Phillip Lockwood

Tips and Tricks for the Ideal 912 Installation Part 2

Focusing on the exhaust and oil lubrication systems

Last month we discussed the primary differences between the Rotax 912UL, the 912ULS, and the 914 engines and how to determine which one is best for your application. We also discussed the various operating parameters and limitations as well as the ideal markings for the engine instruments. Recall, we are focusing on the non-turbo 912UL and 912ULS because they are the most popular LSA engines. This month we'll focus on the exhaust and oil lubrication systems.

Exhaust System Basics

At the end of last month's article I mentioned measuring exhaust gas temperature (EGT) as an option. That's because the 9-series Rotax engines are equipped with a pair of constant-velocity Bing 64 carburetors that do a remarkable job of automatically adjusting mixture for density altitude. Thus, aircraft equipped with 9-series engines do not have or need a mixture control.

But, there is one major qualifier here; you must be installing an exhaust system made from the Rotax factory exhaust component kit (which can be purchased with the engine) or another system that has been properly designed and tested for the 912UL and/or 912ULS. This is important because the design of the exhaust system can affect the exhaust gas temperature as well as engine performance. The system must be tested to ensure the maximum allowable EGT limits are not exceeded. (The 914 comes with its own factory-installed exhaust system.)

912UL

912ULS

Aircraft owners who are designing and building their own exhaust system should check the EGT to ensure they are not exceeding the published limits. Some systems could require slightly richer carburetor jetting.

One advantage of measuring EGT is that it gives you an indication of how the carburetors are performing. If one carb begins to malfunction, you can immediately tell which one is giving you trouble—provided you monitor one cylinder from each side of the engine. You must place the EGT probes 70 mm (2-¾ inches) downstream from the exhaust flange for your readings to be accurate.

The recommended exhaust gas temperatures are as follows:

For the 912UL and the 912ULS:

- Ideal cruise EGT—800°C or 1,470°F
- Maximum cruise EGT—850°C or 1,560°F
- Maximum EGT at takeoff performance—880°C or 1,616°F

For the 914UL:

- Normal cruise EGT—900°C or 1,650°F
- Maximum EGT—950°C or 1,740°F

If you measure all four cylinders, don't expect the temperatures to be

the same. The intake manifolds are designed for optimum fuel distribution at full throttle and tend to yield uneven temperatures at most other throttle settings.

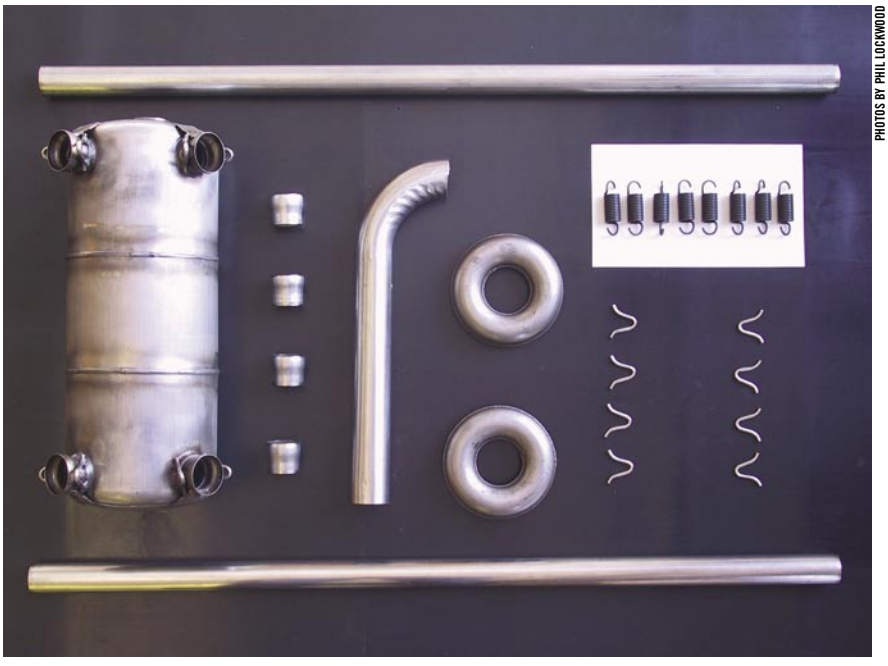
It's best to mount the exhaust system to the engine side of the rubber engine mounts so the engine and exhaust move together, minimizing flexing and fatigue. Safety the exhaust springs in place using .041-inch safety wire. Leave the wire a bit loose or the flexing of the exhaust joint will break it. Place a bead of high temp RTV silicone on the springs and safety wire to prevent the wire from rattling around. This also will help absorb damaging vibration within the springs.

Securing the springs is especially important on pusher aircraft where escaping parts can strike the propeller, resulting in damage to the prop and/or airframe depending on what the spring strikes.

Apply a thin film of high-temperature, nickel, anti-seize lubricant to the contacting surfaces of the exhaust system ball joints. This will help to keep the joints from binding, reducing metal fatigue and decreasing the risk of cracking. There is no way to eliminate the risk of exhaust system cracks, so frequent inspections are a good idea. It is best to give the exhaust system a good preflight check before the first flight of the day and a thorough inspection every 100 hours.

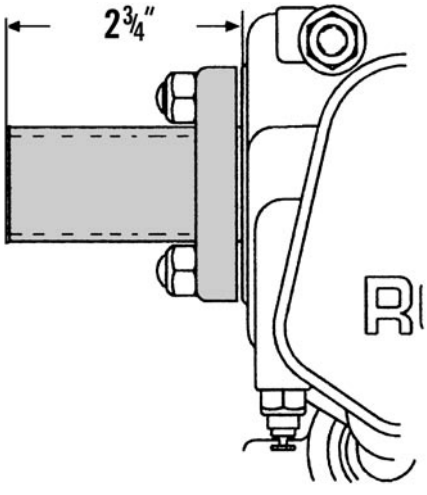
Vibration Is the Enemy

In the first article of this engine installation series in the August issue, we noted that engine vibration can be reduced by setting the engine at the correct minimum engine idle speed and by having pneumatically synchronized carburetors. In addition, vibration can often be further reduced by dynamically balancing the propeller. This requires a special computer that is linked to an accelerometer and an optical sensor, both of which are temporarily mounted to the engine. (A number of FAA-certified repair stations offer this service, as does Lockwood Aviation Repair.) This procedure generally costs about $175.



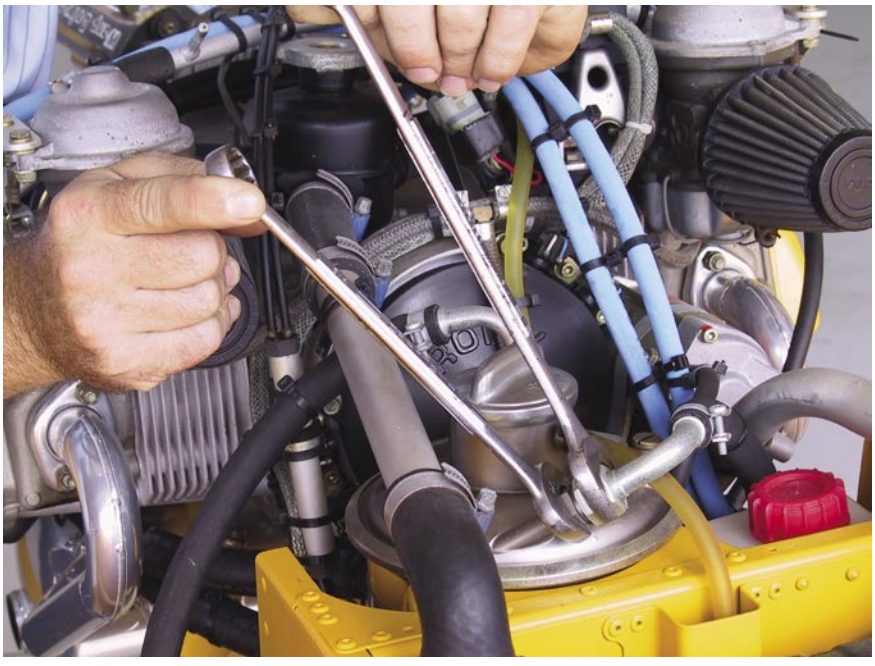
PHOTOS BY PHIL LOCKWOOD

The Rotax stainless steel exhaust kit strikes a good balance between noise and performance, allowing the 912ULS to produce its rated sea-level power of 100 hp relatively quietly.

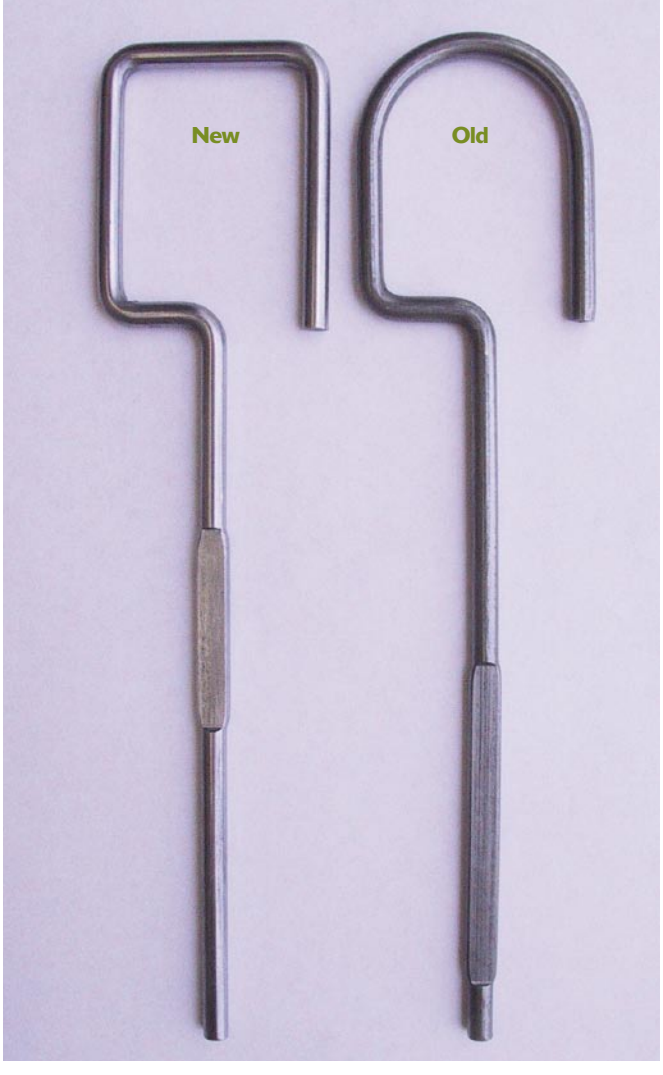


To ensure accurate EGT readings, place the probes 2-¾ inches from the cylinder face. Torque the exhaust flange locking nuts to 177 inch pounds.

Once the top of the oil tank is removed, it's easy to see which fitting is used to supply oil to the engine.



Always use two wrenches when tightening the fittings on the top of the oil tank or you may twist the fitting off the top of the tank. The wrench sizes are 19 and 22 mm.



New and old style oil level dipsticks. Make sure you are using the newest style dipstick with the rectangular handle. It allows a higher oil lever in the tank.

With the aircraft tied down and the engine running, the accelerometer measures the level and frequency of all engine vibration while the optical sensor, which must be aimed at the propeller, relates the vibration to the speed of the propeller. (On Rotax engines, prop speed is different from the crankshaft speed.)

During a series of approximately three runs, weights are added to the propeller hub, in locations determined by the computer, to reduce propeller-related vibration to almost nil. A well-balanced propeller will contribute to longer exhaust system life, and it also will extend the life of just about every other part on the airframe.

The Oil Lubrication System

The Rotax 9-series engines use what is commonly referred to as a dry oil sump. This type of system requires the use of a separate oil tank that has three fittings: one for the oil return line; one for a feed line to the oil pump; and one smaller clamp on the vent line fitting. Newer engines are supplied with oil tanks marked with in and out ports, but some people still connect the lines incorrectly. Remove the top of the oil tank and look inside; it's easy to see which connection goes where. (See photo on page 29)

The oil supply fitting is attached to a drawtube that picks up the oil supply from the lower center portion of the tank, assuring a good oil supply at a wide range of angles.

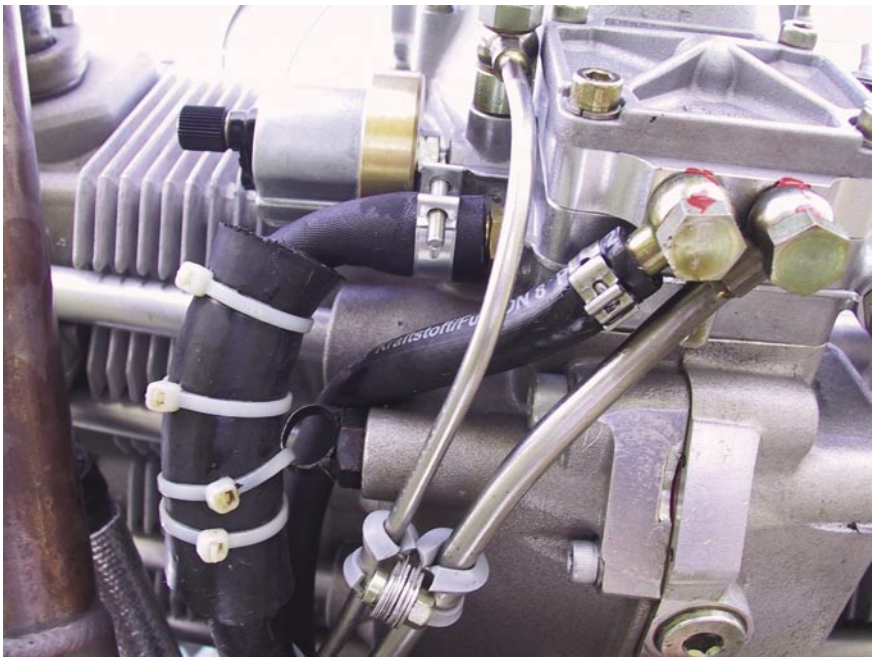
The return line enters the tank at an angle causing the returning oil to swirl in around the outside of the tank for maximum cooling before passing through a circular screen for re-use. *If the oil supply line is mistakenly hooked to the oil return line fitting, the oil pump will draw only air.* This is a fast and efficient way to ruin a new engine. (No, the damage will not be covered under warranty.)

Make certain your oil canister is equipped with the new style dipstick mandated by Rotax, which allows a a higher minimum and maximum level of oil in the tank. You can easily distinguish the new dipstick by

its rectangular handle. Changes in oil technology make today's oils stick to the internal parts of the engine better than in the past. With more oil staying in the engine, a greater volume of oil is required.

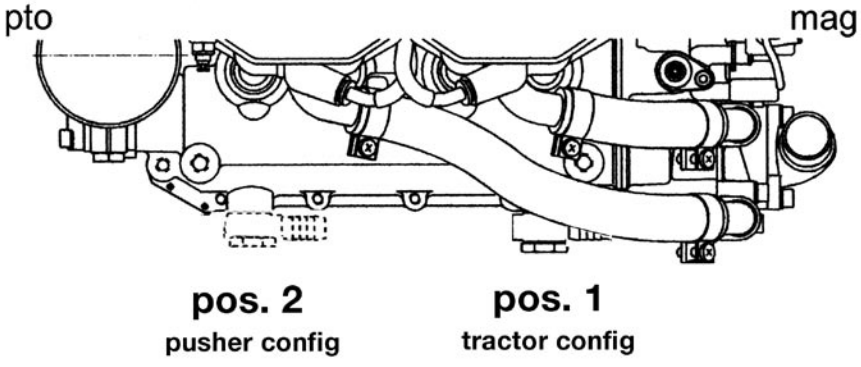
The new, improved oils currently being used require a different technique for checking the oil level. First, remember that it is unusual for a 9-series engine to use much oil. You might use half a pint or thereabouts in 50 hours. If you find the level in your oil tank suddenly becomes low, the missing oil is likely hiding in the engine.

If the engine has just been shut down, give the oil about 20 minuets to collect in the bottom of the crankcase. Then, *with both ignitions off*, crank the engine by hand in the direction of normal rotation until you hear a pronounced gurgle emerging from the oil tank. Leave the filler cap off and the dipstick out while performing this procedure to make it easier to hear the sound of a full oil tank. Most of the oil

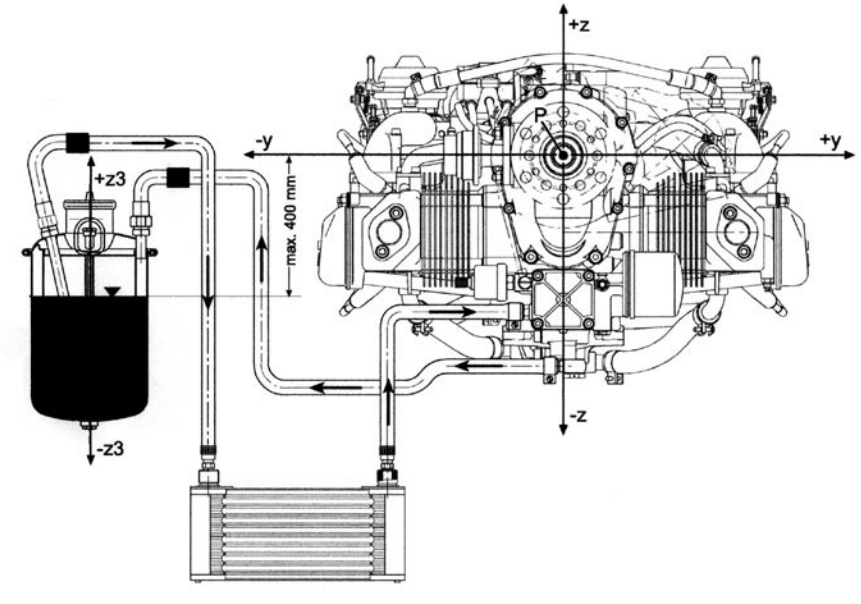


A tight bend is unacceptable in any oil line, but it's especially worrisome when located on the inlet (suction) side. A kink, like this shown on a 914 installation, can cause failure of the crankshaft main or lower rod bearings because of a lack of oil pressure.

This fitting can be installed in the oil pump in place of the standard barbed fitting to allow an immediate 90-degree bend at the inlet side of the oil pump.



There are two locations on the bottom of the crankcase for the oil return line. The line should be connected to the rear fitting (toward the tail of the aircraft). Rotax engines are shipped with the fitting on the magneto side of the engine and must be switched if the engine is installed on a pusher aircraft.



Rotax recommends mounting the oil tank at a certain height relative to the oil pump as depicted in this diagram.

should now have been returned to the oil tank, and you will be able to make an accurate check of the oil level using the dipstick.

If you top off the oil tank without performing this procedure, you will probably blow extra oil out the vent line as the engine starts and quickly pump the now-excess oil back to the oil tank. Don't forget to put the filler cap back on the oil tank when you're finished.

Warning! Never turn the prop backward on a 9-series engine. Doing so will cause the oil pump to work in reverse—drawing oil out of the engine and filling the oil passageways and hydraulic lifters with air.

Oil Flow in the 9-Series Engines

The correct flow of oil in 9-series engines is important, so let's take a look at the overall system.

The oil cooler must be mounted on the inlet side of the pump between the oil tank and the oil pump inlet. Note the oil pump is located below the gearbox. Because of the tremendous amount of suction being applied to the inlet oil line, it is important to avoid tight bends.

The oil is returned to the oil tank by crankcase pressure. The oil return line doubles as the crankcase vent line; ultimately, the crankcase is vented via the vent line on the oil canister. (The vent line can be terminated below the engine, but it must never become blocked.) The return oil line must be moved to the gearbox end of the crankcase on pusher applications. This is an often overlooked detail.

Rotax recommends mounting the oil tank at a specified height (a maximum 400 mm variance) above the engine oil pump inlet. The oil level should fall between the oil pump inlet and the center of the prop shaft, but not lower than the oil pump inlet. If the oil tank is mounted too high, oil will siphon from the tank into the engine block during periods of nonuse. This type of installation makes the method of checking the oil outlined above even more important.

With a high oil tank mount, it is

Because this part of the oil system is under suction, leaks can go on undetected...resulting in a buildup of air in the lifters and subsequent damage to the valve train.

possible for enough oil to flow into the engine and by the pistons to hydraulically lock the engine. If you have an aircraft with a higher than ideal oil tank that sits for more than two weeks without being run, it is a good idea to make certain all of the oil is back in the oil tank before attempting to start the engine.

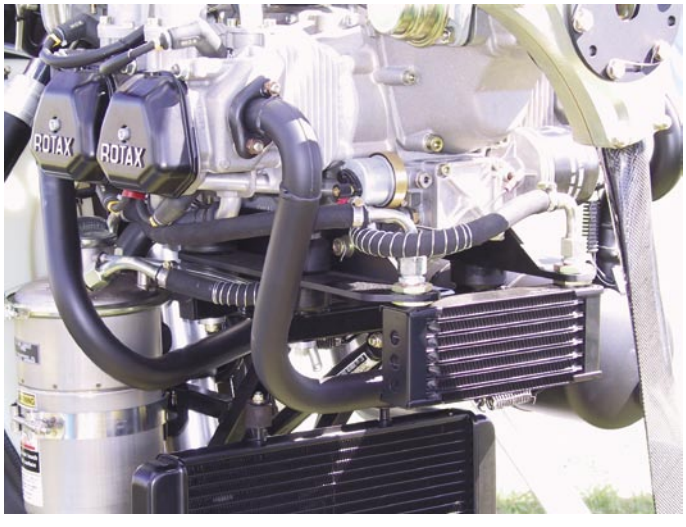
If upon attempting to crank the engine by hand you find the engine to be locked up, you must remove all the lower spark plugs and drain the oil that has accumulated in the combustion chambers. Replace the oil lost with new oil, clean the oil from the lower spark plugs, and reinstall them. Apply heat-conducting compound (available from most Rotax Service Centers) to the spark plug threads and torque them to 177 inch pounds. The spark plug electrode gap for all 9-series engines should be .028 inch.

Engines with oil tanks mounted below the ideal height can suffer from a dry oil supply line on initial start-up. Look for oil pressure immediately upon start-up; never allow an engine to run more than 10 seconds without oil pressure. If an engine with a low-mounted oil tank has not been run for a month or more, remove the lower spark plugs and crank the engine by hand until you get oil pressure before starting the engine.

Before starting your new or overhauled 9-series engine for the first time, or after performing service requiring draining of the suction side oil line or the oil cooler, be sure to follow the procedures outlined in the latest version of Rotax Service Instruction SI-04-1997 R3, Venting of the Oil Lubrication System. (This SI, and all current service information, can be found at *www.rotax-aircraft-engines.com* or *at www.rotax-owner.com.*)

This service instruction explains how to purge a new engine installation's oil system of air, and it has the added benefit of checking the suction oil lines, fittings, and oil cooler for leaks that might not be otherwise found. Because this part of the oil system is under suction, leaks can go on undetected without this test, resulting in a buildup of air in the lifters and subsequent damage to the valve train.

The oil tank on this 912UL engine installation is mounted higher than ideal. On some pusher installations, it can be difficult to locate the oil tank at the recommended height.



This tank is mounted lower than recommended.

Here is a brief explanation of the procedure.

1. Remove the return oil line from the oil tank and let the oil drain into a temporary container below the engine.
2. Plug the return fitting on the oil tank.
3. Remove the vent line and attach a line that will supply regulated air pressure at about 10 psi (No less than 6 and no more than 15) to the oil tank.
4. Remove the four top spark plugs to make it easier to rotate the engine.
5. After the oil tank is pressurized, rotate the engine by hand in the direction of normal rotation until the oil pressure gauge registers oil pressure. This could take as many as 60 turns, but normally it takes about 20 rotations of the propeller.
6. Take a moment to look for oil leaks on the now-pressurized oil lines and oil cooler fittings. This is especially important if your oil tank is mounted lower than recommended because it will be almost impossible to find leaks any other way.
7. Put everything back and add oil as necessary to replace what was drained off.

Lockwood Aviation Supply is developing a kit with everything you need to perform this procedure, including a threaded plug for the return oil fitting on the oil tank, a pressure regulator, and a copy of the Rotax Service Instructions.

One last recommendation before we leave the oil system. Consider mounting an oil thermostat as mentioned in the first article in this series in the August issue.

Disclaimer: The information in this article is based on the opinion of this author and has not been reviewed by Rotax Aircraft Engines.

Each month in Power ON, **Phillip Lockwood**, president of Lockwood Aviation Repair (*lockwood@digital.net*, *www.lockwood-aviation.com*), will address common Rotax engine maintenance or operation issues. In addition, readers are invited to send their questions about various alternative engines to our panel of engine "answer men" or to *editorial@eaa.org*, or

- For HKS engines, write **Dana Persiani**, *danapersiani@yahoo.com.*
- For 1/2 VW engines, write **Bill Bronson**, *onehalfvwguy@sbcglobal.net*
- For Corvair engines, write **William Wynne**, *WilliamTCA,@aol.com.*
- For Subaru engines, write **Don Bouchard**, *dbouchard@earthlink.net.*
- For Hirth engines, write **Matt Dandar**, *rpe@bpsom.com.*
- For (non-Rotax) two-stroke engines, write **Torello Tacchi**, *tacchi88@bellsouth.net.*

We'll reprint questions and answers of interest in upcoming Power ON columns.