 .27 Performance Wrist Pin
FAN10436 .27 Head Shims (pack of 3)
FAN10437 .27 Machined Heat Sink Head
FAN10438 .27 Crankcase with Bearings
FAN10439 .21 Head Button for Standard Glow Plug
FAN10440 .21 Head Button for Turbo Glow Plug
FAN10441 .27 Head Button for Standard Glow Plug
FAN10442 .27 Head Button for Turbo Glow Plug



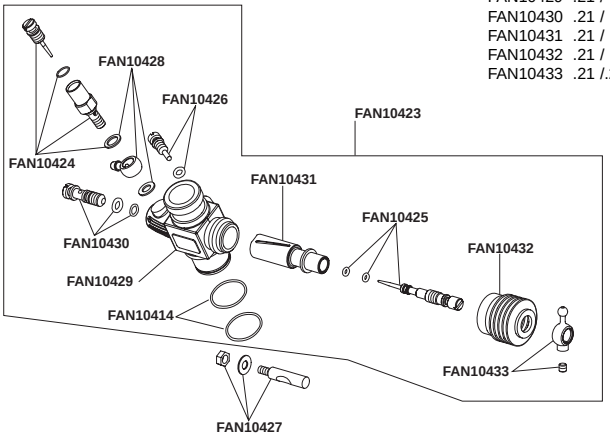
FR 21/27 REPLACEMENT PARTS LIST CONT.

FAN10406 .21 / .27 Pull Start Assembly
FAN10407 .21 / .27 Pull Start One-Way Bearing
FAN10408 .21 / .27 Pull Start One-Way Bearing Shaft
FAN10409 .21 / .27 Rear Plate for Pull Start
FAN10417 .21 / .27 Rear Plate Screws for Pull Start (pack of 4)
FAN10420 .21 / .27 Pull Start Assembly Screws (pack of 4)



FR 21/27 REPLACEMENT PARTS LIST CONT.

FAN10414 .21 / .27 Gasket Set
FAN10423 .21 / .27 Competition Slide Carburetor
FAN10424 .21 / .27 High Speed Needle Assembly with Gasket
FAN10425 .21 / .27 Low Speed Needle Assembly
FAN10426 .21 / .27 Idle Screw with O-Ring
FAN10427 .21 / .27 Carburetor Securing Pin with Washer & Nut
FAN10428 .21 / .27 Fuel Inlet Nipple with 2 Gaskets
FAN10429 .21 / .27 Carburetor Main Body
FAN10430 .21 / .27 Carburetor Spray Nozzle w/ O-Ring
FAN10431 .21 / .27 Carburetor Slide Rotor
FAN10432 .21 / .27 Carburetor Rubber Boot
FAN10433 .21 /.27 Carburetor Ball Tip Throttle Linkage Ring w/ Screw



FR21 / FR27 MANUAL ADDENDUM

EXTREMELY IMPORTANT – READ BEFORE STARTING ENGINE

WWW.FANTOMRACING.COM

NEW PARTS UPDATE INFORMATION: Some of the parts in the 2005 model FR21 and FR27 engines have been updated since this manual was printed. Please use the following new part numbers when ordering replacement parts:

- FAN10450 – '05 .21 piston and sleeve set
- FAN10451 – '05 .27 piston and sleeve set
- FAN10452 – '05 .21/.27 crankshaft
- FAN10453 – '05 .21 head shims (pack of 2)
- FAN10454 – '05 .27 head shims (pack of 2)

NOTE: The above '05 piston & sleeve sets, as well as the '05 crankshaft can be used in older model FR21 and FR27 engines, but the '05 piston/sleeve sets and '05 crankshaft MUST be used together.

NOTE: The easiest way to tell if you have a 2004 or 2005 model FR21 or FR27 is to look at the crankcase nose area, around the crankshaft bearing. 2005 models are machined in this area, from the front edge to approximately 1/8 inch back, with the natural aluminum showing through. 2004 model crankcases are completely black in this area.

NEW GLOW PLUG UPDATE INFORMATION:
The head buttons on 2005 model FR21 and FR27 engines have been updated to turbo type head buttons, however, as shown in the parts list of your owner's manual, we offer optional standard head buttons, if you prefer to run standard type glow plugs. Whichever head button option you prefer, we now offer the perfect glow plug for any application with our new line of racing glow plugs. Please review the following options below.

2005 head buttons have been updated to turbo style, requiring the use of a turbo type glow plug. We recommend using the following glow plugs:

- FAN10602 – FR21/FR27 turbo glow plug for off-road applications (common aftermarket turbo glow plug is O'Donnell® 97T / part#ODO97T)
- FAN10604 – FR21/FR27 turbo glow plug for on-road applications (common aftermarket turbo glow plug is O'Donnell® 99T / part#ODO99T)

If you prefer to use a standard type glow plug, you can obtain our standard head buttons sold separately (part#FAN10439 for FR21 and FAN10441 for FR27). We recommend using the following glow plugs if you convert to a standard head button:

- FAN10605 – FR21/FR27 standard glow plug for monster truck applications (common aftermarket standard glow plug is O'Donnell® 100 / part#ODO100)
- FAN10603 – FR21/FR27 standard glow plug for off-road applications (common aftermarket standard glow plug is O'Donnell® 99 / part#ODO99)

BASELINE NEEDLE SETTINGS UPDATE: We have changed the baseline needle settings, found on page 17, to the following updated settings:

- High-Speed Needle: 3-1/2 to 3-3/4 turns counter clockwise (CCW) out from closed.
- Low-Speed Needle: See illustration 1 on page 17 of manual, but change the dimension to between 1mm and 1.25mm.

BREAK-IN PROCEDURE UPDATE: We have updated our break-in procedure for better clarification. Please disregard pages 12 through 15 of your manual and follow the new break-in procedure below.

You may find the following break-in steps to be different than what you are normally used to, but it is very important that you follow our instructions to obtain the best performance and longest engine life.

As your engine starts for the first time, the break-in process begins. For all ABC-type engines proper break-in is critical in obtaining the best performance and longest life. Nearly every part on your engine was produced using CNC (computer numerical control) production machinery. These programmed machines are highly accurate and produce individual engine components that fit together almost perfectly. Despite such accuracy, metal components (primarily the piston and cylinder-sleeve) require minor "seating" (e.g. mating parts perfectly that operate together) and heat-cycling to relieve internal stresses in the metal, due to their fabrication. Therefore, "break-in" can be summarized as the process of "seating-in" and heat-cycling of all engine components from ambient (outside air temperature) to normal operating temperature, by running the engine time after time, until optimal fit and stress relief are achieved.

Your new Fantom engine is built using the latest ABC technology (Aluminum piston - Brass sleeve - Chrome plated inner sleeve wall). All ABC engines are designed with a tapered sleeve, so that the piston is pinched at the top of the piston stroke, known as Top-Dead-Center. This area, at TDC, is called the "pinch-zone". You can feel it by turning over the crank by hand and noting how the crank gets hard to turn once the piston reaches TDC. Since ABC engines don't have piston rings, this "pinch" is necessary, in place of the rings, to create compression in the combustion chamber. The most critical aspect of a model nitro engine is compression, because without it an engine will not run properly and is nearly impossible to tune, and in some cases will not run at all. Both the fuel and glow plug require compression to work effectively. Proper break-in ensures that maximum compression and the longest usable piston and sleeve life are achieved. The piston and sleeve are made of aluminum and brass because these are two metals that work together perfectly for this application, due to their ideal expansion characteristics when heated by normal engine operation. The chrome plating serves as a very slippery and wear resistant surface for the piston to efficiently operate against. The ideal expansion rates of aluminum and brass help maintain good compression throughout the engine's normal operating temperature range. Metal expands when it is heated and by matching the piston's expansion (determined by the silicon content in the aluminum alloy) to the expansion of the chrome plated brass cylinder-sleeve, the best running-fit is obtained once the engine reaches normal operating temperatures of 220º-260º F. Getting the engine quickly into its normal operating temperature range during break-in is critical, because if the engine is ran too cool, the sleeve will not expand enough, causing the piston to wear against the smaller diameter sleeve size. This commonly happens when someone tries to break-in an engine using the method of letting the engine idle for break-in, as instructed by some engine manufacturers.

This idle break-in method does not produce enough heat to expand the sleeve to normal operating size, so the piston wears to the under-expanded sleeve size. Once the engine is run at normal temperatures, the piston is too small for the sleeve, creating loss of compression. For proper break-in and normal operation, it is critical that your engine is ALWAYS warmed up as quickly as possible to within its normal operating temperature range in order for the piston and sleeve to expand to their normal operating sizes, otherwise the piston will scrub the under-expanded sleeve too much causing premature wear and loss of compression quickly.

WARNING: Pinch-zone wear, resulting in loss of compression, is NOT covered by warranty. We have no control over what brand of fuel you use, and/or the way you tune and operate your engine. Your Fantom engine is built using the latest ABC technology, and will last just as long as any other brand of ABC type engine, as long as it is used in accordance with this instruction manual, therefore it is your responsibility to operate your engine properly, to obtain the longest usable life possible.

WARNING: Do not let the engine sit and idle for its break-in. Proper operating temperatures will not be obtained to achieve the correct “seating” of the piston and sleeve in the pinch-zone area.

WARNING: Never run your engine at wide-open throttle for extended periods of time. No engine, no mater what brand, is designed for this type of operation. Running your engine wide-open for extended periods of time will cause premature engine failure, which is not covered under warranty. We recommend limiting your wide-open passes to 200 feet or less at a time, and not repeatedly time after time, right in a row. Engines are generally designed for racing type conditions, so think of how you would run your engine on a racetrack. Typically, a racetrack consists of one or two long straightaways and a series of short straights and turns. In a racing situation you are never running your engine wide-open for extended periods of time, so neither should you run your engine this way when using it for fun in the back-yard or street. Use common sense and your engine will last much longer and your experience will be much more enjoyable.

Here's how to perform the break-in procedure correctly:

1. Decide on a fuel brand and type of blend (nitro and oil content) that you want to use.

WARNING: Whichever type of fuel that you choose, use the same fuel for break-in and everyday operation, for the life of the engine, especially the nitro content. Here's why: By changing fuels, chances are that either the nitro and/or oil content will change. Different ratios of nitro and/or oil in the fuel will cause combustion chamber temperatures to change. As combustion chamber temperatures change, the expansion rate of the piston and cylinder-sleeve will also change slightly. During the break-in process, primarily affected is the piston and sleeve size, which "seat" (fit) together at a certain expansion rate, determined by the normal operating temperature. Nitro and oil content in different fuels have an effect on normal operating temperature. By changing fuels after break-in, chances are the normal operating temperatures will change. These temperature changes will change the perfect fit (established during break-in) between the piston and sleeve, usually causing improper and/or greater piston and sleeve clearance, causing combustion "blow-by" (loss of compression). Also, by changing nitro and/or oil contents, all needle settings will require readjustment.

2. Start your engine following the starting procedures previously covered. During the break-in period it is much easier if you have someone to help you, so that you can concentrate on keeping the engine running while your helper adjusts the needles and keeps track of the temperature of the engine. A temperature gun is especially important during the break-in period.

TUNING TIP: At any time (during and after break-in), when you first start your engine, rev the engine in quick intervals a few times, before placing it on the ground. This helps clear out any excess fuel in the pipe, crankcase and combustion chamber and helps get the engine warmed up quickly. It is very important to keep in mind that you should NOT fine-tune your needles this way; this is only a quick warm-up procedure to clear the engine out and to get some quick heat into the engine. Optimal carburetor settings will be set once the vehicle is placed on the ground and warmed up completely, following the "SETTING THE NEEDLE VALVES FOR OPTIMUM PERFORMANCE" section further in the manual.

3. Once you have cleaned out your engine, following the “tuning tip” above, place the vehicle on the ground and begin driving it around while cycling the throttle between 1/4 and wide open, while you or your helper periodically check the engine’s temperature and make adjustments to the Main needle (if necessary) during quick pit stops. We strongly recommend doing this by running your vehicle in figure 8’s, in an area approximately 30’ x 50’. Figure 8’s, in this size area, work good because they allow you to cycle the engine between 1/4 and full throttle without over-reving the engine, while at the same time maintaining normal operating temperatures. Immediately, evaluate how the engine is running. It should be running rich, meaning the engine should feel low on power and quite a bit of smoke should be coming from the exhaust at full throttle. Break-in is a 4-tank procedure, and the goal during the first 4 tanks is to start the Main needle (also known as the high-speed needle) at a rich setting. NOTE: a good starting point is approximately 5/8 turn richer than the baseline Main needle setting found on page 17 of the manual. With each consecutive tank, the Main needle should be leaned about an1/8 turn. As you lean the needle each tank, you should notice that the engine’s temperature and performance will also increase. Once you are ready for the 5th tank of fuel, ideally your Main needle should still be slightly on the rich side and within 1/8 to 1/4 turn from optimum setting. Following these procedures, run the engine for a complete tank of fuel – then shut it down. Allow the engine to cool down COMPLETELY before re-starting.

WARNING: During the break-in procedure NEVER allow the engine to over-rev to maximum RPM, as this will cause excess stress on the piston, which can lead to the piston shattering. During break-in, when running at full throttle, always let off the throttle before the engine reaches approximately 50% of its RPM potential.

NOTE: the low-speed needle will be fine-tuned later; however, during the break-in procedure it is a good idea to make sure it is set about 1/4 turn richer than the baseline setting found on page 17 of the manual.

4. Continue this process for 4 tanks of fuel, making sure to allow the engine to cool down completely to ambient temperature before running the next tank of fuel. Also, make sure to lean the Main needle 1/8 turn prior to starting the engine each tank. On the 5th tank of fuel, you should be ready for fine-tuning the carburetor to optimal settings and cool-down between tanks of fuel are no longer necessary.

TUNING TIP: Over the years it has become customary to set the Main needle valve by engine cylinder head temperature (usually called temperature tuning); however, we have found that many people tend to rely too much on tuning their engine by temperature alone. Temperature tuning can lead to overly rich or overly lean needle settings. While overly rich settings normally are not too much concern and usually just result in poor engine performance, overly lean settings can cause severe and permanent damage to internal engine components in less than one tank of fuel. We recommend using a temperature gun whenever you run your engine, but use it to reference your operating temperatures, not to tune to them. It is most important that you get a "feel" for how your engine runs best by listening to its tone, watching for the proper smoke coming from the pipe, and noting its power and acceleration characteristics while driving. Once you learn your engine's operating characteristics, a temperature gun can be very useful in referencing operating temperatures for different conditions. Depending on your operating conditions (e.g., weather conditions, altitude, surface you are running on, fuel type, etc.), you should find that the FR21 and FR27 cylinder head temperatures (taken with a temperature gun; aiming down inside at the glow plug area of the cylinder head) will generally range between 220º and 260º F.

WARNING: Just because the engine is designed to run up to 260º F, do not lean the primary (main) needle valve to achieve this head temperature, unless your operating conditions dictate it! It's OK to run the engine this temperature ONLY if the air-fuel mixture is properly set for the operating conditions that YOU are running in. If you are ever in doubt whether your engine is running too lean, it is always the best practice to run your engine more on the rich side.