Rotax Engine Troubleshooting
and
Maintenance From Experience.

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My Rotax Certification is quite old and at 65 I'm not sure I care to go back to school to stay current, but I'll keep an A&P as current as I can afford. I have trouble shot many an engine and listened to many other problems over the last ten years and wanted to share some of your and my trials and tribulations so our new and second hand Europa owners may avoid our painful learning experiences.

The official Rotax troubleshooting guide is basic (except for the 914 Turbo Control Unit) and many hours have been spent on the internet sharing our particular engine problems over the years. We have all learned the hard way, through study, experimentation and just plain dumb luck, some of the techniques and maintenance checks necessary to keep our Rotax engines in tip top shape. Previously, I had hoped to stimulate some troubleshooting guides from the field on the Matronic's Europa List with a comment about a year ago but no one joined in, so here are my late night miscellaneous ramblings, condensed for those trying to troubleshoot their Rotax engine.

I have been surprised and miserable because of recurring problems of late in the older (Pre 2005 912S and 914 engines) so most of this below pertains to older engines and our second hand owners who may be unfamiliar with the Rotax servicing. The new 912S/914 are more robust, and alas I have no real experience with the iS fuel injected engines other than to take it to the dealer to maintain the electronics.

Troubleshooting guides most of the time cover systems first then crankcase mechanical so this one will be no different. However I have added a 2nd part in which I will break down symptoms which occur during phases of flight where they are most likely to occur and what they could be.

Full disclosure: My 914 is a 1999 engine and is quite old. Every SB, SI, SL or note applies to my engine. If the SB said there may be a problem, there was. So please pay attention to the SB, SI list for your engine and join the Rotax Owners Forum.

Most pilots want the maintenance checks complete just before the flying season starts and are in a rush to get it done. Consider doing them at the end of the season so you have time to fix things right.

Starters:

Low torque starters are re-buildable and quite reliable.
Trouble: I have had two that were full of grease covering the armature and making intermittent or weak turning. The battery was changed but alas the problem persisted.

Culprit: The front seal wore out at about 3-400 hours and grease got on the armature and made a mess of carbon dust and grease shorting/decreasing starter armature continuity. The performance of the armature was so diminished that cranking became somewhat slow or intermittent forcing the need for a rebuild. The starter is well sealed so no grease was evident on outside of the case.
Maintenance Service: Just remove, clean, buy $100 worth of seals and brushes if you choose and rebuild it. Make a note every 5 years/400 hours to pull the starter and check the shaft end fore and aft movement. If the shaft moves in and out over 0.3 mm, I guarantee you will have a problem soon.
If replacing your old starter with a high torque (AP style), you may need to cut a couple tabs off the housing to fit past our engine mount. (In Florida, I never needed the high torque, even on the 912S, provided the starter and battery are operating properly...

Ignition:

Trouble: While tuning the carbs on an annual I leaned on the ignition module and the engine began running rough. Grounds were OK. I moved the ignition red wires and the engine quit. NOT GOOD!
Culprit: The red power leads from the stator had broken right where they made a 90 degree bend as installed by the Rotax factory on a 2004 912S engine and a 1999 914 engine. The break occurred 3/8" or about 10 mm behind the crimped pin inside the insulation and invisible to the naked eye. The wire pulled right out of the insulation on disassembly. The wire was clean except at the break. (OLDER ROTAX ENGINES GENERALLY WERE NOT REPAIRED UNDER SB 912 013 OR 914 016, WHICH CALLED FOR RENEW AND REPLACE OF IGNITIONS. FRANKLY, WHO HAD THE MONEY!)
Maintenance: CHECK YOUR WIRES ON THE ANNUAL CAREFULLY. Make sure the leads are secure and suspect any tight wire bends. Do not zip tie directly to the wire insulation as the insulation is weak and the zip tie cuts through it over time. Use heat shrink and or wire ties over the heat shrink to secure the plugs from vibration. ALTHOUGH YOU MAY HAVE A NEWER ENGINE WITH SUPPORTS FOR THE IGNITION PLUGS, CHECK THE WIRES AT THE BENDS.

Coils:
Intermittent rough mag check but good rpm drop.
Culprit: Coil has been on the engine ten years. The metal core material was corroded and the plates were spilt apart. The coil ohmed out OK. The split plates of the core reduced the coil output. Changed the coil and all was well.
Maintenance: Pay attention to your coils on the 5 year check. Corrosion X or ACP50 helps prevent the unprotected steel from becoming a barnacle. If split ends are present, you will have problems eventually. Wait until it starts to miss and swap out the offending coil(s).

Plug wires:
These are just copper wires. Rotax says change the plug wires at 5 years...NOBODY DOES!

Maintenance: These wires last at least 10 years provided the wires are removed (around the 5-10 year point) and trimmed 1/4 or 3-4 mm to get clean wire at the ends (they burn or corrode on the tips), then re-screw into the coil and plug cap to finish. After 1000 hours or so, change the wires due to corrosion as copper won't hold up after 10-15 years.

Plug caps and spark plugs:
Mag drop rough on B mag.
Culprit: The lower plugs tend to run rougher on the lower module on a 914. (The 912S plugs fire top plugs on cylinders 1/3 and bottom plugs on cylinders 2/4 on one module and opposite on the other side so you don't necessarily notice the difference between upper plug and lower during a 912 mag check.) However, checking the plugs on the 914 revealed no problem with gap or continuity of the plugs, The NGK cap ends can sometime make poor contact and cause rough running.
Maintenance: Unscrew the plug cap and check the wire end as well as the cap inside for corrosion and clip bent out of shape. Changing the plug end is the best answer. I keep one in my spares bin.
Service: Change the plugs, they're cheap. I change mine every annual or 100 hours just because you are removing 50% of the plugs for the compression check anyway, just change them all. Never reuse a dropped plug. If it fails internally, you can't tell. Look in the plug cap every time you reinstall for any reason check for corrosion and bending. Because the system is a double spark (fires on every rotation) troubleshooting a plug or coil with a timing light is very difficult. I look for an obvious miss, but on such a low energy system, a fouled plug won't spark but you may or may not get a timing light flash. It is frustrating. If a circuit is completely out, you can see it on the timing light. If you still suspect an ignition problem read on.

Grounds:
Engine intermittently rough:
Culprit: Always check the grounds first on any ignition or stumbling problem. There is a service bulletin or instruction on the ring terminal crimps so pay attention.
Maintenance: Every 5 years unscrew the ground wire bolt, inspect, clean the terminals and check the crimp. If all is OK reinstall. If it still has an intermittent roughness and the coils, wires and plugs are OK, it is the carbs so read below on carb issues.

Charging problems:

Stator: Charging seemed weak and the regulator proved OK.
Culprit: The main yellow dynamo wires are crap. If running at a full 18 amps continuous, the wires heat, the insulation gets soft and fails. This was fixed with a new stator in 2004-5 and is expensive. If you suspect your dynamo is failing with low charging and the regulator is good. It pays to ohm it out as it may need work.
Maintenance: Inspect your wires coming out of the stator, and check for soft insulation. Ohm out the yellow leads per the service manual and check to see if you have an open circuit. If suspect, remove the stator, and rewire with #10 or equivalent Tufzel wire, or any good quality aircraft grade wire if you can still get a proper lead off the coil to get a solid fix. I solder the leads at or near the windings, and seal with epoxy again

and heat shrink, then run the wires to the regulator. Or you can just buy a new stator winding for $1000.

Regulator:
Culprit: Charging completely quit.
Much has been written about these Ducati regulators. I know that my Rotax dealer has a regulator checker they use for troubleshooting, and this is what I learned. The Rotax can only charge up to about 15 amps before voltage starts to drop from the 13.8 volts it should charge at. By 18 amps, the regulator is getting stressed, voltage drops and it will die. No amount of cooling air will keep an overworked regulator from dying.
Maintenance: Cut your amp load.

Regulator troubleshooting:
Culprit: Charging voltage is higher than 13.8 or the regulator is failing very often.
Technique: The regulator circuit is designed to connect the "B+", the "C" and the "R" to each other directly. The C, or control voltage, must be the same voltage as the R and B+ or the regulator will try to drive itself to raise the C voltage to the desired 13.8 volts. Many builders will run a power lead from the battery directly to a fused main buss and the C from the main bus through an alternator switch or from an automatic bus controller back to the regulator. These short runs don't seem to cause much of a drop in voltage but in the automatic busses (such as the EXP), because of their design, supply a lower output voltage from the bus (and the control voltage to the regulator) by some .3-.5 volts. The PTCs they use absorb voltage by design. If the control voltage is lower than the output voltage, the regulator allows more current/voltage to compensate to reach its desired 13.8 control voltage which is more stress. This may cause premature regulator failure. My technique is to install a small 30 amp relay from the R/B/C terminal then to the bus. The alternator switch will turn on the relay to buss connection which prevents a voltage drop on the C circuit. (914 owners run the aux boost pump off the R/B/C terminal directly to be in compliance with the Rotax install manual. This is the intention of the Rotax installation wiring diagram.

Aux Alternators:
Culprit: Low aux alternator output from the gearbox alternator.
Cause: The gearbox only turns at prop speed. Any alternator will be turning too slow for proper operation. A 40 Amp B&C alternator attached to the PTO will only deliver about 15 amps at cruise. Nil at idle or approach speeds. Simply look at the RPM vs output graphs on these alternators. At 5000 RPM the gearbox is only turning 2050 RPM. You are getting no more power than the Rotax alternator can deliver and less at lower RPMs. Gearbox driven alternators are only good as a backup in my opinion or for split bus operations. At idle or during approach these alternators cannot keep up.

Technique: Install a belt driven alternator. The pulley ratio allows full current delivery at 14+ volts. It can easily put out all your power needs down to idle power. This requires modifying the cowl and perhaps the propeller slip rings if you have an electric propeller. Another new type of rotor attaches to the back of the Rotax and gives another Ducati style alternator which works just fine also with no cowl modifications.

Turbo Problems:

Full disclosure: My 1999 Rotax 914 Turbo is unique as I stated above. The new 914s have somewhat better supports for the turbo. Electrically, the Rotax maintenance manual is quite good for specific component troubleshooting but poor for symptom diagnosis.

Culprit 1: Cracks form on the support around the ring on the hot section where the bolts attach. The stainless bracket is brittle from heat cycles. Cracks here will cause bracket failure, the turbo to vibrate, and the tubular arm with fail next. Cost of a new turbo is at about $8000.
Maintenance: Inspect supports every oil change. Once a crack is detected, remove the turbo, from its bracket, and weld stainless washers (507 is OK) to reinforce and prevent cracks around the bolt holes. Newer 914 models (2006 and up) are better supported but bear watching. If the tubular support is cracked, this must be removed, a sleeve installed inside the tube and welded in properly. Do not weld around the crack as a quick fix as it will fail again.

Culprit 2: The binx nut loosens on the engine mount and turbo bracket on the lower starboard side mount. This loose support and resultant vibration will cause the remaining turbo supports to flex and eventually crack. This can cause the exhaust pipes to crack as well. Watch for this.
Maintenance: Loop a safety wire strand through the binx nut slit and secure from loosening.

Oil leaks at the Turbo:
Oil can come out of the turbo seal and out of the small oil reservoir under the hot section of the bearing.
Culprit 1: Oil is coming from the oil reservoir under the turbo only.
Maintenance: There is a small ball and spring check valve in this reservoir. If oil is coming out of the reservoir, simply remove the reservoir and its lines, clean the parts and seats and the ball. Install new seals and install.

Culprit2: The turbo is the lowest point on the engine, oil will pool as the internal ceramic seal works great when hot but drips like all get out when cold. Your oil will eventually run out of the mouth of the turbo and into the filter and muffler. To add further to the insult, the oil on the hot side is forced through the exhaust and will coat your aircraft belly or left gear leg if you have a trigear. NASTY! This drippy oil also causes the filter to get oil soaked and it falls off the turbo inlet on engine start or in flight. Also, on engine start, the oil pooled in the compressor section is flung into the plenum, coating the carbs, the fuel pressure regulator inlet, and sensors. Eventually the oil soaked plenum rubber hose connecting the inlet to the carbs won't stay on and the leaking inlet will reduce your 914 to a 912 (80 HP) due to boost pressure loss.

Maintenance: Run your engine often to prevent oil pooling. Clean your plenum inlet out annually or by 100 hours with carb cleaner spayed into the carb side of the plenum and let it drain out. Suck the pooled oil out of the turbo if it has sat a long time (a year) to prevent pooled and congealed oil from throwing the turbo out of balance. Clean or change your plenum to carb inlet hoses for good traction for the clamps. Once these hoses become oil soaked, they are worthless, change them. If on cross country and the manifold vibrates off, safety wire the plenum to the carb to get home.

Safety wire the air filter on to the turbo to prevent loss of the filter as a rule.

Once all this work around with safety wire and cleaning is done, start the engine and warm it up. Run to full power, and fly with reckless abandon, land, and wash off the oil on the belly. You will be good for another year. (GOD I HATE IT, BUT LOVE IT!)

Waste gate sticky: Oil, heat, corrosion etc. causes the waste gate to stick. Use penetrating oil and make sure the waste gate operates freely every oil change. Adjust the cable properly. The waste gate should be full closed or allowing full turbo at idle and engine off, but it must not be hard at the stop. During initial electrical power up, make sure the cable will pull slightly farther open before the cycle. The cable should be firmly pulling the return spring and should keep the cable taught.

Maintenance: Lube with penetrating oil and cycle by hand until smooth. Operate the servo to check the cable performance.

Note on servo installations: Fabricate a tube for a guide for the cable coming out of the servo to keep the end of the wire from binding or fraying against bulkheads. The cable supplied is long and whips around during its cycling, and may jam against the bulkhead and can loosen over time and get frayed out. I make a tube to keep the cable in a sleeve and this keeps the operation silent and guides the cable to prevent a failure right at the set screw. Many installers follow the Rotax manual and put the turbo servo behind the firewall, and any problems there are a miserable fix. Consider making a box and mounting it to the firewall or foot well top with a supply of cooling air, where it can be maintained.

Carbs:

Leaks. Any leaks in the float bowls, carb exterior, or internally (as in fuel is burbling out of the carb inlet), must be fixed immediately. The fire hazard is not worth it.

Engine rough and vibrates:
If vibrations or roughness is felt, I normally start with the carbs, then ignition tests, then I go to mechanical engine problems.

Notes: 90 percent of the rough running issues are the carbs. Balance of the carbs must be done at idle for a smooth ground operation but for optimum engine component life, must be smooth from idle to full military power (oops, I mean full takeoff power). Any out of balance in the mid-range will cause excessive shaking of the engine. Most of us can tell when we have a small vibration in our engines and investigate immediately as small things never get better. We have had folks completely change out an engine, because they couldn't get it to run smoothly and were fed up. The old 912S engines were *a bit shaky and you could feel vibrations in your calves even at cruise. No amount of carb synchronization, ignition swap out, and tuning can fix a bad engine. The Rotax should be able to be run without the ignition modules shaking due to roughness from idle to takeoff power. I have heard it said many times and found it to be true that in the mid range from 2000-3500 RPM (before the main jet takes over and the pistons are fully up*) *there will be a slight vibration at a small RPM range due to carb pistons being out of sync. This piston sync can be checked with a mirror while running and you may be able to correct this problem. Normally, the engine should be smooth from idle to full power.*

Note also: If the prop is out of balance statically, or dynamically, or not tracking properly, it can cause you to think it is the engine. If your engine shakes to the point where the ignition modules (and your body) vibrate, and the engine has been checked, have the prop looked at. Most prop manufacturers (Airmaster/Whirlwind/Sensenich) statically balance their props. Airmaster dynamically balances their prop, so these props when new should be very smooth. Most of the time, vibrations of the engine/gearbox need a few grams of weight on the prop spinner flange to balance out the engine/prop combination and make the engine/prop combination smooth. A good dynamic balancing of the prop after carb tune can sometimes allow an owner to isolate whether it is a mechanical problem or not. The newer graphical dynamic balancers will show intermittent roughness very well.

Symptom: Engine starts OK. Idle to 2000 RPM the engine really shakes even with the crossover tube attached. The carb mechanical balance is off.

This is a basic carb setup problem. Make sure the throttle cables are working smoothly and the engine is at operating temperature. If the carbs cannot be set on the same manifold pressure, the throttle plates or idle circuit is not set up properly. Rebuild the carbs.

Maintenance: Most Rotax mechanics will rebuild the carbs every two years or a couple hundred hours. If they are running smooth it is a bit overkill to remove your carbs just to renew the O-rings and gaskets, but the throttle O-ring does wear and will leak and mess up the carb balance. If the carbs are dirty or not running perfect, rebuild the O-rings and gaskets at a minimum. The diaphragm and manifold to carb rings generally last 5-10 years. Look for cracks and wear. LEARN HOW REBUILD THE CARBS! Set the carb throttle plate so when closed, little or no light penetrates the bore before setting the screws and peening them to the shaft. A poorly aligned throttle plate will not balance properly at idle. Once a good seal is found, open the bore with the idle screw to expose the second small hole located in the bottom center of the carb exit (it is a .020 super small hole behind the air bleed enrichening hole), or just follow the Rotax mechanical set procedure. (Make sure your idle stops are not bent or damaged. These stops must be even to give proper idle to full operation.) The carbs will allow an engine start with this procedure and be extremely close to balance. They will be easily capable of setting dead equal on manifold pressure, or just look at the engine and tune by ear and eye until dead smooth. This should only take the moving of a single cable fore or aft a half of a turn of the nut to achieve. I set the idle to 1650-1700 or so when using an Airmaster with the idle stop on the carb. I adjust the throttle stop screw in the cockpit to 1800. That way if I keep overshooting the airport, I can back off my idle in the cockpit a bit for summer landings or compensate for winter low initial idle by turning a screw in the cockpit. *See Airframe throttle cable maintenance.*

Symptom 2: The engine becomes rough or has excessive RPM drop during ignition/mag check, but very smooth running at 4500 to full power. This is a typical carb sync issue.

Note: I use only a match set of gauges to tune my carbs so I can see exactly what the manifold pressure is behind each carb. Never balance the carbs at idle only and go fly. Always run up through 5000 RPM to check the manifold pressure difference between the two sides. I do not use the electric balancers sold by Rotax as they are not as accurate as I like for this type of testing. Once I set the balance, and adjusted the cable set nuts, it is not uncommon that after the engine cools and a restart is done a day later, the setting may be off just a bit as the cables and carbs are cold. Let it warm up and adjust again if necessary.

If you change fuel from auto fuel to AV gas the engine will idle slightly faster. If your auto fuel is old, it is difficult to get a good tune sometimes. Use good fresh fuel.

Culprit: The manifold pressures are way off during run-up. (Pistons in the carbs do not operate in unison.)
Maintenance: Rebuild the carbs. Rotax will tell you to buy new carbs and have Rotax tune them to match. Or you can troubleshoot.

To check the pistons operate in unison:
With the carbs dry and free of fuel, I hook a Y pipe to my shop vacuum cleaner (complete with used carb manifold gaskets) to pull air through both the carbs simultaneously as the engine does. I operate the throttles in unison to assure the carb pistons also operate in unison. If they don't move together, start looking for why. In the rebuild of the carb, you must check that the piston and the body have no burrs or problems. If the body is badly scarred, your piston has cut a slot in the body wall and is probably hanging up. This is caused by a foreign object or your engine has been shaking so long it has caused the pistons to slap the body side until worn. In this case, it's time to buy a new set of carbs. If the pistons can be made to move together, check the floats and valve. Fill the carbs with fuel and check for flooding. *(I use a fuel mechanical pressure gauge Teed into a line and a syringe full of fuel to push fuel into the carb and verify the floats and needles are operating properly.)* If they are good with no leaks, install them on the plane and start it up. Do an initial balance. Run up the engine. I normally see no more than 1/2 inch difference in manometer pressures from idle to full power. If you see large differences in pressures during run up, you have a piston sync problem. If you are in the field and don't have a vacuum cleaner to check as I do above, and suspect the carb pistons are out of sync, then pull back the plenum from the carb a bit and use a mirror and check the pistons for operation. *USE CAUTION as you are close to the prop. Tie the plane down well.* If one piston is higher than the other, take them off again and

investigate. Expect to be wind blasted so keep FOD (Foreign Objects) from going in the carbs while doing this.

Symptom 3: The engine is rough from mid range to full power.

Maintenance: If the manometers are fairly even, it's electrical or mechanical. If the compression is good, its most likely is electrical. Check the plugs again.

Manifold Leaks:

Leaks in the manifold system and the tubing connecting the carbs to the manifold are fairly easy to troubleshoot. But knowing where to look and paying attention to what the solution is to a carb bowl air leak or manifold leak and recognizing its symptoms is not intuitive. The first thing to note is that the float bowl must be at the same pressure as the carb inlet, or mixture control will be affected. The small tubes that attach to the carb bowl to the manifold must be clear. Never assume on a 914 that the rubber hoses of the carb bowl to manifold attachment are good. Check them well.

912/912S Manifold:

The 912 and 912S have only one tube each from the bowl to the intake manifold or filter area. In the 912 Classic, the tube was just tucked under the float bowl clip. Of course, if the tube was bent shut or crimped, the carb float bowl would not vent properly. This manifested itself as a roughness at higher RPMs and during climb out.

914 Manifold:

This is a bit trickier. The 914 vent plumbing is more complex and requires close inspection. The 914 Bing 64s are designed with a pressurized float bowls. It is essential that for proper atomization of the fuel and continuous fuel flow, the air pressure in the float bowl needs to be near the boosted air box pressure to achieve this. In order to allow fuel into the carb under the turbos max pressure of 5 psi, the turbo control unit uses two vents taps from the manifold tube to the carb float bowls via an air solenoid. One tap is at the top of the vertical tube coming from the turbo (ram pressure source) and the other is near the fuel pressure regulator which is an average air box air pressure. When running at max continuous power (35 inches MP or less) the intake air is vented to the carb float bowls directly from the center of the manifold. The fuel pump of course only puts out 5 PSI at low power settings and as power is increased the air box pressure builds to about 2 PSI, so the effective fuel pressure of the fuel pushing into the float bowl is only at 3 PSI. When full power is applied, now 5 PSI air pressure is in the manifold and on top of the fuel in the float bowl, so the fuel pressure regulator must kick up the fuel pressure to 7 PSI min just to prevent the fuel from being forced out of the float bowl. But at the same time, the TCU directs the air pressure solenoid to allow air from the ram inlet to deliver higher ram, pressure to the float bowl. If the solenoid fails or there is a plugged or damaged air line, the engine leans out and runs poorly.

Symptom 1:
If the engine runs fine up to about 30-32 inches of MP then when full boost is applied the engine begins running rough as if out of sync or one carb is starving for fuel.
Maintenance: One normally assumes a fuel problem, but if one of the rubber manifold lines is leaking, one carb bowl is now unpressured. This starts out seeming like a balance problem, then it becomes a fuel delivery problem.

Symptom 2:
The engine runs up to 35 inches or maximum continuous 100% OK, but as soon as full turbo (115%) is selected the engine begins running rough as above. Here, there is either a leak in the tubes or more likely the solenoid has failed or is plugged. Oil is always in the intake manifold, clean it out once in a while...

Maintenance: Before replacing the air pressure solenoid, test it. If you can't be sure it is operating just re-plumb it to bypass the solenoid and direct full air from the ram tube directly to carbs and run up past 35 inches. If the engine runs smooth, you found the problem is the solenoid. Don't run a long time with this setup, as below 34 inches the carbs are getting too much pressure and will lean out.

Carb Fuel Leaks:

Carb leaks as seen by a faint staining on the float bowl, or fuel in the tray, followed by fuel dripping out of the carb at full turbo on a hot exhaust.

914:
Note: A carb float bowl leak at full power causes the engine to lean out and EGTs may be high or running is a bit rough. Of course the leak should be caught by the drip tray supplied on the engine. *912 engine bowl leaks only stains and causes fires as it drips on the exhaust. See below.*

Culprit: Gasket at top of float bowl is damaged or was not soaked and softened on install or was not seated properly.

Maintenance: Paper gasket should be soaked for 30 minutes in fuel to soften so it can compress and take form on install. If the float bowl is bent or distorted it must be repaired or replaced. Set the bowl on a dead flat surface and check the upper surface and lower. These should be dead flat.

Maintenance 914: Until about 2006, the carb float bowl attachment had a fiber washer. It was replaced with an O ring on the carb bottom. If you have an older 914 your torque settings for the float bowl bolt is suspect as an O ring cannot be torqued properly. As the O ring ages, it will soften and it will leak in only a few hours. Omitting the O ring and over torqueing the float bowl may cause the main pickup to be near or on the bottom of the bowl and limit fuel supply causing hi rpm leaning or rough running. Rotax came up with a new idea to increase the distance between the float bowl bottom and the main pickup by adding an O-ring. It works great on initial install but compresses permanently and loses its torque later on. I have found that if I leave the fiber washer on, add the O ring, torque or squish the O ring to specification and wait 24 hours and retighten, I can get buy for a year without re-torqueing or leaking.

I have also managed to get a thicker phenolic ring gasket in place of the O ring. This works so far as the thicker washer prevents clearance issues, but bending of the bottom of the bowl can still be an issue so I use the O ring as well. It works OK.

How to tell if your float bowl is bent:
When the float bowl is over tightened the bottom of the bowl deflects and the float pins are bent inwards on inspection. The bowl bottom is now concave and the pickup may not be getting its full fuel delivery.

Maintenance: Carefully set the float bowl on a flat surface and install a large socket which just covers the bottom ring and insert an extension in the upside down socket. Gently tap the inside to flatten the bottom. Very carefully bend the posts back straight. *Caution, the cast aluminum may crack!* When in doubt, replace the float bowl.

914 carb removal hint. *Pulling the older carbs off the old style round tight fitting fuel trays is a bit tricky. Normally one disconnects the 12mm compression nut, pulls the stainless steel fuel tube back, then removes the carb from the manifold by twisting and elevating the rear of the carb and pull it out. If the carbs are in trouble and must be repeatedly removed, The 12 mm compression nut fittings at the carb may be compromised. These fuel lines are difficult to find if one starts leaking. Don't use sealant to cure this problem. Get a new tubing assembly made up or buy one from Rotax.*

Technique: *To prevent damage to this compression fitting, disconnect the banjo bolt from the pressure regulator, loosen the manifold clamp and spring and simply rotate up and out the carb with the supply tube, choke and throttle cables still all still attached. Then fool with the bowls.*

912 Float bowl leaks:
Maintenance: This is almost always the gasket. The spring clip keeps good pressure on the gasket, so check for carb flooding or the floats are sinking or needle leaking. If the fuel level is too high, it will slosh out of the carb and cause the engine to be rich on one side, making for a distinct burbling sound on the mag check.

912 and 912S owners should fabricate a drip pan to prevent future fuel drips from dripping on the exhaust. One technique is to bend a piece of 0.032 inch aluminum, into a tray shape and simply attach it to the foot well. Weld the corners and provide for a line to carry the fuel away from the area as in the 914. Another method is to form an L shaped tray as in the newer 914 drip trays and attach it to the manifold. Or simply buy the expensive new 914 drip tray with the two bolts to remove the tray for float bowl inspection. Do not use the old round 914 drip trays, they are a pain to work around.

Airframe manufacturer problems engine related:

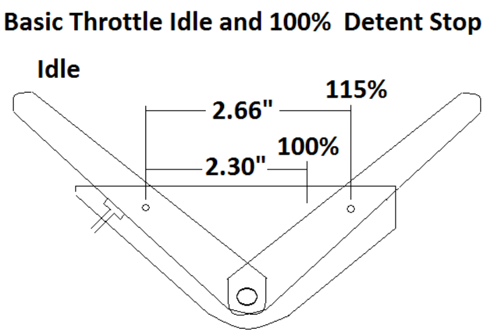
Throttles:

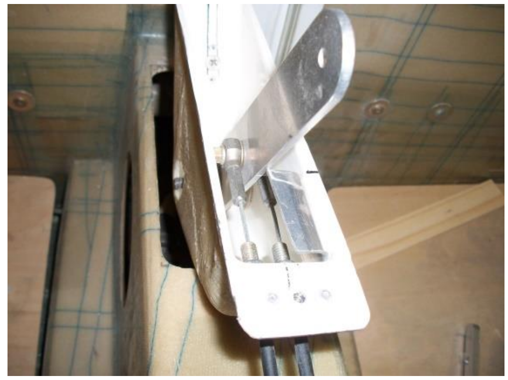
Symptom: The throttle cables always hang up and don't work in unison. The throttle cables don't seem to be able to push the throttle open or the springs seem to be weak:

Carb Throttle Maintenance:
The springs on the carbs should not be tweaked or modified, leave them alone. If the throttle arms move freely and don't hang up it's your cable installation. Many have made up solid wires and other things, for a better push pull operation, but I have no problem with the bicycle cables used by Europa. Keep the bends long and loopy and do not fasten the throttle cables with zip ties or try to lock them in place. Any sharp radius turns or tight bindings will prevent smooth operation and idle setting difficulty. (Not unlike a bicycle shifter cable.) Don't cut the cables unless you have the proper equipment. Care must be taken to cut the sheath and seal the cable without burrs. Don't over tighten the cable pivots on the throttle arms. Just tighten until the cable slightly bows from the tightening or is just snug. Every oil change, lube the pivots at the arms.

Note: The mono wheel firewall penetration almost guarantees a cable binding problem. Much care and planning is necessary to fit the cable over the bungee and that short bend up on exit of the firewall then bend around to the carb is fairly tight. Technique: Run the cables down and offset from the bungee and then smoothly up around the engine frame and loop smoothly up to the carbs. This has been a great help, but requires new and unique ways to run the cable through that low on the firewall, clear other items, and still make a smooth loop. I have found that running the fuel line, choke and throttles through one hole helps with the cable runs and limits the number of holes in the firewall.

Build your throttle quadrant right. Start on the bench. The cables should not flex or drag on the cable sheath threaded end inside the quadrant. Pay attention and shim your cable sheaths to be as perfectly aligned as you can. If one is angled up or down, it will not operate exactly like the other. The 914 throttle housing in the cockpit should have a small detent installed in the throttle at 100% throttle. (This is about 2.3 inches from idle as the total throw is 2.66 inches). You should see 34-35 inches at the stop of a 914 and have to push slightly outboard to go to full turbo (38-40 inches). For both the 912 and 914, there must be a stop for idle. A metal tab can be used also that can be removed, filed and reset on carb tune for a proper stop. I have a screw in the back of the throttle for the adjustable throttle stop set. Use an AN525 10R8 or similar and nutplate riveted to the back of the fiberglass throttle molding to make an adjustable idle stop.





Once installed in the airframe but not hooked to the carb throttle, the cables should move smoothly <u>in and out.</u> With no spring to pull the carbs forward, this will tell if your throttle run is free from binding. If all works well prior to cable to carb connection, you will have trouble free operation.
I never zip tie my cables to hold them firmly attached to anything. Every mechanic wants to secure these lines. If they work on initial install, and with the firewall attached, don't fool with it. Never use the Bing idle stop on the carb as your throttle stop. It will bend easily and eventually the carb balance will be off forever because of it.

Choke or Enrichening circuit cables:
Culprit: The choke knob pulls off the barb because the cable is so stiff to operate.
The cable moves without fine without being attached to the choke arm. The choke arm works fine also. The tension on the choke cable going through the brass 90 degree tube is dragging in the tube on top of the carb and that is where the resistance is coming from.

Maintenance: One installation note is for the installer to pre-bend the choke cable to be nearly the same arc as the tube. Installing the choke and twisting the sheaths during install is a common problem. So don't do that. To improve the cable through the brass tube on top of the carb, use an old wire to burnish the inside of the tube making it smooth. Make nice wide loops in the cable housing. Run the cable from the right carb to the left in a straight line so the cable has limited bends at the end except for the one in the tube. Don't shorten the cables, just run the right one to the left carb and loop back to the left carb copper tube. Thread the cable into the choke arm. Lube with graphite. Safety wire the sheath to the Rotax cable tube with .020 wire to hold the end of the sheath to the copper tube fitting. Affix the cable to the choke arm and check. It will be firm but should move freely. Every year, use some graphite lube in the tube to help it slip if it gets sticky.

If the knob pulls off, remove the knob, and redux on. If you don't want to redux, then remove the knob, drill through the sides of the knob plastic and brass and tap in for a 3/32 or similar set screw on each side. Clean the threads after tapping and reinstall. Set the set screws and it is trouble free.

Engine mechanical problems:
Some may require major overhaul or specialized training:

Annual Compression Check Concerns:
Many builders/mechanics will do the compression checks first while draining the oil during an annual type condition inspection, as it is part of the normal task of cleaning, leak checking and inspection process of an annual condition inspection. Normally I don't drain the oil any longer first, as you will get air in the oil lines and require a purge. I run the engine or fly the aircraft first to determine its normal engine operation (unless it is unsafe). On landing, I post flight the engine, remove the cowl and check for leaks and wipe the engine down again. Run the engine to operating temperature and check for leaks (exhaust, oil, gas), and burp the engine to get all the oil in the tank. Then with the engine fully warm, follow standard procedure and use a proper differential compression tester with the proper orifice. They are cheap for a tool, so buy a Rotax one. Check at top dead center. Normally a differential compression will be 78 over 80 for a new engine. Used engines of 3-500 hours are 75/80 plus or minus a couple. For smooth running, all four cylinders should be nearly the same.

Culprit: One of my cylinders is low by 5 or 10 psi. Let's say 3 cylinders are 75/80 and one is 65/80 but the engine is smooth. Don't panic! With the prop properly blocked, and pressure in the offending cylinder listen in two areas with a stethoscope.

Leak detection sounds: If the air can be heard leaking out of the carburetor, you most likely have a dirty intake valve seat and the valve isn't sealing well. If the air is leaking sound is coming out of the exhaust (really hard to hear in a turbo) it is an exhaust valve leaking. This is most likely due to carbon or a bit of lead buildup. Pull the valve cover and tap the valve. If it seals, you have confirmed you are getting dirty valve seats. If the compression ratio doesn't improve, borescope the cylinder and check that the engine didn't over speed and the valves may have contacted the piston top and bent the valve slightly (as seen as a ring on the piston top). Have the heads removed and investigate if this is the case. If it looks good after a borescope, run the engine with Mogas and clean valves by running at max continuous for a few minutes. If still low, the valves may need a cleanup and lapping. A valve cleaning and lapping is a fairly inexpensive job of under $2000 for all four.

Oil crankcase leak sound: This means the rings are worn, or the ring gap of all three rings are near alignment. These rings will rotate in use and it is common to find one cylinder
that has had this ring gap alignment happen. Run the engine after maintenance for a couple of flights and recheck. Normally it will clear. If the compression is still low, look harder with the borescope and check cylinder scoring and the like. It could be just a cleanup of the cylinder and reinstall or a new cylinder and rings.

Caution: Rotax engines should not leak oil, fuel or coolant, EVER!

Oil Leaks:
If your engine has an oil leak, immediately look for the source.
Visually inspect and mark or photo areas where the leaks appear.
Clean the engine very well. Allow to dry. Developer is a fine talc like material sold in spray cans for far too much money. But it works and allows the talc to stick to the engine surface to easily observe oil leaks. Spray developer or spread talc powder on your suspected areas.

Prop blast will make hunting for a leak miserable. You may have to cowl the engine to find your problem. Oil from cowl pressure may cause oil to stream out from behind the prop on to the cowl. Oil may swirl inside the cowl and find new and unique ways to puddle.

Some possible causes:
Oil Pump:
Occasionally an oil pump O ring may leak due to a factory install error. Install a new O ring, and coat the sealing surfaces with a thin layer of Loctite 515. Allow 24 hours to cure. Recheck up to full power. If it continues to leak after installing a new one, something is really wrong. See case fretting below.

Engine Case:
Engine block heating bolts can cause leaks. Once it leaks due to removing a factory bolt and installing a heater bolt, the sealant may be compromised. You're screwed. Try to fill the screw hole with sealant and re-torque. **I never recommend the heated case bolts.**

Heads and valve guide tube areas:
Heads have two cap nuts under the valve rockers that have no sealant. If you have a leak at the
head inboard of the valve cover contact the dealer and get a new cap nut. I coat the cap nut with 515 on its flange only and re-torque. Only due one head bolt at a time or you are re-torqueing the engine.

Mechanical Fuel Pump 912/912S:
912 Fuel Pump gasket:
Rarely does this happen, however, this may be a premonition of a failing fuel pump. Be sure the leak is from the gasket and not from the pump itself. The mechanical pumps are driven by a gearbox lobe pushing a plunger and are a simple diaphragm pump. No oil or fuel should ever leak out of these pumps. The original pumps had no drain tube coming out of the pump, just an inlet and outlet line. If your aircraft has been modified with the latest pump there is a drain line on the pump. No fuel or oil should ever come out of this drain or from the crimped or bolted body. Make sure the drain line is clear and vented to a neutral pressure area so as not to affect the pump pressure. If only the gasket is leaking, simply remove, clean, and replace the gasket and watch.

Gearbox:
Gear boxes sometime leak at the 6 O'clock positon. Normally the gear box just needs to be pulled and the flanges cleaned and recoated with 515. Apply a bit more than a thin film at the 12 and 6 O'clock position. If the case haves are not even, get it fixed under warranty on a new engine.

Coolant Leaks:
Glycol will cause corrosion over time. When changing the hoses, clean the nipples of any scale. Use proper clamps. The nipples have O rings on a flange on the top, and some have sealant and just screw in. Use developer to determine where the leak is, and remove, reseal and replace the nipple seals which are leaking. If Loctite sealant is used, allow to cure before refilling and running the engine.

Water Pump:
The water pump has one bolt that goes through the wet section of the pump and must be sealed properly. If a drip is evident at the water pump, use talc powder or developer to look for where the leak is. Pull the water pump, clean the seating surfaces. Check for casting errors in the stator housing and pump housing. It is not uncommon. If the long wet section bolt is corroded, replace it with another stainless bolt.

Casting Errors:
Both the stator housing, crankcase, heads and gearbox have been known to have casting errors that can cause a leak or in extreme cases structural failure. Most of the casting failures are found fairly early during leak checks. Always troubleshoot leaks and document them with the dealer and determine if your engine has a warranty still on any component in question. You may get it fixed for free. Do not pass up a chance to document a problem. Some manufacturers ignore inputs, Rotax documents them. Especially problems from the recreational flyer as their engines are rarely stressed.

Gearbox 600 hour checks:
I would recommend removal of the gearbox using the proper tool (a slide hammer purchased from Rotax) and sending it off to a Rotax repair center. The spacing and torque settings for the slipper clutch and bearing seats is easily done with the proper tools and a dealer rebuild is very cost effective.

Reinstalling the gearbox requires a small amount of time and technique. If a PTO spline is installed, its gear must be aligned carefully on install of the gearbox. Never try to just push on the gearbox. Once aligned and the gear box fitted, rotate the engine by hand. If it doesn't rotate easily immediately or seems stiff as you pull down on the prop blade, STOP. Pull off the gearbox as the PTO spline is not seated properly. If you rotate the engine by force, you will break a small plastic cog in the gearbox and you will have to have the gears pulled out again. Don't worry, the gearbox fix is easy and only one small plastic spacer will need to be replaced. Also don't worry about removing the gearbox again during the install if you bound up the gears. Just remove, clean, seal and reinstall properly with PTO movement. When reinstalling the gearbox, always use Loctite 515 and apply a thin flat bead all around and especially on the upper and lower case split sections.

If you don't know what I am talking about, pull the prop and engine and take it to the dealer.

Engine Case:
I do not recommend an amateur try to rebuild a Rotax. There are too many special tools and fixtures needed and it is time consuming. It is not rocket science, it just requires the tools, time and technique.

I especially do not recommend cracking the case apart. Buy a short block if you have internal problems. The labor costs on cracking the case can be daunting.

Mechanical problems evident to a pilot which require grounding and dealer servicing:

Case Fretting:
The older Rotax engines have exhibited problems with the internal engine flanges flexing and wearing at the bearing seats. These flanges are built into the case halves on the crankcase and hold the bearings for the crank shaft. The typical case fretting occurs in the 912S and 914s engines which are operated at full boost often and for short periods of time such as in glider tow. However, any 912S or 914 subjected to long hard climbs at full power for 15-30 minutes per flight, should be looked at just as hard.

Case fretting or internal failures are evident when burping the engine prior to flight. If the initial force required to move the propeller blade is high (I think the new manual says 100 foot pounds), then seems to move freely after breaking free, the case internally is fretting or wearing against the other case half causing the bearing to be squeezed on the crank shaft. Your oil system will not show iron content as the bearings are tight, but not spalling. The original SB indicates that cracks can be seen at the case bolts. It doesn't always show there. Look for oil leaks on the case split and between the cylinders. The engine flexes during running and it is very likely that cracks will form and be evident as oil leaks or as a wet spot on the case. This is actually a crack in the case from the internal flange failure. It also can be seen as leaks from the cylinder to case or head to cylinder areas, as well as the oil pump. The case fretting or failure will cause many other symptoms such as numerous oil leaks, strange vibrations or performance problems. I've only seen it once, and the engine ran just fine. But it was a ticking time bomb.

Engine Accessories, Sensors and Consumables:

Exhaust:
Exhaust leaks:
The 912S is a high vibration engine due to its high compression. This lateral shaking is high in amplitude and is tough on exhaust components, such as the joints, springs, down

pipes, and mufflers of your exhaust. It is essential that the engine roughness be checked and solved or the exhaust system will fail often. The 912 (80 HP) is not as prone to this shaking but bears watching as it often has the same exhaust system as the 912S. The 914 and Classic Europa exhaust are a different animal but each its own unique problems.

Any exhaust leak is bad. 1300 degree heat milling around the cowl will burn through coolant and oil lines. Exhaust jetting out of the pipe to head or pipe to muffler joints can hit the exposed carb and cause a fire, or boil the fuel in the bowl and cause rough and lean operations. Evidence of a problem is a brown soot stain on the pipes or surrounding components. Once installed, the exhaust system should stay put. If the exhaust continues to move during operation, you have a problem with the engine, or the muffler support. The CKT exhaust system is light, well built, and fairly reliable, but if the engine is particularly shaky, it may move on its own, causing leaks, head to exhaust seal wear, broken springs, and cowl wear or burning. Not even strapping the exhaust down will fix the problem.

Maintenance of the exhaust:
Check the fit at the head to pipe joint. Replace pipes that have irregularities in the sealing cone. If the head is slightly out of round, use lapping compound and lap the pipe to head for a good fit at exactly the angle of the pipe fit. The heads are aluminum so a little lapping may be required for a good fit. Never over tighten the exhaust studs and nuts. Use Loctite 243 or similar to install the exhaust studs and <u>allow them to cure</u>. The Loctite will allow you to properly torque your exhaust bolts. Never torque a loose exhaust stud. Once the engine fires up, the Loctite will fail, but we have not had a problem with the studs unscrewing unless the exhaust is moving on the engine. Those members of the department of redundant redundancy can safety wire the nuts to each other to avoid loosening. See below if the exhaust system is moving. Remember, if it leaks at the head you can lap it.

Check the fit of the down pipe to exhaust muffler. Loose fitting or heat warped seals cannot be fixed easily. First off, the muffler manufacturers which use ball joints do not have a convex joint on the muffler to properly seal the down pipe ball joint in. I have used, with some success, a Permatex muffler sealant paste which is water based and has proven to seal these muffler to pipe joint leaks for at least 100 hours. If your downpipe to muffler joints are leaking I would try it with new springs as it has been effective over the short term.

Look for exhaust down pipe cracks. Especially near the EGT holes. Replace the pipe or pipes if cracked immediately.

Springs are a pain. Normally a Classic 912 Exhaust or 914 with slip fit pipes and or bolted flanges are no problem as the springs simply hold the two slip fit pipes together. The 912S is a different animal. It tends to be rougher in its horizontal movement. This causes the exhaust to build momentum and want to move. The springs are designed to hold the ball joint very securely but not secure the muffler or down pipes from moving fore/aft/or laterally. The springs supplied do a very good job of keeping the joints pulled up tight. With proper sealing and cylinder head to down pipe exhaust stud torqueing, the exhaust system should not move at all.

Springs fail for a number of reasons. Any exhaust leak, heats the spring, it loses temper, and will eventually fail. Also the harmonics of the engine causes a harmonic in the spring, which causes premature fatigue failure. But these things are fixable. Always remove the exhaust and assemble the springs on to the down pipes off of the engine. Remove the exhaust system, rotate the pipe down to horizontal to loosen the springs. Replace the springs, rotate the down pipes back into the sockets (with sealant if desired) and reinstall the system and wipe up the excess sealant before it dries. To prevent a failed spring from being a hazardous dropped object or FOD hazard, run a piece of .032 safety wire from the spring mounting hook inside the spring to the upper hook and twist and secure. To prevent harmonic oscillation, coat the spring with red RTV on one side to dampen vibrations. This greatly increases spring life, plus you can see where the spring failed and go back to the manufacturer. He may give you a new one.

Types of springs vary. One thing to be sure, the spring itself must be made very smooth. Any marks from tooling will lead to premature failures (a common problem with CKT springs some 5 years ago). If a spring failed, many owners went to the local motorcycle shop and bought 3 inch springs with a simple hook to replace their original springs. These hook style springs can be installed by simply pulling up on the spring with a spring tool (a few loops of .040 safety wire with a wooden handle will do also) and hooked in place without removing the exhaust. After all, if the muffler system wasn't leaking or broke, why take it apart for a single spring.

Again, quality of the spring is important. Any good spring will work. The failure rate of the simple hook springs seems to be on par with the factory springs. They seem to favor failing at the hook. Stay away from simple carbon steel springs as they rust out very quickly and fail. Stainless springs last quite a while, but do need attention.

If you need a quick fix on a factory spring (type with the loop like a tail wheel spring) pull it up taught and safety wire it in place with .040 safety wire looped 4or more times. It will hold. It is a tedious job to pull tension on the spring, while looping the wire. It takes two people and 4 hands.

Engine Sensors:

Oil sensors for the Rotax can be problematic, especially on the 912S engine. Rotax uses a simple VDO sensor of 10 bars. At the factory they install a brass ring on the VDO sensor to reduce vibration induced failure of the internal components. This failure and patch has gone on for years. Many have opted to run a fitting from the oil pressure NPT fitting to a line connecting to a sensor mounted on the foot well. Honeywell makes a very nice sensor as do other manufacturers. I just use a plain VDO sensor. I heat the failed sensor, remove the brass ring and JB weld on the ring to the new sensor and put it back on the engine. Good for another ten years.

The VDO cylinder head temp sensors work quite well and seem to last forever. Problem is Rotax uses their own thread pattern so the cost is way up there ($180 over a $30 VDO sensor which uses a different thread pattern). The ring style sensors (as on many engine monitors) work well, but are on the outside of the cylinder head. I tend to prefer the Rotax sensor. Especially now with the new head design.

Note: The Rotax oil temp and cylinder temp senders are the same, so if the oil temp fails, swap it with the head sensor to troubleshoot.

Coolants:
Ethylene Glycol is fine, but use the factory 50/50 mix or use distilled water. The heat transfer rate is quite good for glycol. It is true that local boiling occurs in the head about 260 and I know that every engine I have done, if I let the head temp get above 245 it boils over some due to the XS cooler being a bit small. Why use it. So I don't have to change radiators. The BTU transfer rate of a 50/50 mix is excellent, but the Europa glycol cooler must be sealed very well, and the climb speed kept up around 90 to climb to 10K in my aircraft. The bummer is you have to change coolant every couple years and you will see at the 5 year hose change some corrosion at the nipples. Change your pressure cap also, as they tend to last only about 5-10 years before they lose a bit pressure.

Waterless coolants have lower BTU transfer rates and some have to be watched for the additives they have as some attack aluminum. But you can go with a lower cap pressure and corrosion should not be a problem ever. I used Evans NPG+ for a while and it works well, but I needed either a larger radiator and or water pump to keep the temps down in my southern climate. Global warming you know.

Pressure caps are important:
.9 Bar for Evans
1.2 for Glycol

Fuel concerns:
Aviation (AV Gas) fuel of 100LL :
Pro: Starts fast, found at all airports (manned airports anyway) never has an octane issue. Airports have very efficient fuel filtration for 100LL.
Con: More expensive (although fuel is the cheapest running cost on the Rotax), Lead reduces time between oil changes to 25 hours, and gray nasty soot gets on the fuselage and in the engine. You have to add an additive to prevent lead from plugging everything up on the inside. On about every 150 to 200 hours you have to clean the lead out of the oil can. Gearbox oil contamination reduces the gearbox overhaul time a bit. Valve seats can get sticky without the TCP additive, so add it religiously.

Auto Fuel non ethanol MOGAS:
Pro: Cheaper than AV Gas, burns cleaner. Oil change interval 50 hours
Con: Difficult to find 94 octane for the 914 (91AKI rating) or even 92 Octane (91AKI rating) for the 912S.

If left for a couple months, the octane rating drops as the ethanol absorbs water. Most pilots cannot hear detonation in a 912S but it leads to a serious amount of damage if low octane fuel is used even for short periods of time.

MOGAS is great for the 912 (80HP) as the engine is good down to 87 Octane (The engine normally lasts forever on this fuel).

Only buy fuel from hi volume gas stations to prevent poor grade crossover and water. There is a fueling and fire hazard using refueling containers and filtering is suspect at the pump unless using a reputable gas station to fill from.

Auto Fuel with ethanol:
Pro: Cheaper to buy. Farmers are happy selling ethanol. The gas stations get a kickback. Octane levels are higher. 93, 90 and 87 octane is available at the pump (RON) Use premium for 912S/914 and anything in the 912.

Con: Hi octane but fewer BTUs so fuel burn is a bit more for the same power setting of RPM and MP.
Avoid long full turbo climbs in the 914 if octane is suspect.
Old gas is a problem. If the fuel is more than three weeks old the octane rating drops to basically 87-89. Again, great for the 912 (80HP)
Ethanol absorbs water and deteriorates some rubbers, epoxy for sure, and Pro Seal type fuel sealants are degraded also. Fuel turns milky in modest humidity in just a month. It starts growing brown stuff in the tank after 6 months.
Always clean and flush with a non-ethanol fuel or AV Gas if storing the aircraft for any time longer than a couple weeks or in very high humidity conditions.   Use Stabil or similar to prevent winter time water condensation in an unheated hangar in your float bowls and pumps.
Note: There is a fueling and fire hazard using refueling containers due to static electricity. Also fuel filtering is suspect using refueling containers unless they are clean and you are using a reputable gas station to fill from.

Oil Types:
Aeroshell Sport plus 4 is a specifically formulated oil for the Rotax. It is just a multi blend or semi-synthetic. Use it with AV Gas or Car gas.

Mobile one Racing Motorcycle oil MX4T synthetic works great. It should only be used with unleaded auto fuels.

Oil Specifications to consider when using other manufacturers:

Rotax recommends using a high quality, major brand, **4-stroke motorcycle oil** with gear additives and “SF” or “SG” API classification.

The gear additives are required to withstand the high stresses in the reduction gearbox. The “GL4” or “GL5” specification is recommended.

Oil Filter:

I use the Rotax oil filters as any oil issues will be questioned on any oil related problems without it. Other manufacturers make Rotax engine specific filters with the specific pressure relief valve requirements such as the Tempest AA825706 and others. I'm afraid I have not used them.

Caution in oil changes:
If the oil system has been left open for anything longer than a few minutes for a simple drain, refill and oil filter change, do a pressure purge, write it up in your logbook that the oil pressure purge was accomplished, and the hydraulic lifter check had been done or your warranty may be voided if you have any internal problem with the engine...

Part Two: Common Problems Associated With Phases of Flight

Ground:

Starter: On initial check, battery was 12 volts. During cranking if the voltage drops down to about 9 volts, it's time for a new battery. Typically the Rotax must make at least 300 RPM to start. If the battery is weak, or the starter is deficient for any reason (armature damaged or greasy) and you don't get 300 cranking RPM, it won't fire the plugs. Get a jump and if that cures it, take the battery to a shop and have it tested. The Odyssey batteries are pretty good at coming back if deep cycled and properly recharged.

I can't tell how fast it's turning and its cold. If the cranking voltage drops to less than 10 volts, the battery is probably good, but a jump won't hurt. Heat the oil and battery, hand prop it to move the oil through the engine and start it. Watch for excessive oil pressure.

Fuel: Cold weather starts are improved using fresh Premium Fuel or 100LL. If using ethanol laden gas, any water will be absorbed with fresh gas. Old ethanol laden gas will have a very low octane and may have water/slush in the tank.

Rough Running after start or idle:
After engine start, the engine does not run smoothly.
Once the engine starts using the choke/enrichening circuit, the throttle should be opened above 2000 but less than 2500 until smooth. If the engine is still very rough, turn off one mag at a time and check if the engine still runs rough on each mag. If mag drop and roughness is the same, let it warm up and investigate. It is fuel/carb related if during the run-up, the mag drop is out of tolerance, but the engine is fairly steady. If the roughness is significantly different, with the mag changes, then it is most likely dirty plugs or a coil problem. Perhaps you are lucky and it is both carbs and plugs. Run it up to full power and burn off the plugs and re-check. However, if it dies completely on only one of the mags, it is likely an ignition box or wiring problem.

Run-up Roughness:
If the idle is smooth, and during the ignition check at 4000 RPM, the drop is out of tolerance or slight roughness is encountered, it's the carbs. They are out of balance. If one ignition is smooth and the other rough in a 912, it is most likely plugs, in a 914 it may be the lower plugs are flooded. In either case, run up to 5-5500 RPM to burn off the plugs and do the mag check again. If it is still rough, it's the carbs.

Charging is weak:
If the Ducati does not charge at 13.8 volts, or near there, at 5000 RPM check it out. Check the C voltage first. It should be at battery voltage, at all times.

Note: After engine start, a great deal of stress is placed on the Ducati if the full load of the buss is put on the system shortly after start while at idle. Technique, after engine start, prior to turning on the high amp items such as the COM/NAV/Landing lights, Pitot Heat, etc. allow the alternator to charge the battery a bit. On an ammeter one can see immediately after start the battery is pulling 3-10 amps (depending on battery charge state) immediately to recharge itself after start. Within 10-15 seconds, the ammeter will decline to about 1-2 amps. Once the amps drop to this level, then turn on avionics systems. Ammeters should be installed to show the amps going to the battery rather than a load meter (which is the ammeter going to the main bus only) for the best method of determining your battery charge state.

I must mention again, if your charging is weak and you have a non-belt driven alternator as the main alternator, they do not put out sufficient power at idle to 4000 to meet the needs of most aircraft systems.

TAKEOFF:

Most engine problems manifest themselves during takeoff. Rarely do problems occur in flight.

Engine Boost Below Normal (914 only). Engine is smooth running (RPM within limits).

1. Check your airbox is attached and hasn't slipped off, then:

a. Fuel pressure is normal: Servo controller not closing waste gate or cable has slipped. With the engine off, look into the inlet and observe the waste gate arm and watch it cycle when the TCU is turned on. If it looks good, see below. If it has little movement, move the throttle and watch it open and close. If the cable slipped, readjust the cable per spec. Check the servo controller. Check the throttle position sensor and clean the contacts.

b. Turbo controller temperature input inoperative. The temp probe may be showing too high an airbox temperature, therefore, the TCU or Turbo Control Unit will open the waste gate reducing boost and lowering power output. Clean the temp probe contacts. Ohm out the probe if suspect and or replace.

c. Check your float bowl vents and plumbing is sound.

If the engine is not running smooth and sounding lean or running rough above 34 inches or 5500 RPM:

a. Fuel pressure low: Fuel pressure regulator failed or failing. The turbo boost will max out at 5 psi or about 40 inches of MP on takeoff. A rough correlation between boost and MP is for every one psi of boost you see two inches of MP. (14.7 psi is equivalent to 29.92 inches of mercury.) For every pound of boost pressure, the fuel pump pressure must be increased to the carb by one psi also.

Note: Fuel pressure increases as boost pressure increases to prevent the carbs from leaning out. It is true that the plenum pressure will actually force the fuel from the float bowls, starving the carbs of fuel under high boost conditions. The Rotax manual states that a differential between boost pressure and fuel pump pressure must be maintained at approximately 2.5 to 5.8 psi. UMA produces a gauge to read this, however, if the fuel pressure regulator has failed, and the pump is working fine, the carbs will begin to empty of fuel and the engine will very soon sag and run very rough or even die. The pilot will not see the fuel pressure problem because this guage only reads the difference between airbox and fuel pressure. This drop in RPM drops the boost pressure due to lack of exhaust flow causing fuel starvation which is confused by many as low boost and rough running.

Example of how to use a standard fuel pressure gauge: On a direct reading fuel pressure gauge attached aft of the fuel pressure regulator (typically a banjo nipple added on to the output side of the pressure regulator) the fuel pressure static at idle or off is about 5 psi at zero boost (2.5 to 5.8 required)... On takeoff, the max continuous power setting will yield 34-35 inches of MP (35 less 30 atmospheric is 5 inches and your boost pressure is found by taking half of that which yields approximately 2.5 psi of boost). The fuel pressure must rise this amount (2.5 psi) to give the equivalent of 5 psi at the bowl to maintain proper flow rate and atomization. Therefore, your fuel pressure will be about 7.5 psi. At Takeoff power, your fuel pressure can be as high as 11psi at sea level and higher at higher pressure altitudes. If you have a UMA differential gauge the fuel pressure less the boost pressure will indicate 5 psi or less fuel pressure. If the boost side of the pressure regulator fails, the fuel pressure will still read 5 psi on the gauge because the regulator only reads the pressure differential. This makes troubleshooting a little more difficult. Simply remove the airbox pressure hose from the pressure regulator and plug the line. This makes the UMA differential gauge a direct reading gauge.

On Takeoff, the engine runs smoothly but begins to sag or power output low.

a. Fuel pressure low: See above. Check the fuel filters for blockage.

b. Fuel Pressure normal: Fuel vent blockage. If the fuel tank vent becomes blocked, the fuel will feed to a point where the unvented tank will form a suction and restrict fuel flow to unacceptable levels and even completely starve the engine.

c. Airbox may have loosened but not slipped off. This is noted by low MP (no more than 30 inches or normal atmospheric pressure) and only 80 HP is available because without the pressurized airbox, the 914 becomes a 912 with funky carbs. It will run OK, just provide a lot less power.

Caution: With a constant speed or cruise prop the loss of pressure in the airbox may reduce the power to the point the propeller will be turning at a very low RPM (about 4000) making takeoff impracticable or impossible. Abort if the engine is not performing properly and investigate.

Warning lights flashing or engine surges.
TCU hang-up, simply stop the servo with the reset switch. Reduce the throttle to takeoff or lower to keep MP in check. Refer to the Pilots operating manual.

Note: If a constant speed propeller is installed, a failing propeller controller or speed sensor will cause the prop to fail to hold its governed RPM and the RPM may fluctuate or hunt by over 100 RPM. Go to MANUAL control on an Airmaster constant speed propeller or on a hydraulic propeller, reduce throttle to get stable operation.

912 or 912S engine sags at full power:
Typically if a normally aspirated engine sags it is fuel related.

a. The carbs may be impacted by an exhaust jet from a leaky muffler or broken pipe causing one carb to boil off fuel. This is typically seen as a rough running engine just prior to the sag due to fuel starvation. Heat damage can destroy the carburetor. Look for soot and find the leak.

b. Fuel pump failure to supply sufficient flow: Fuel pressure is a must, even on a 912. Your fuel pump may show signs of leakage. Replace it if leaking.

c. Fuel tank vent blocked. See above.

d. Fuel filters dirty or fuel line clogged.

e. The 912 series have an orifice (FS02) to relieve pressure instead of a pressure regulator. If this small orifice is in a fuel line and becomes dislodged it may clog the return line or allow complete fuel bypass. Investigate thoroughly as this allows insufficient pressure as well as flow if bypassing and overpressure and flooding of the carb if clogged.

IN FLIGHT and LANDING:

Once the engine is stable at cruise, few problems occur. Monitor the oil pressure, temperature and fuel. Some common inflight problems are:

Slowly lowering fuel pressure is probably bad gas at the last stop and a fuel filter is clogging. Always carry a spare filter. Be sure the filter is assembled correctly as it tends to loosen up a bit after a few hours and leak. Again, pay attention. After any servicing, recheck after a test flight before proceeding on.

Fluctuating oil pressure or temperatures are almost always the senders. (Although a sticky pressure bypass spring in the pump can cause fluctuations.) You will troubleshoot days, change the plunger or ball in the oil pump pressure regulator but normally it is not a mechanical problem. To be safe, check with a direct reading gauge, clean or change the ball or plunger and clean the cavity on the oil pump. Replace the sender. It is not uncommon to have a bad oil pressure sensor, affect the oil temp sensor because of a short in the oil sensor affecting the peaceful ground or wiring of the oil temp.

Many folks have installed water temperature probes in their radiator cooling lines to monitor coolant temp. These are notoriously inaccurate because of their grounds. If the water temp is sky high, and the cylinder heads normal, disconnect the water temp sensor and press on. I monitor the cylinder head temps only.

Builders and installers will often put a terminal block on the firewall or foot well with some or all the sensor wires connected there. If that terminal gets wet during a flight, expect very unusual engine readings. Either waterproof or don't use this type of terminal connection as it is prone to collecting engine dirt, and shorting or leaking voltages, which affects engine instrumentation.

Fuel pumps do fail and leak. A smell of fuel or loss of pressure is a symptom. Turn on the aux boost pump, land and investigate. Piersburg pumps do fail. I had a very old pump go out due to ethanol destroying the internal seal. I have also landed after smelling fuel and found the outlet plastic fitting cracked and leaking under pressure on a 25 hour. The new Piersburgs are fine with 10% ethanol. The mechanical pump on the 912/912S engine was changed in 2014 to a new larger style that may affect cowl clearances. Pay attention. The new pump has a drain line as stated above. Use clear tube on this to monitor if the diaphragm is leaking. Place the vent in a neutral cowl pressure area, to prevent sucking pressure on the fuel pump as it affects pump operation.

Normally we see rough running after a long cruise or descent at low power as the plugs foul a bit. Run the engine up to 5000 or 5500 to clear the plugs.

Approaching the field, during a descent, complaints of engine vibration are normal at low power settings. With the propeller in a course pitch and the power very far back, the propeller can be on the verge of wind milling the engine. If the power setting is near to causing the prop to pull, and the prop to windmill the gearbox lash may be heard and felt as a vibration. Simply push the power up or down out of this range. This is common on ground adjustable propellers set for cruise flight.

In conclusion, these are my troubleshooting experiences, and it is not comprehensive but a guide. Please download this file and save on your electronic device for reference.