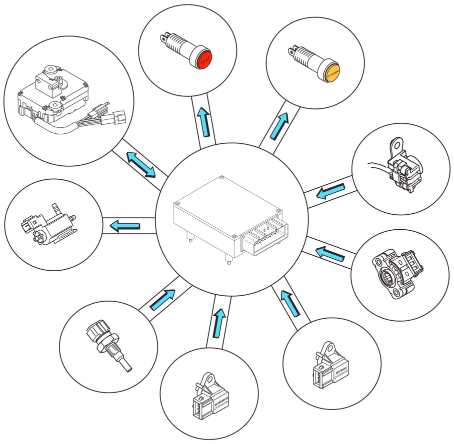
UNDERSTANDING THE 914 ROTAX

Warning: All information is provided for training purposes only. Always refer to the appropriate manual provided by BRP-ROTAX.

This following is a brief summary of the 914 turbo system. This summary is provided to assist owners and operators better understand the engine and reach optimum operational conditions. Reading these instructions will not eliminate a hazard, but understanding and applying the information will enhance the operation of the engine.

1) TURBO CONTROL UNIT (TCU)

The TCU is the “brain” of the system designed to sense and deciphers data from the engine and determines the wastegate setting to achieve the optimum level of boost.



The operating program within the TCU controls these functions. To monitor what is taking place within the TCU, a communication program (TLR) is available to monitor the TCU and determine which sensor pickups are being received. The TLR program also enables users to view and record engine parameters for review and evaluation.

Two operating lights are required for the TCU, which are to be installed in the aircraft panel. As the master switch is turned on both lights are momentarily activated to indicating power is supplied to the TCU and that normal electrical power-up has occurred.

1. The **Caution light** (green on early version 914, orange light on later versions). A blinking warning light indicates a sensor or wiring failure.

2. The **Warning light** (red light) is attached to a built-in timer which is activated whenever the throttle is placed in the full throttle position. This light comes on after 5 minutes of full throttle operation and resets itself each time the throttle power setting is below the 108% position for a minimum of 5 minutes. The purpose of this is to prevent the operator from using full throttle for more than 5 minutes, which could result in excess heat build-up in the engine. The red light will permanently illuminate if an overboost situation occurs.

2) TWO AIR-PRESSURE SENSORS

The ROTAX 914 engine is equipped with two air-pressure sensors. One measures aircraft ambient pressure and the other measures airbox pressure. Both air-pressure sensors report to the TCU and play a vital function in helping the TCU achieve the optimum level of boost. It is critical that the ambient pressure sensor is sensing from a neutral pressure zone within the aircraft. Generally the aircraft static source is a good place for this sensor. (consult airframe manufacture)

3) TACHOMETER READ OUT

An internal tachometer is built into the TCU which receives vital sensory inputs from a designated trigger coil on the engine. This same trigger coil can also drive a second electric tachometer on the instrument panel. An optional mechanical tachometer drive is also available

4) AIRBOX TEMPERATURE SENSOR

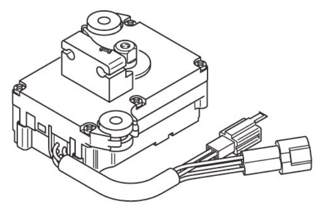
This sensor monitors the airbox temperatures. The TCU operating program is designed to reduce boost pressure if this sensor indicates the airbox temperature is above 72ºC (162ºF). In the normal course of running a turbo, the natural compression of air (adiabatic compression) as well as heat transfer from the hot turbo, raises the temperature of the incoming intake air. Testing has shown that intake air temperatures below 60ºC (140ºF) provides an adequate safety margin in preventing detonation in the engine in the event of a lower octane fuel and a high intake air temperature. In cases where the airbox temperature is run between 60ºC (140ºF) and 72ºC (162ºF), a higher-octane fuel must be used (see suitable fuels: section 12 of this article and section 10.2.2 of your Operators Manual).

On certain installations and geographic areas, high airbox temperatures may be a problem, resulting in less than optimum performance. An intercooler may be required to keep the intake air box temperature down to a reasonable level. Your testing should verify this potential problem with your particular installation without an intercooler. The operator may have to reduce power if the airbox temperature gets too high, otherwise the TCU will do it automatically by opening the wastegate.

Some operators have elected to install an additional airbox temperature gauge in the aircraft panel, so the pilot can tell exactly how high the airbox temperature is getting. Special consideration must be given to carb icing, especially when using an intercooler. See section 17 of this article for more information on carb heat.

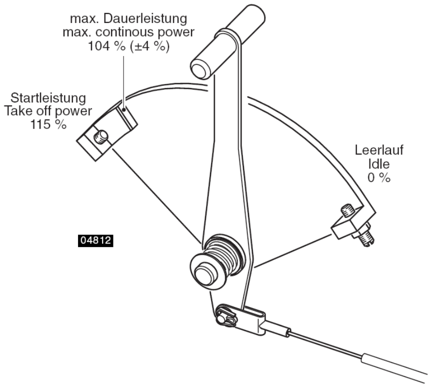
5) SERVO MOTOR

The servo motor is controlled by the TCU and adjusts the wastegate position. On initial start-up, the servo motor will cycle for a new position as the TCU is establishing the sensory inputs.



Normally the servo motor will turn ¼ to ½ of a turn in one direction, and then return to its original pre-start-up position. After this cycle, the wastegate should be fully closed. The servo cable is adjusted at the factory, but must be re-adjusted if the cable is disconnected. It may also require some fine tuning once the cable stretches. It is important to note that after initial start-up and the servo cycles, the cable is adjusted to shut/close the wastegate. Over-tightening the cable will put undue load on the servo, too loose a cable will not fully close the wastegate and could cause the cable to tangle. Refer to current maintenance Manual for wastegate adjustment.

6) THROTTLE POSITION SENSOR



This sensor is mounted on the 2/4 carb and relays to the TCU the exact position of the throttle. When correctly calibrated it relays 0% position at idle to 115% at wide open position. The TCU operating program is designed to start adding full boost when the sensor relays a 108% to 115% throttle position. It is important to note that the maximum continuous cruise throttle position is 100% (35 inHg at 5500 RPM). It is not advisable to cruise in the 108% area. In this position the TCU will add full boost as its logic thinks you are going to full power. From 108% to 110% throttle position it is very difficult to set your manifold pressure to a given value, as the throttle becomes very sensitive in this area. For this reason it is recommended to make a detent or mark on your throttle so the pilot can recognize exactly where 100% is, allowing the pilot to avoid the sensitive 108% throttle position.

Correct calibration of the throttle position sensor is critical, and is an adjustment you can achieve, using the TLR communication program.

It is possible to manually mark throttle positions, based on the calibration sheet (supplied by the factory) which details the exact throttle positions through a physical measurement taken on the carburetor throttle arm above the number four cylinder. Using this data, the engine installer can mark the exact throttle position in the cabin, so the pilot can easily identify specific throttle settings. This will assist in proper operation of the engine during flight and help verify proper TCU function and throttle position calibration.

Please review the above section until it is clearly understood.

7) THROTTLE POSITION SENSOR CALIBRATION

Under the guidance of a trained 914 mechanic/specialist and using a PC and a special communication program (TLR) you can ensure that the TCU operating program reads 0% position when the throttle is at idle, and 115% position at full throttle. Detailed instructions can be found in the current maintenance manual and the TCU Users Guide

In the event that the pilot cannot match the power settings as shown on the chart in section 9, a recalibration of the throttle position sensor may be required. Contact your local service centre for assistance in this regard.

8) THROTTLE POSITION DETENT OR MARK

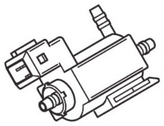
As previously discussed, using the physical or visual means of verifying the 100% throttle position, which should equate to 35” airbox pressure and 5500 RPM, helps verify that the system is calibrated correctly. The normal procedure to set maximum cruise is to bring the throttle back to 100% throttle position mark, then adjust the RPM via the prop pitch (with adjustable props) to 5500 RPM, and finally verify that the airbox pressure is 35inHg (±1inHg)

If you want to increase power, you would first adjust to the desired RPM, using the prop pitch, then increase the throttle to the corresponding throttle position, and finally verify that the airbox pressure is correct. The following is the correct airbox pressure for a given RPM, for all full and cruise power settings.

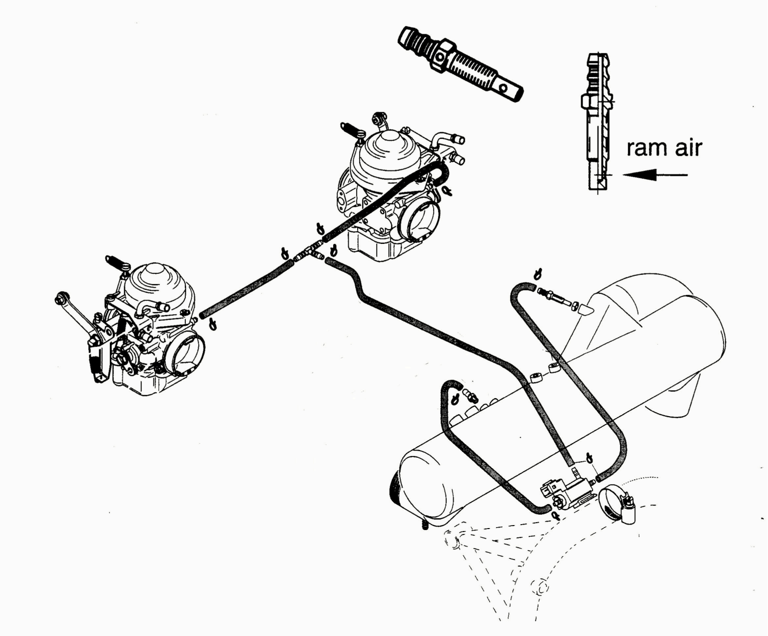
RPM	MAP inHg	Percent of power	Throttle position
5800	40”	100% Power (Full Throttle)	115% Throttle Position
5500	35”	85% Power (Maximum Cruise)	100% Throttle Position
5000	31”	75% Power (Normal Cruise)	Approx. 85% Throttle Position.
4800	29”	65% Power (Economy Cruise)	Approx. 65% Throttle Position

It is important to note that 115% throttle position equates to 100% engine power (full take-off power), don’t get the two number confused.

9) ENRICHENER SOLENOID



The enrichener solenoid (or valve) is mounted on later production series engines to better control carburetor mixture. In order to maintain proper air pressure the carburetor float bowls are vented to the airbox. By increasing the air pressure in the float bowls the engine can be made to run richer, thereby cooling the combustion chamber and preventing detonation.



The standard routing of the float bowl vent is to inside the airbox. When the Enrichener Solenoid is activated the float bowl vents are routed to a ram air port near the turbo inlet tube.

This solenoid valve is activated by the TCU sensing throttle positions above 108%, which creates a richer fuel mixture to help prevent detonation during high engine loads.

10) AIR BOX TEMPERATURE

Make sure you pay attention to how your particular installation affects the airbox temperature. Remember once the airbox temperature rises to 72ºC (162ºF), the TCU will automatically decrease boost pressure by opening the wastegate. This could happen before the 5 minute time limit is up. In most cases full boost is only required for short periods during takeoff, and the pilot knowing his airbox temperature is nearing 72ºC (162ºF), can adjust accordingly.

11) RPM, CHT, OIL TEMP, OIL PRESSURE, ETC,

Respect all operational limits:

Maximum RPM	5800 for 5 minutes
Maximum continuous RPM	5500
Maximum Cylinder Head Temp.	135ºC / 275ºF
Minimum Oil Temperature	50ºC / 120ºF
Maximum Oil Temperature	130ºC / 265ºF
Normal Oil Operating Temp.	90 to 110ºC / 190 – 230ºF
Normal Oil Pressure	1.5 – 5 BAR / 22 – 73 PSI
Maximum Oil Pressure	7 BAR / 102 PSI
Minimum Oil Pressure *below 3500 rpm*	0.8 BAR / 12 PSI
Minimum Oil Pressure *above 3500 rpm*	1.5 BAR / 22 PSI
Maximum Exhaust Gas Temperature	950ºC / 1742ºF
Normal Exhaust Gas Temperature	900ºC / 1652ºF

12) SUITABLE FUELS

Fuels are commonly rated based on octane quality or Anti-Knock Index (AKI). The AKI is a measure of fuels ability to resist engine knock (ping). The AKI of a motor fuel is the average of the Research Octane Number (RON) and the Motor Octane Number (MON), or {(RON +MON) / 2}. The AKI is often displayed on the gasoline pump.

Optimum performance and fuel economy is achieved when the AKI of a fuel is adequate for the engine in which it is used. The RON and MON of fuels are measured by recognized laboratory engine test methods. Results of these tests may generally be translated into approximate field performance. In general, the RON affects low to medium speed knock and engine run-on. If the RON is too low, the engine could experience engine knock during periods of power acceleration such as during a takeoff or climb. The anti-knock performance of a fuel, in the case of a 914, is established by ROTAX using the RON.

When the airbox temperature is below 60ºC (140ºF), under all flight conditions, an unleaded minimum 91 octane rated fuel can be used. Above 60ºC (140ºF) airbox temperature, a premium unleaded minimum 92 octane rate fuel (RON 98) must be used. If it is difficult to establish a certain fuels octane level, always choose the higher number, with 100LL also being a viable choice. When choosing 100LL fuel, operators must consider the long-term disadvantages of this high lead content fuel, such as greater deposits in the combustion chamber, piston rings and higher valve seat wear.

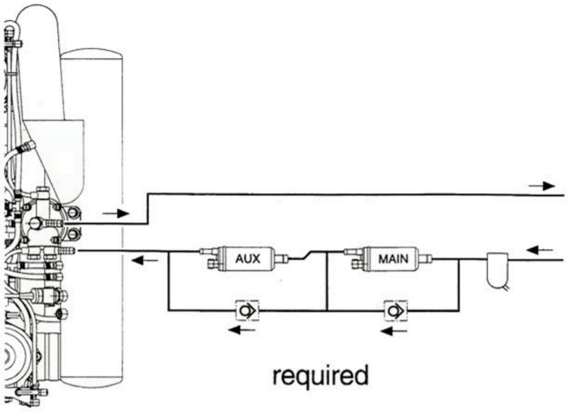
13) FUEL PUMPS

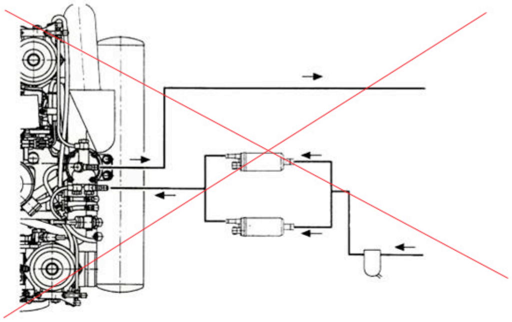
The electrical pumps are an auto-suction vane-cell type. The electrical fuel pumps should be installed near the fuel tank in order to guarantee a safe fuel supply through the advantage of a "cool" mounting place, particularly during hot operation. The fuel pumps should be mounted below the level of the fuel or under the tank (maximum suction height of 250mm or 10"). When mounting the electrical fuel pumps, vapour lock situations must be taken into consideration (see installation manual). It is not recommended to mount the pumps in the engine compartment unless they are properly heat and fire shielded.

For redundancy, one electric fuel pump acts as the main pump, and is usually powered by the internial18 amp generator. For simplicity it is wired with no switch other than a pull type circuit breaker for wire protection and pilot control. The other pump acts as the auxiliary, and is generally wired off the bus bar. This pump should be switched so the pilot can manually control it.

NOTE: Check valves are needed to prevent reverse flow between the pumps. The current maintenance manual supersedes the Installation manual until the next revision.

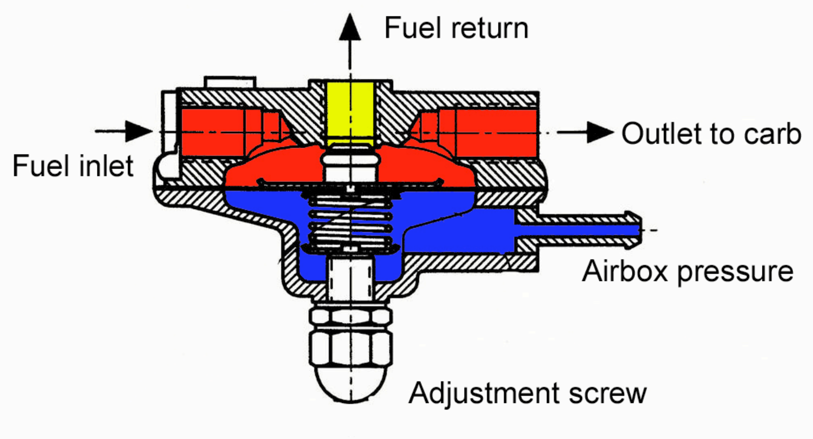
NOTE: These pumps use a fine mesh nylon filter inserted in the intake side of the pump. The aircraft maintenance schedule should include proper inspection/maintenance of this system.





14) FUEL REGULATOR

The fuel regulator is mounted on the airbox and plays a critical role in maintaining fuel pressure to a minimum 0.15 BAR (2.18 PSI or 4.45”) above airbox boost pressure. The regulator is calibrated at the factory and normally no adjustments are required.



In the event that the fuel pressure gets too low, due to a maladjustment or malfunction of the fuel regulator, the engine would experience fuel starvation due to the higher airbox pressure sensed in the carburetor float bowls not allowing the fuel supply to enter. A high fuel pressure can result from regulator maladjustment, malfunction or restriction in return line. A properly adjusted fuel regulator will maintain fuel pressure above airbox pressure within the following parameters:

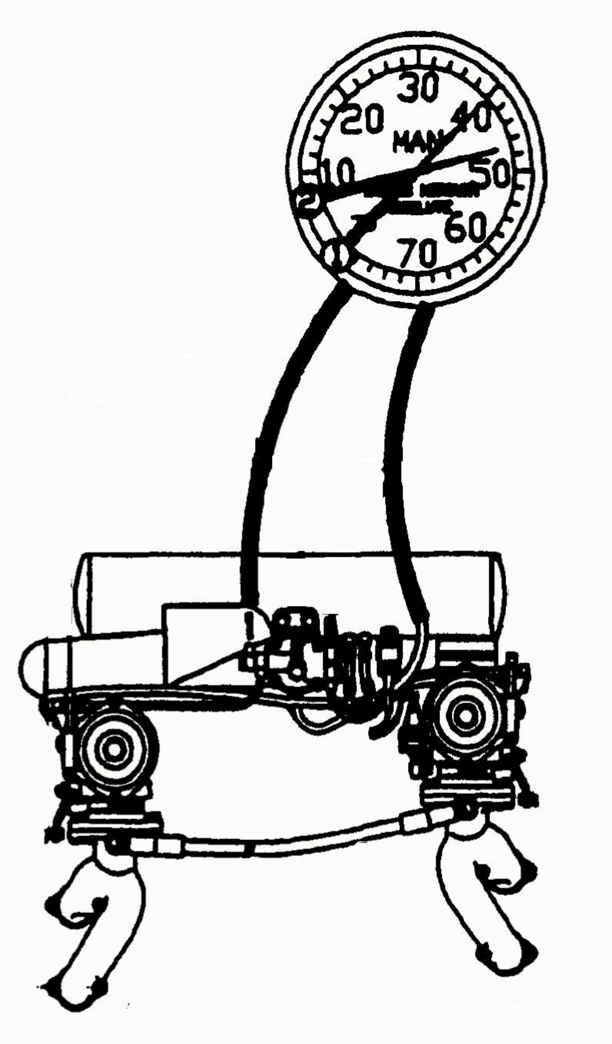
Maximum fuel pressure is 0.35 BAR (5.08 PSI or 10.36”) above airbox pressure
Minimum fuel pressure is 0.15 BAR (2.18 PSI or 4.45”) above airbox pressure
Normal fuel pressure is 0.25 BAR (3.63 PSI or 7.41”) above airbox pressure

IMPORTANT: These values reflect correct fuel pressure above airbox pressure and do not relate to total pressure. There are no values given for total pressure. See next page for more information.

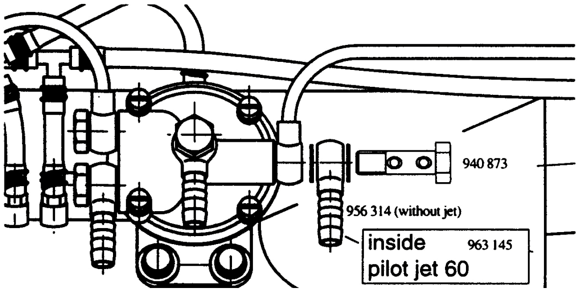
15) FUEL PRESSURE

Field experience has shown that one of the best ways to monitor fuel pressure is in direct relationship and in the same value as airbox pressure. One viable method is a twin manifold pressure gauge from a turbocharged twin engine aircraft. One side of the gauge is plumbed to the airbox and the other is plumbed to the fuel outlet of the regulator. A restrictor (pilot jet p/n 963145) must be used in the fuel outlet to prevent massive leaks should a problem occur in the plumbing.

The overlapping indicator needles used on this type of gauge give the pilot an intuitive indication of the relationship between the actual fuel pressure and boost pressure. The needles can be conveniently marked “FUEL” and “MAP” by an instrument shop. The gauge replaces the separate “stand alone” MAP and fuel pressure gauges so extra panel space is freed up.



Fuel pressure is taken here.
Double banjo bolt, restrictor and fitting are available as spare parts



16) FUEL RETURN LINE

The fuel return line plays an important role in the fuel system and must be carefully designed with no restrictions. It must be properly routed and plumbed or else it will affect the ability of the fuel regulator to perform its job. Any restrictions in the return line could lead to excessive fuel pressure.

17) SUITABLE PROPELLER

The 914 engine works best with a constant speed propeller. In-flight adjustable propellers can also work well, but add complexity to operation, and compromise performance. Fixed pitch propellers are not recommended due to the engines non-linear power curve.

18) CARBURETOR HEAT

As with any aircraft engine, carburetor icing can occur in certain conditions. In the case of the 914, operation without an intercooler generally heats the intake air above most icing conditions. When using an intercooler, operators may find that the airbox temperatures are lowered to temperatures where icing is more likely, especially with the heat loss that takes place from the venturi effect of the carbs.

All new installations should be appropriately tested for possible icing conditions by measuring the venturi/airbox temperatures with the TLR program or another accurate instrumentation in all flight profile ranges. Effective carb heat can be gained with the addition of a simple “alternate air” valve opening to the hot engine compartment or a heat duct built around the muffler. Operators must also consider that too much heat in the airbox (above 72ºC / 162ºF) will cause the TCU to decrease boost pressure resulting in a gradual power loss. To avoid this, the pilot must precisely control the airbox temperature by adjusting the amount of carb heat supplied. With or without the use of an intercooler, proper testing for the possibility of carburetor ice should be conducted on your installation.

19) ELECTRICAL POWER SUPPLY

The standard 18 amp internal generator is a permanent magnet 10-pole single-phase AC generator. For the DC supply, an electronic voltage regulator with full-wave rectification is used

The internal generator must sense 12 volts to be excited. Consult the Installation Manual for wiring diagrams. An optional 40 amp external alternator is also available.

Using dual or single alternators, the requirements of the electric fuel pumps and aircraft electrical load must be considered when determining appropriate wiring design.
In al cases the electrical system design should assure that no single failure mode (IE: alternator, battery, voltage regulator) causes both fuel pumps to stop. Careful design consideration must be given towards this issue! Consult with your airframe manufacture for more information.

20) ALTERNATOR AND FUEL PUMP CONTROL

As described in the FUEL PUMP section, the continuous operation of at least one electric fuel pump is mandatory for normal engine operation. With this in mind, two methods for control of alternators and fuel pumps follows:

1. Integrated 18 amp generator and battery

When the integrated 18 amp generator provides sufficient power for the total amp load of the buss the main fuel pump is powered from the B+ output of the regulator/rectifier (see installation Manual) via a circuit breaker (in the cockpit), while the auxiliary fuel pump is powered from the buss via a circuit breaker and switch. (refer to AC43.13 for wire and circuit breaker selection)

The 22,000 uF/24 Volt capacitor provides a continuous control voltage for the regulator/rectifier in the event of momentary interruption of battery voltage. This is necessary as alternator output voltage is variable with RPM and may increase to as much as 240 volts AC.

The regulator/rectifier is dependent on 12 volts DC from terminal C to prevent possible uncontrolled output voltage at terminal B+. A number of different failure modes can be accommodated and still provide 12 volts DC to operate at least one pump.

Alternatively, the battery may be used to power the auxiliary or standby pump. This configuration allows for failure of the generator and bus bar but still provides power to the auxiliary pump from the battery for a specified period of time depending on battery capacity and state of charge. The 914 installation manual gives the fuel pump a max value of 3 amps at 18 psi.

2. Integrated 18 amp generator and optional 40 amp alternator connected to the bus in parallel

   Testing has shown that running the two alternators connected to the bus as shown in the 914 Installation manual is possible. The 40 amp alternators regulated output at 14.3 volts and the 18 amp generator is 13.5 volts. When the bus was progressively loaded, the 40 amp alternator would carry all of the load until approximately 30 to 32 amps. At this point voltage decreased to 13.6 volts and additional loading was directed to the 18 amp generator.

   As the load increased, the 40 amp alternator carried 30 to 32 amps and the 18 amp generator carried 14 to 15 amps. Any further loading could cause the voltage of both alternators to fall more and the battery would carry that load, effectively limiting the combined load to 40 to 45 amps. This may be an option for operators requiring OCCASIONAL bus loads in excess of 30 amps. Since the performance is dependent on the individual voltage regulation, other installations may vary depending on regulator differences. This situation requires the 40 amp alternator operate near maximum continuously, which is not the best for long term reliability. There is also the necessity of making correct and prompt pilot decisions in the event of failure of one of the alternators. Obviously, if a 25 amp load were being carried and the 40 amp alternator failed, loads would have to be reduced to a maximum of 14 to 15 amps for the 18 amp internal generator.

21) SUMMARY OF ELECTRICAL SYSTEMS

If the continuous total electrical load requirement for the installation is less than 12 to 15 amps, using the 18 amp integrated generator and battery would be the best choice. If the installation requires 15 to 30 amps, the 40 amp alternator supplying the buss and the 18 amp alternator standing alone to supply the main fuel pump may be the best choice.

22) SUMMARY OF THINGS TO REMEMBER:

1. Fuel Pressure vs. Airbox Pressure (boost):
    - Fuel pressure must always remain above boost pressure to a minimum 0.15 BAR (2.18 PSI or 4.45”).
    - An accurate means of monitoring fuel pressure and airbox pressure, and maintaining an understandable relationship between the two is critical. The dual manifold pressure gauge works well, although it’s not specifically approved for such use.
2. The relationship between the electric fuel pumps and the 12 volt power supply must be understood. Declining voltage will lead to declining fuel pressure.
3. High airbox temperatures will lead to declining boost levels. Intake air source should be well outside of any heat influence, from a cool air supply. Accurate monitoring of airbox temperatures is critical.
4. Throttle positions, i.e.: 115%, 100%, 85%, 75%, should be accurately marked for pilot reference during flight. The power chart listed in section 9 should be within view of the pilot at all times during operation.
5. All operational temperatures should be respected. A proper engine installation and cowling design will allow for this.
6. The fuel system must be carefully designed with no restrictions. The return line must be properly routed and plumbed. Any restrictions in the return line could lead to excessive fuel pressure. Incorrect fuel system design can also cause returned fuel to be vented overboard.
7. All new installations should be carefully tested for proper function. Tests should be conducted to find any hot spots within the cowling design at all mission profiles and flight regimes and problems resolved.
8. Installation should be done according to the requirements of the FAR’s to a certified standard or higher. These requirements will help ensure design safety. All possible failure modes on item critical for flight should have appropriate back-ups
9. The current ROTAX 914 Operators Manual should be consulted and well understood by the pilot. Additional instructions for proper pre-flight, inflight, take-off and landing requirements should be found in the relevant Aircraft Operators Manual. Placarding of all vital controls is essential.

CONVERSION TABLE

1 ft = 0.305 metres	1 metre = 3.281 ft.
1 mm = 0.03937 in	1 inch = 25.4 mm
1 cm = 0.394 inches	1 inch = 2.54 cm
1 mb = 0.029536 in Hg.	1 in Hg = 33.8639 mb
1 in Hg = 0.49 PSI	1 PSI = 2.04 in. Hg.
1 bar = 14.504 PSI	1 PSI = 0.0689 bar
1 kW = 1.341hp	1 hp = 0.7457 kW
1 kg = 2.205 lbs	1 lb = 0.4535 kgs
1 Nm = 0.737 ft. lbs	1 ft. lb = 1.3569 Nm
1 Nm = 8.848 in. lbs	1 in. lb = 0.113 Nm
1 litre = 0.264 US gals.	1 US gal. = 3.7879 litres
1 km = 0.540 nautical miles	1 Nautical Mile = 1.852 km
(ºC x 1.8) + 32 = ºF	