Chapter 11

Light-Sport Aircraft Engines

Engine General Requirements

Engines used for light-sport aircraft and other types of aircraft, such as some experimental aircraft, ultralight aircraft, and powered parachutes, must be very light for the power they develop. Each aircraft requires thrust to provide enough forward speed for the wings to provide lift to overcome the weight of the aircraft. An aircraft that meets the requirements of the light-sport categories must meet the following requirements.

Note: All of the following requirements and regulations are subject to change. Always refer to the latest Federal Aviation Regulations for current information.

A light-sport aircraft means an aircraft, other than a rotorcraft or powered-lift, since its original certification, has continued to meet the following:

1. A maximum takeoff weight of not more than 1,320 pounds (lb) (600 kilograms (kg)) for aircraft not intended for operation on water; or 1,430 lb (650 kg) for an aircraft intended for operation on water.
2. A maximum airspeed in level flight with maximum continuous power (V_H) of not more than 120 knots calibrated airspeed (CAS) under standard atmospheric conditions at sea level.
3. A maximum never-exceed speed (V_{NE}) of not more than 120 knots CAS for a glider.
4. A maximum stalling speed or minimum steady flight speed without the use of lift-enhancing devices (V_{S1}) of not more than 45 knots CAS at the aircraft's maximum certificated takeoff weight and most critical center of gravity.
5. A maximum seating capacity of no more than two persons, including the pilot.
6. A single, reciprocating engine, if powered.
7. A fixed or ground-adjustable propeller, if a powered aircraft other than a powered glider.
8. A fixed or auto-feathering propeller system, if a powered glider.
9. A fixed-pitch, semirigid, teetering, two-blade rotor system, if a gyroplane.
10. A non-pressurized cabin, if equipped with a cabin.
11. Fixed landing gear, except for an aircraft intended for operation on water or a glider.
12. Fixed or retractable landing gear, or a hull, for an aircraft intended for operation on water.
13. Fixed or retractable landing gear for a glider.

Powered parachute means a powered aircraft comprised of a flexible or semirigid wing connected to a fuselage so that the wing is not in position for flight until the aircraft is in motion. The fuselage of a powered parachute contains the aircraft engine, a seat for each occupant, and is attached to the aircraft's landing gear.

Weight shift control aircraft means a powered aircraft with a framed pivoting wing and a fuselage controllable only in pitch and roll by the pilot's ability to change the aircraft's center of gravity with respect to the wing. Flight control of the aircraft depends on the wing's ability to flexibly deform rather than the use of control surfaces.

As the weight of an engine is decreased, the useful load that an aircraft can carry and the performance of the aircraft are obviously increased. Every excess pound of weight carried by an aircraft engine reduces its performance. Since light-sport aircraft have a narrow margin of useful load, engine weight is a very important concern with all of the light, low airspeed aircraft. Tremendous gains in reducing the weight of the aircraft engine through improvements in design, operating cycles, and metallurgy have resulted in engines with a much improved power to weight ratio.

A light-sport aircraft engine is reliable when it can perform at the specified ratings in widely varying flight attitudes and in extreme weather conditions. The engine manufacturer ensures the reliability and durability of the product by design, research, and testing. Although most of these engines are not certificated by the Federal Aviation Administration (FAA), close control of manufacturing and assembly procedures is generally maintained, and normally each engine is tested before it leaves the factory and meets certain American Society for Testing and Materials (ASTM) standards. Some engines used on light-sport aircraft are certificated by the FAA and these engines are maintained as per the manufacturer's instructions and Title 14 of the Code of Federal Regulations (14 CFR).

Most light-sport engines require a definite time interval between overhauls. This is specified or implied by the engine manufacturer. The time between overhauls (TBO) varies with the type of engine (cycle), operating conditions, such as engine temperatures, amount of time the engine is operated at high-power settings, and the maintenance received. After reaching the time limit, the engine has to be overhauled. Sometimes this requires the engine to be shipped to an authorized manufacturer's overhaul facility. *[Figure 11-1]*

One consideration when selecting a light-sport engine is the shape, size, and number of cylinders of the engine. Since these engines range from single cylinder to multicylinder engines, the mounting in the airframe is important to maintain the view of the pilot, aircraft center of gravity, and to reduce aircraft drag.

Personnel Authorized to Perform Inspection & Maintenance on Light-Sport Engines

Given they meet all applicable regulations, the holder of a powerplant certificate can perform maintenance and inspections on light-sport engines. The holder of a sport pilot certificate may perform preventive maintenance on an aircraft owned or operated by that pilot and issued a special airworthiness certificate in the light-sport category under the provisions of 14 CFR part 43, section 43.3 (g). All maintenance must be performed in accordance with 14 CFR part 65, section 65.81, which describes specific experience requirements and current instructions for performing maintenance.

The following is used to determine eligibility for a repairman certificate (light-sport aircraft) and appropriate rating. To be eligible for a repairman certificate (light-sport aircraft), you must:

- Be at least 18 years old.
- Be able to read, speak, write, and understand English. If for medical reasons you cannot meet one of these requirements, the FAA may place limits on the repairman certificate necessary to safely perform the actions authorized by the certificate and rating.
- Demonstrate the requisite skill to determine whether a light-sport aircraft is in a condition for safe operation.
- Be a citizen of the United States, or a citizen of a foreign country who has been lawfully admitted for permanent residence in the United States.
- To be eligible for a repairman certificate (light-sport aircraft) with an inspection rating, the applicant must:
    - o Meet the requirements stated above for a repairman's certificate.
    - o Complete a 16-hour training course acceptable to the FAA on inspecting the particular class of experimental light-sport aircraft for which these privileges are intended to be exercised.
- To be eligible for a repairman certificate (light-sport aircraft) with a maintenance rating, the applicant must:
    - o Meet the requirements stated above for a repairman's certificate.
    - o Complete a training course acceptable to the FAA on maintaining the particular class of light-sport aircraft upon which the privileges are intended to be exercised. The training course must, at a minimum provide the following number of hours of instruction:
        - For airplane class privileges: 120 hours.
        - Weight-shift control aircraft class privileges: 104 hours.
        - Powered parachute class privileges: 104 hours.
        - Lighter-than-air class privileges: 80 hours.
        - Glider class privileges: 80 hours.

Designation of Engine Type	For Engine S/N	Time Between Overhaul (TBO)	SB To Be Carried Out To Increase TBO
914 F	to 4,420.313	1,000 hours or 10 years, whichever comes first	SB-914-027 1,000 hours to 1,200 hours or 12 years, whichever comes first
914 F	from 4,420.314	1,200 hours or 12 years, whichever comes first	None
914 UL	to 4,418.103	1,000 hours or 10 years, whichever comes first	SB-914-027 1,000 hours to 1,200 hours or 12 years, whichever comes first
914 UL	from 4,418.104	1,200 hours or 12 years, whichever comes first	None

Figure 11-1. *Examples of TBO and calendar life for engines.*

The holder of a repairman certificate (light-sport aircraft) with an inspection rating may perform the annual condition inspection on a light-sport aircraft that is owned by the holder, has been issued an experimental certificate for operating a light-sport aircraft under 14 CFR part 21, section 21.191(i), and is in the same class of light-sport aircraft for which the holder has completed the training specified in the above paragraphs.

The holder of a repairman certificate (light-sport aircraft) with a maintenance rating may approve and return to service an aircraft that has been issued a special Airworthiness Certificate in the light-sport category under 14 CFR part 21, section 21.190, or any part thereof, after performing or inspecting maintenance (to include the annual condition inspection and the 100-hour inspection required by 14 CFR part 91, section 91.327), preventive maintenance, or an alteration (excluding a major repair or a major alteration on a product produced under an FAA approval). They may perform the annual condition inspection on a light-sport aircraft that has been issued an experimental certificate for operating a light-sport aircraft under 14 CFR part 21, section 21.191(i). However, they may only perform maintenance, preventive maintenance, and an alteration on a light-sport aircraft for which the holder has completed the training specified in the preceding paragraphs. Before performing a major repair, the holder must complete additional training acceptable to the FAA and appropriate to the repair performed.

The holder of a repairman certificate (light-sport aircraft) with a maintenance rating may not approve for return to service any aircraft or part thereof unless that person has previously performed the work concerned satisfactorily. If that person has not previously performed that work, the person may show the ability to do the work by performing it under the direct supervision of a certificated and appropriately rated mechanic, or a certificated repairman who has had previous experience in the specific operation concerned. The repairman may not exercise the privileges of the certificate unless the repairman understands the current instructions of the manufacturer and the maintenance manuals for the specific operation concerned.

Authorized Personnel That Meet FAA Regulations

All applicable aviation regulatory authority regarding maintenance procedures must be met. Maintenance organizations and personnel are encouraged to contact the manufacturer for more information and guidance on any of the maintenance procedures.

It is a requirement that every individual or maintenance provider possess the required special tooling, training, or experience to perform all tasks outlined. Maintenance providers that meet the following conditions outlined below may perform engine maintenance providing they meet all of the following FAA requirements:

- Knowledge of the specific task as a result of receiving authorized training from a training provider.
- Previous experience in performing the task and formal instruction from a manufacturer's authorized training facility or "on-the-job" instruction by a manufacturer's representative.
- A suitable work environment to prevent contamination or damage to engine parts or modules is needed.
- Suitable tools and fixtures as outlined in the manufacturers' Maintenance Manual should be used while performing maintenance requiring such tooling.
- Reasonable and prudent maintenance practices should be utilized.

Types of Light-Sport & Experimental Engines

Note: All information in this text is for educational illustrational purposes and is not to be used for actual aircraft maintenance. This information is not revised at the same rate as the maintenance manual; always refer to the current maintenance information when performing maintenance on any engine.

Light-Sport Aircraft Engines

Light-sport/ultralight aircraft engines can be classified by several methods, such as by operating cycles, cylinder arrangement, and air- or water-cooled. An inline engine generally has two cylinders, is two-cycle, and is available in several horsepower ranges. These engines may be either liquid-cooled, air-cooled, or a combination of both. They have only one crankshaft that drives the reduction gearbox or propeller directly. Most of the other cylinder configurations used are horizontally opposed, ranging from two to six cylinders from several manufacturers. These engines are either gear reduction or direct drive.

Two-Cycle, Two Cylinder Rotax Engine

Rotax 447 UL Single Capacitor Discharge Ignition (SCDI) & Rotax 503 UL Dual Capacitor Discharge Ignition (DCDI)

The Rotax inline cylinder arrangement has a small frontal area and provides improved streamlining. *[Figure 11-2]* The two cylinder, inline two-stroke engine, which is piston ported with air-cooled cylinder heads and cylinders, is available in a fan or free air-cooled version. Being a two-stroke cycle engine, the oil and fuel must be mixed in the fuel tank on some models. Other models use a lubrication system, such as the 503 oil injection lubrication system. This system does not mix the fuel and oil as the oil is stored in a separate tank.

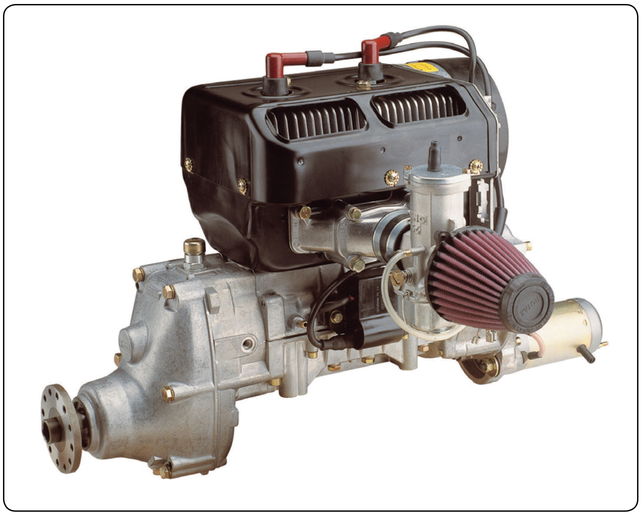

Figure 11-2. *Rotax inline cylinder arrangement.*

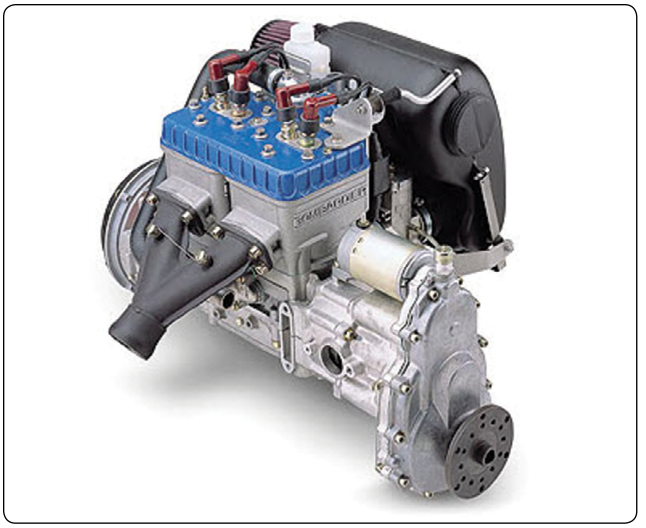

Figure 11-3. *Rotax 582 engine.*

As the engine needs lubrication, the oil is injected directly from this tank. The typical ignition system is a breakerless ignition system with a dual ignition system used on the 503, and a single ignition system used on the 447 engine series. Both systems are of a magneto capacitor discharge design.

The engine is equipped with a carburetion system with one or two piston-type carburetors. One pneumatic driven fuel pump delivers the fuel to the carburetors. The propeller is driven via a flange connected gearbox with an incorporated shock absorber. The exhaust system collects the exhaust gases and directs them overboard. These engines come with an integrated alternating current (AC) generator (12V 170W) with external rectifier-regulator as an optional extra.

Rotax 582 UL DCDI

The Rotax 582 is a two-stroke engine, two cylinder inline with rotary valve inlet, has liquid-cooled cylinder heads, and cylinders that use an integrated water pump. *[Figure 11-3]* The lubrication system can be a fuel-oil mixture or oil injection lubrication. The ignition system is a dual ignition using a breakerless magneto capacitor discharge design. Dual piston type carburetors and a pneumatic fuel pump deliver the fuel to the cylinders. The propeller is driven via the prop flange connected gearbox with an incorporated torsional vibration shock absorber. This engine also uses a standard version exhaust system with an electric starter or manual rewind starter.

Description of Systems for Two-Stroke Engines

Cooling System of Rotax 447 UL SCDI & Rotax 503 UL DCDI

Two versions of air-cooling are available for these engines. The first method is free air-cooling, which is a process of engine cooling by an air-stream generated by aircraft speed and propeller. The second is fan cooling, which is cooling by an air-stream generated by a fan permanently driven from the crankshaft via a V-belt.

Cooling System of the Rotax 582 UL DCDI

Engine cooling for the Rotax 582 is accomplished by liquid cooled cylinders and cylinder heads. *[Figure 11-4]* The cooling system is in a two circuit arrangement. The cooling liquid is supplied by an integrated pump in the engine through the cylinders and the cylinder head to the radiator. The cooling system has to be installed, so that vapor coming from the cylinders and the cylinder head can escape to the top via a hose, either into the water tank of the radiator or to an expansion chamber. The expansion tank is closed by a pressure cap (with excess pressure valve and return valve). As the temperature of the coolant rises, the excess pressure valve opens, and the coolant flows via a hose at atmospheric pressure to the transparent overflow bottle. When cooling down, the coolant is sucked back into the cooling circuit.

Lubrication Systems

Oil Injection Lubrication of Rotax 503 UL DCDE & 582 UL DCDI

Generally, the smaller two cycle engines are designed to run on a mixture of gasoline and 2 percent oil that is premixed in the fuel tank. The engines are planned to run on an oil-gasoline mixture of 1:50. Other engines use oil injection systems that use an oil pump driven by the crankshaft via the pump gear that feeds the engine with the correct amount of fresh oil. The oil pump is a piston type pump with a metering system. Diffuser jets in the intake inject pump supplied two-stroke oil with the exact proportioned quantity needed. The oil quantity is defined by the engine rotations per minute and the oil pump lever position. This lever is actuated via a cable connected to the throttle cable. The oil comes to the pump

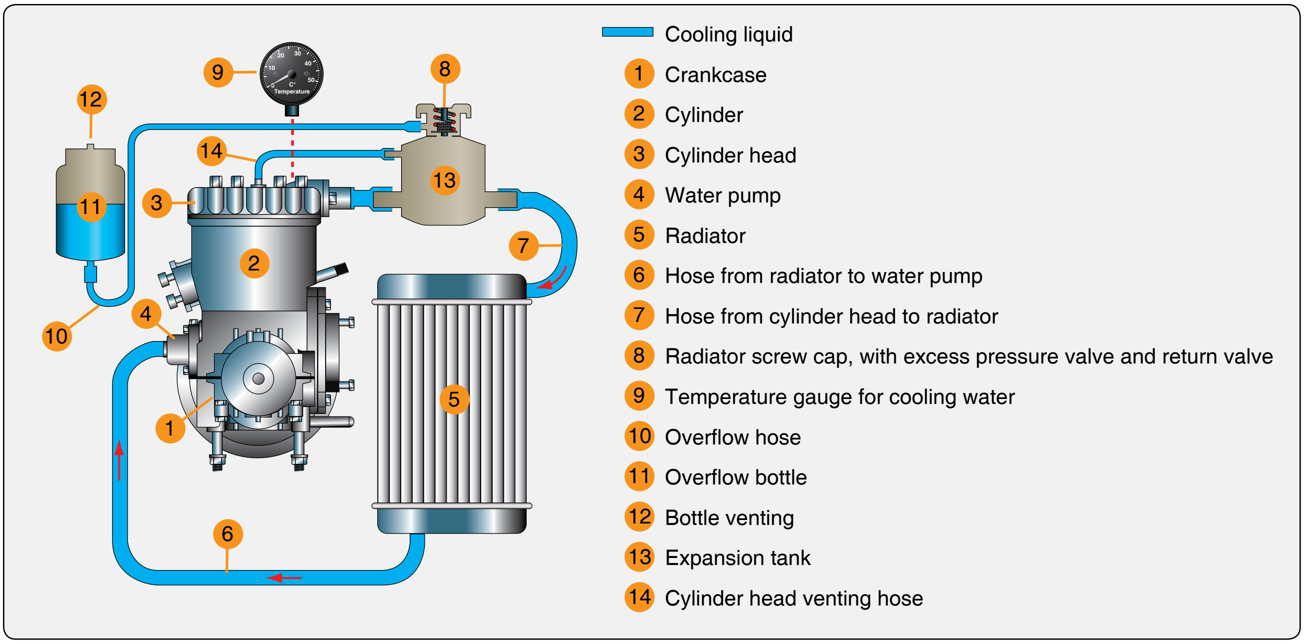

Figure 11-4. *Rotax 582 cooling system.*

from an oil tank by gravity.

Note: In engines that use oil injection, the carburetors are fed with pure gasoline (no oil-gasoline mixture). The oil quantity in the oil tank must be checked before putting the engine into service as the oil is consumed during operation and needs to be replenished.

Electric System

The 503 UL DCDI, 582 UL DCDI engine types are equipped with a breakerless, single capacitor discharge ignition unit with an integrated generator. *[Figure 11-5]* The 447 UL SCDI engine is equipped with a breakerless, single capacitor discharge ignition unit with integrated generator. The ignition unit is completely free of maintenance and needs no external power supply. Two charging coils fitted on the generator stator, independent from each other, each feed one ignition circuit. The energy supplied is stored in the ignition capacitor. At the moment of ignition, the external triggers supply an impulse to the control circuits and the ignition capacitors are discharged via the primary winding of the ignition coil. The secondary winding supplies the high voltage for the ignition spark.

Fuel System

Due to higher lead content in aviation gas (AVGAS), operation can cause wear and deposits in the combustion chamber to increase. Therefore, AVGAS should only be used if problems are encountered with vapor lock or if the other fuel types are not available. Caution must be exercised to use only fuel suitable for the relevant climatic conditions, such as using winter fuel for summer operation.

Fuel-Oil Mixing Procedure

The following describes the process for fuel-oil mixing. Use a clean approved container of known volume. To help predilute the oil, pour a small amount of fuel into the container. Fill known amount of oil (two-stroke oil ASTM/Coordinating European Council (CEC) standards, API-TC classification (e.g., Castrol TTS) mixing ratio 1:50 (2 percent)), into container. Oil must be approved for air-cooled engines at 50:1 mixing ratio. Agitate slightly to dilute oil with gasoline. Add gasoline to obtain desired mixture ratio; use fine mesh screen. Replace the container cap and shake the container thoroughly. Then, using a funnel with a fine mesh screen to prevent the entry of water and foreign particles, transfer mixture from container into the fuel tank.

Warning: To avoid electrostatic charging at refueling, use only metal containers and ground the aircraft in accordance with the grounding specifications.

Opposed Light-Sport, Experimental, & Certificated Engines

Many certificated engines are used with light-sport and experimental aircraft. Generally, cost is a big factor when considering this type of powerplant. The certificated engines tend to be much more costly than the non-certificated engines, and are not ASTM approved.

Rotax 912/914

Figure 11-6 shows a typical four cylinder, four-stroke Rotax horizontally opposed engine. The opposed-type engine has

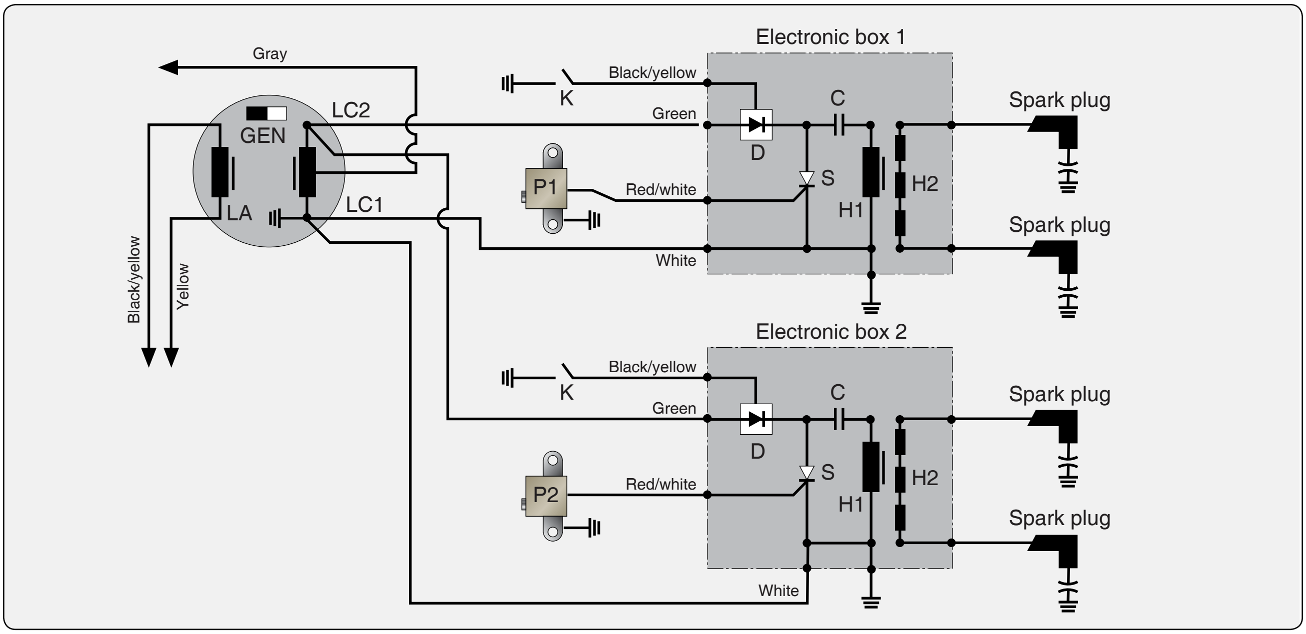

Figure 11-5 *Rotax 503 and 582 electrical system.*

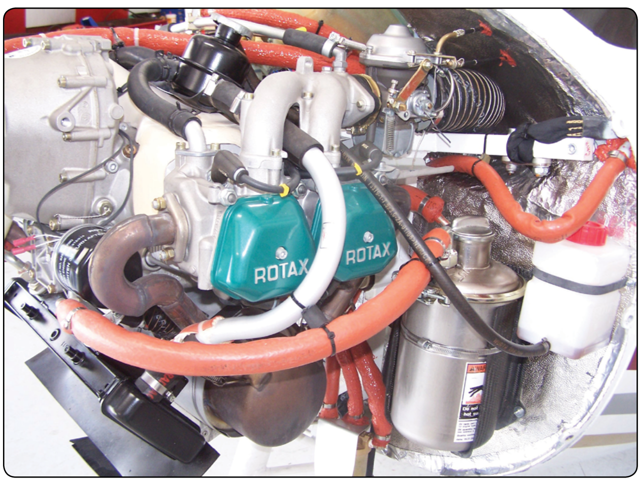

Figure 11-6. *Typical four-cylinder, four-stroke horizontally opposed engine.*

two banks of cylinders directly opposite each other with a crankshaft in the center. The pistons of both cylinder banks are connected to the single crankshaft. The engine cylinder heads are both liquid-cooled and air-cooled; the air-cooling is mostly used on the cylinder. It is generally mounted with the cylinders in a horizontal position. The opposed-type engine has a low weight to horsepower ratio, and its narrow silhouette makes it ideal for horizontal installation on the aircraft wings (twin-engine applications). Another advantage is its low vibration characteristics. It is an ideal replacement for the Rotax 582 two-cylinder, two-stroke engine, which powers many of the existing light aircraft, as it is the same weight as the Rotax 582. These engines are ASTM approved for installation into light-sport category aircraft, with some models being FAA-certificated engines.

Description of Systems

Cooling System

The cooling system of the Rotax 914, shown in *Figure 11-7*, is designed for liquid cooling of the cylinder heads and ram-air cooling of the cylinders. The cooling system of the cylinder heads is a closed circuit with an expansion tank. *[Figure 11-8]* The coolant flow is forced by a water pump driven from the camshaft, from the radiator, to the cylinder heads. From the top of the cylinder heads, the coolant passes on to the expansion tank (1). Since the standard location of the radiator (2) is below engine level, the expansion tank located on top of the engine allows for coolant expansion.

The expansion tank is closed by a pressure cap (3) (with excess pressure valve and return valve). As the temperature of the coolant rises, the excess pressure valve opens and the coolant flows via a hose at atmospheric pressure to the transparent overflow bottle (4). When cooling down, the coolant is sucked back into the cooling circuit. Coolant temperatures are measured by means of temperature probes installed in the cylinder heads 2 and 3. The readings are taken on measuring the hottest point of cylinder head depending on engine installation. *[Figure 11-7]*

Fuel System

The fuel flows from the tank (1) via a coarse filter-water trap (2) to the two electric fuel pumps (3) connected in series. *[Figure 11-9]* From the pumps, fuel passes on via the fuel pressure control (4) to the two carburetors (5). Parallel to each fuel pump is a separate check valve (6) installed via the return line (7) that allows surplus fuel to flow back to the fuel tank. Inspection for possible constriction of diameter or

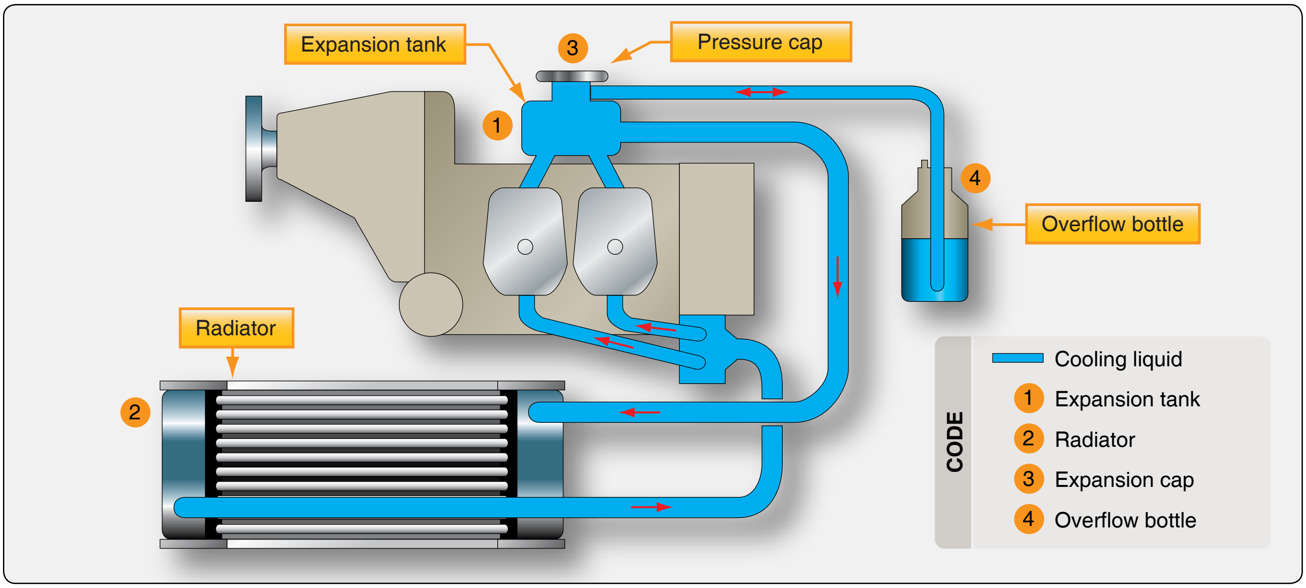

Figure 11-7. *Rotax 914 cooling system.*

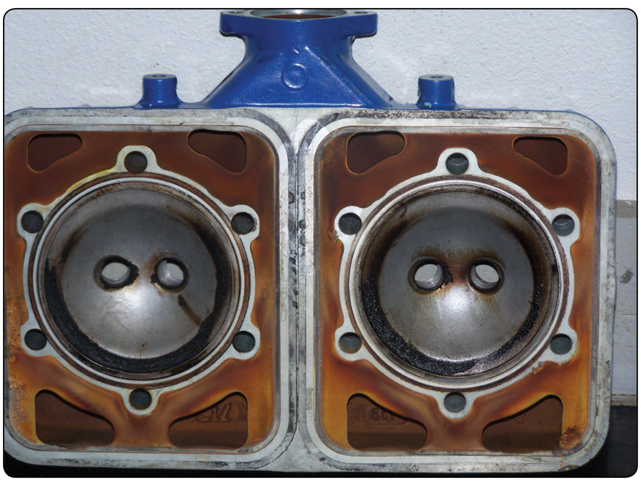

Figure 11-8. *Water-cooled heads.*

obstruction must be accomplished to avoid overflowing of fuel from the carburetors. The return line must not have any resistance to flow. The fuel pressure control ensures that the fuel pressure is always maintained approximately 0.25 bar (3.63 pounds per square inch (psi)) above the variable boost pressure in the airbox and thus, ensures proper operation of the carburetors.

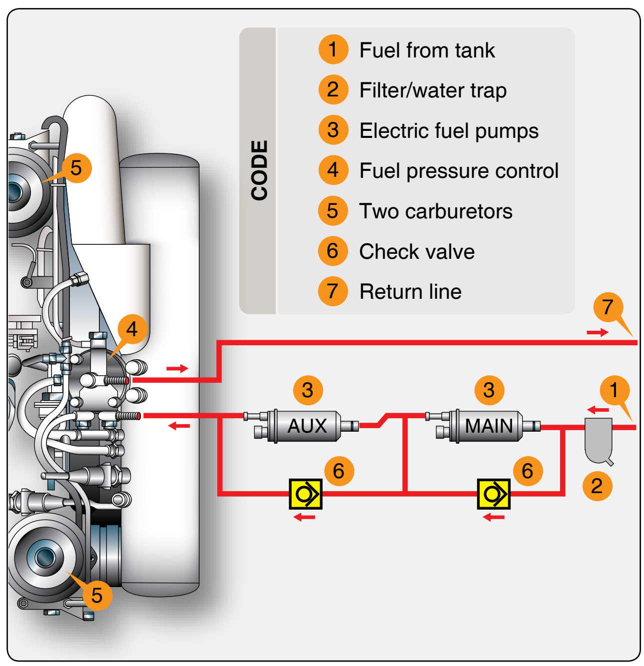

Figure 11-9. *Fuel system components.*

Lubrication System

The Rotax 914 engine is provided with a dry, sump-forced lubrication system with a main oil pump with integrated pressure regulator and an additional suction pump. *[Figure 11-10]* The oil pumps are driven by the camshaft. The main oil pump draws oil from the oil tank (1) via the oil cooler (2) and forces it through the oil filter to the points of lubrication. It also lubricates the plain bearings of the turbocharger and the propeller governor. The surplus oil emerging from the points of lubrication accumulates on the bottom of crankcase and is forced back to the oil tank by the blow-by gases. The turbocharger is lubricated via a separate oil line (from the main oil pump). The oil emerging from the lower placed turbocharger collects in the oil sump by a separate pump and is pumped back to the oil tank via the oil line (3). The oil circuit is vented via bore (5) in the oil tank. There is an oil temperature sensor in the oil pump flange for reading of the oil inlet temperature.

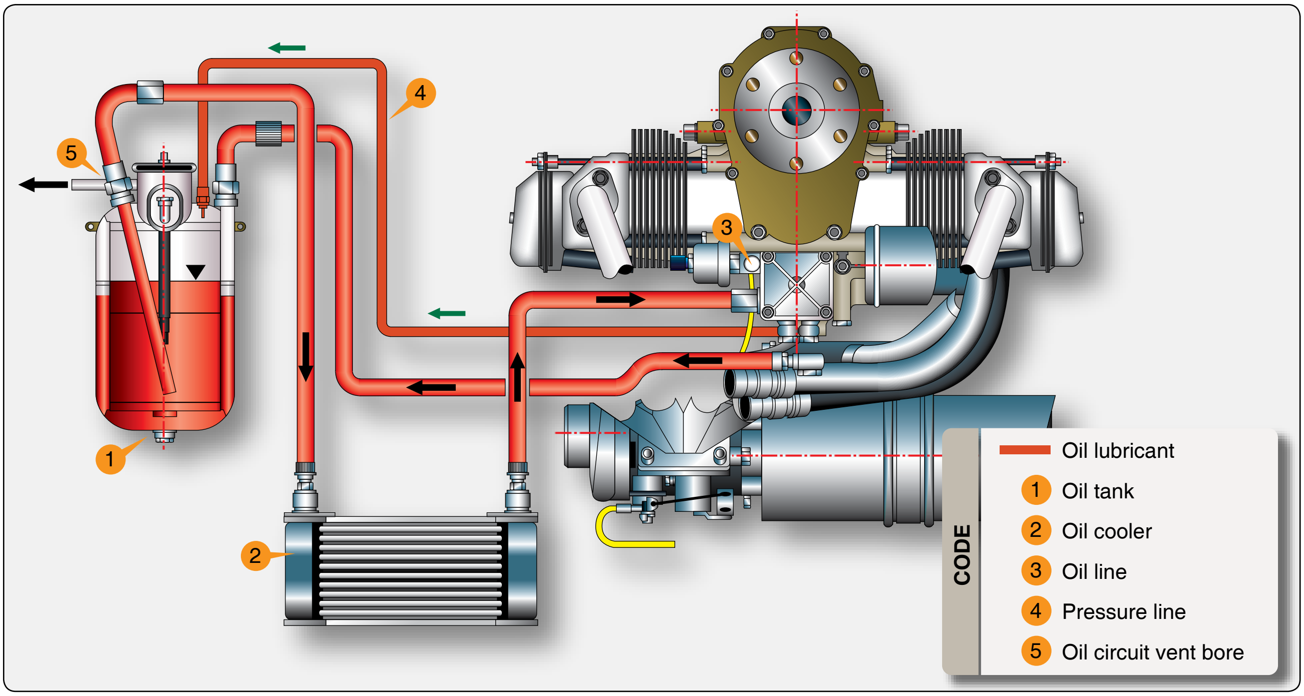

Figure 11-10. *Lubrication system.*

Electric System

The Rotax 914 engine is equipped with a dual ignition unit that uses a breakerless, capacitor discharge design with an integrated generator. *[Figure 11-11]* The ignition unit is completely free of maintenance and needs no external power supply. Two independent charging coils (1) located on the generator stator supply one ignition circuit each. The energy is stored in capacitors of the electronic modules (2). At the moment of ignition, two each of the four external trigger coils (3) actuate the discharge of the capacitors via the primary circuit of the dual ignition coils (4). The firing order is as follows: 1-4-2-3. The fifth trigger coil (5) is used to provide the revolution counter signal.

Turbocharger & Control System

The Rotax 914 engine is equipped with an exhaust gas turbocharger making use of the energy in the exhaust gas for compression of the intake air or for providing boost pressure to the induction system. The boost pressure in the induction system (airbox) is controlled by means of an electronically controlled valve (wastegate) in the exhaust gas turbine. The wastegate regulates the speed of the turbocharger and consequently the boost pressure in the induction system. The required nominal boost pressure in the induction system is determined by the throttle position sensor mounted on the carburetor 2/4. The sensor's transmitted position is linear from 0 to 115 percent, corresponding to a throttle position from idle to full power. *[Figure 11-12]* For correlation between throttle position and nominal boost pressure in the induction, refer to *Figure 11-13.* As shown in the diagram, with the throttle position at 108–110 percent results in a rapid rise of nominal boost pressure.

To avoid unstable boost, the throttle should be moved smoothly through this area either to full power (115 percent) or at a reduced power setting to maximum continuous power. In this range (108–110 percent throttle position), small changes in throttle position have a big effect on engine performance and speed. These changes are not apparent to the pilot from the throttle lever position. The exact setting for a specific performance is virtually impossible in this range and has to be prevented, as it might cause control fluctuations or surging. Besides the throttle position, overspeeding of the engine and too high intake air temperature have an effect on the nominal boost pressure. If one of the stated factors exceeds the specified limits, the boost pressure is automatically reduced, thus protecting the engine against over boost and detonation.

The turbo control unit (TCU) is furnished with output connections for an external red boost lamp and an orange caution lamp for indications of the functioning of the TCU. When switching on the voltage supply, the two lamps are automatically subject to a function test. Both lamps illuminate for one to two seconds, then they extinguish. If they do not, a check per the engine maintenance manual is necessary. If the orange caution lamp is not illuminated, then this signals that TCU is ready for operation. If the lamp is blinking, this indicates a malfunction of the TCU or its periphery systems. Exceeding the admissible boost pressure activates

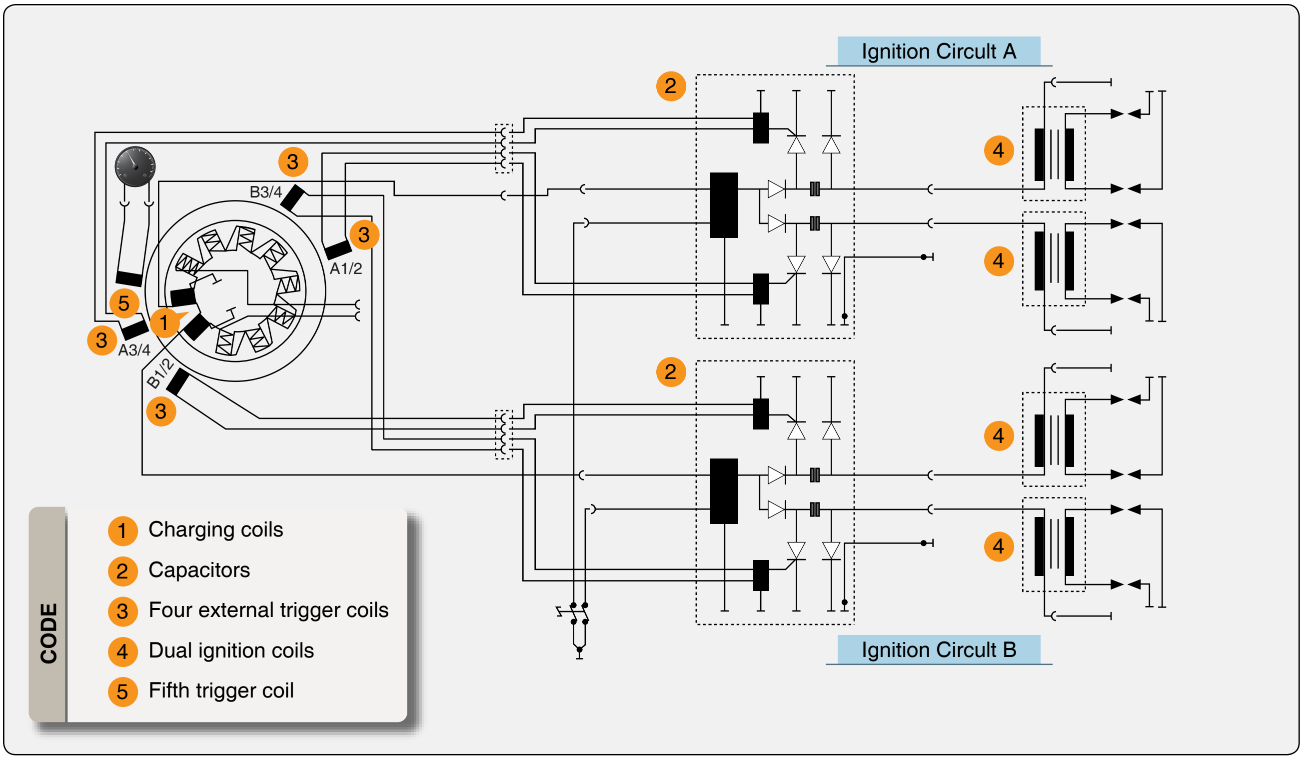

Figure 11-11. *Electric system.*

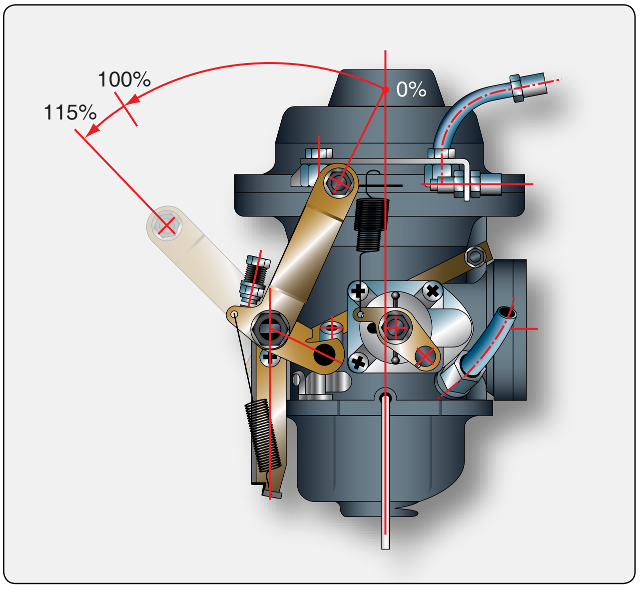

Figure 11-12. *Turbocharger control system throttle range and position.*

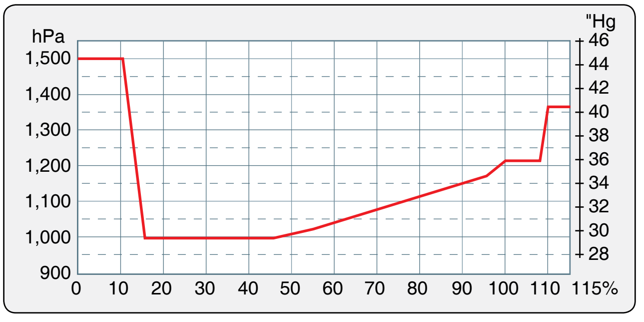

Figure 11-13. *Correlation between throttle position and nominal boost pressure.*

and illuminates the red boost lamp continuously. The TCU registers the time of full throttle operation (boost pressure). Full throttle operation for longer than 5 minutes, with the red boost light illuminated, makes the red boost lamp start blinking. The red boost lamp helps the pilot to avoid full power operation for longer than 5 minutes or the engine could be subject to thermal and mechanical overstress.

HKS 700T Engine

The HKS 700T engine is a four-stroke, two cylinder turbocharged engine equipped with an intercooler. *[Figure 11-14]* The horizontally opposed cylinders house four valves per cylinder, with a piston displacement of 709 cc. It uses an electronic control fuel injection system. A reduction gearbox is used to drive the propeller flange at a speed reduction ratio of 2.13 to 1. The engine is rated at 77 horsepower continuous and 80 horsepower takeoff (3 minutes) at 4,900 rpm and 5,300 rpm, respectively. A total engine weight of 126 pounds provides a good power to weight ratio. The 700T has a TBO of 500 hours.

Jabiru Light-Sport Engines

Jabiru engines are designed to be manufactured using the latest manufacturing techniques. [*Figure 11-15*] All Jabiru engines are manufactured, assembled, and ran on a Dynometer, then calibrated before delivery. The crankcase halves, cylinder heads, crankshaft, starter motor housings, gearbox cover (the gearbox powers the distributor rotors), together with many smaller components are machined from solid material. The sump (oil pan) is the only casting. The cylinders are machined from bar 4140 chrome molybdenum alloy steel, with the pistons running directly in the steel bores. The crankshaft is also machined from 4140 chrome molybdenum alloy steel, the journals of which are precision ground prior to being Magnaflux inspected. The camshaft is manufactured from 4140 chrome molybdenum alloy steel with nitrided journals and cams.

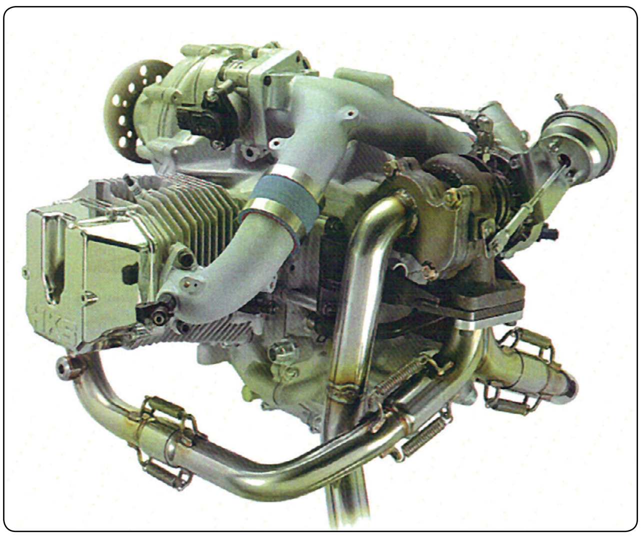

Figure 11-14. *HKS 700T engine.*

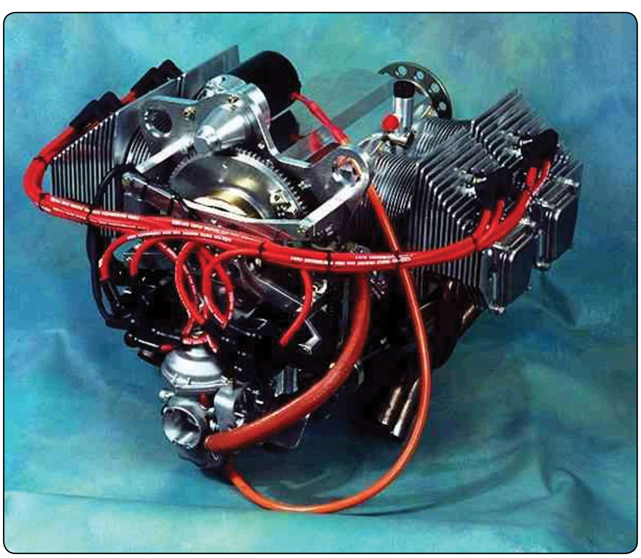

Figure 11-15. *Jabiru engines.*

The propeller is direct crankshaft driven and does not use a reduction gearbox. This facilitates its lightweight design and keeps maintenance costs to a minimum. The crankshaft features a removable propeller flange that enables the easy replacement of the front crankshaft seal and provides for a propeller shaft extension to be fitted, should this be required for particular applications. Cylinder heads are machined from a solid aluminum billet that is purchased directly from one company, thereby providing a substantive quality control trail to the material source. Connecting rods are machined from 4140 alloy steel and the 45 millimeters big end bearings are of the automotive slipper type. The ignition coils are sourced from outside suppliers and are modified by Jabiru for their own particular application.

An integral alternator provides AC rectification for battery charging and electrical accessories. The alternator is attached to the flywheel and is driven directly by the crankshaft. The ignition system is a transistorized electronic system; two fixed coils mounted adjacent to the flywheel are energized by magnets attached to the flywheel. The passing of the coils by the magnets creates the high voltage current, that is transmitted by high tension leads to the center post of two automotive type distributors, which are simply rotors and caps, before distribution to automotive spark plugs (two in the top of each cylinder head). The ignition system is fixed timing and, therefore, removes the need for timing adjustment. It is suppressed to prevent radio interference.

The ignition system is fully redundant, self-generating, and does not depend on battery power. The crankshaft is designed with a double bearing at the propeller flange end and a main bearing between each big end. Thrust bearings are located fore and aft of the front double bearing, allowing either tractor or pusher installation. Pistons are remachined to include a piston pin, circlip, and groove. They are all fitted with three rings, the top rings being cast iron to complement the chrome molybdenum cylinder bores. Valves are 7mm (stem diameter) and are manufactured specifically for the Jabiru engine. The valve drive train includes pushrods from the camshaft from the camshaft followers to valve rockers. The valves are Computer Numerical Control (CNC) machined from steel billet, induction hardened, polished on contact surfaces, and mounted on a shaft through Teflon coated bronze-steel bush. Valve guides are manufactured from aluminum/bronze. Replaceable valve seats are of nickel steel and are shrunk into the aluminum cylinder heads. The valve train is lubricated from the oil gallery. Engines use hydraulic lifters that automatically adjust valve clearance. An internal gear pump is driven directly by the camshaft and provides engine lubrication via an oil circuit that includes an automotive spin-on filter, oil cooler and built-in relief valve.

The standard engines are supplied with two ram-air cooling ducts, that have been developed by Jabiru to facilitate the cooling of the engine by directing air from the propeller to the critical areas of the engine, particularly the cylinder heads and barrels. The use of these ducts remove the need to design and manufacture baffles and the establishment of a plenum chamber, which is the traditional method of cooling air-cooled, aircraft engines. The fact that these baffles and plenum chamber are not required also ensures a cleaner engine installation, which in turn facilitates maintenance and inspection of the engine and engine components.

The engine is fitted with a 1.5 kilowatt starter motor that is also manufactured by Jabiru and provides very effective starting. The engine has very low vibration level; however, it is also supported by four large rubber shock mounts attached to the engine mounts at the rear of the engine. The fuel induction system uses a pressure compensating carburetor. Following the carburetor, the air-fuel mixture is drawn through a swept plenum chamber bolted to the sump casting, in which the mixture is warmed prior to entering short induction tubes attached to the cylinder heads.

An effective stainless steel exhaust and muffler system is fitted as standard equipment ensuring very quiet operations. For owners wanting to fit vacuum instruments to their aircraft, the Jabiru engines are designed with a vacuum pump drive direct mounted through a coupling on the rear of the crankshaft.

Jabiru 2200 Aircraft Engine

The Jabiru 2,200 cc aircraft engine is a four-cylinder, four-stroke horizontally opposed air-cooled engine. At 132 pounds (60 kgs) installed weight, it is one of the lightest four-cylinder, four-stroke aircraft engines. Small overall dimensions give it a small frontal area width (23.46 in, 596 mm) that makes it a good engine for tractor applications. The Jabiru engine is designed for either tractor or pusher installation. The Jabiru engine specifications are listed in *Figure 11-16*.

The Jabiru 3300 (120 hp) engine features *[Figure 11-17]*:

- 4-stroke,
- 3,300 cc engine (200 cubic inches),
- 6-cylinder horizontally opposed,
- 1 central camshaft,
- Fully machined aluminum alloy crankcase,
- Overhead valves (OHV) - push rod operated,
- Ram air-cooled,
- Wet sump lubrication - 4 liter capacity,
- Direct propeller drive,
- Dual transistorized magneto ignition,
- Integrated AC generator,
- Electric starter,
- Mechanical fuel pump, and
- Naturally aspirated - 1 pressure compensation carburetor.

Aeromax Aviation 100 (IFB) Aircraft Engine

Aeromax Aviation produces a version of a 100 hp engine called the Integral Front Bearing. The engine features a special made integral front bearing. *[Figure 11-18]* The engine uses an integral permanent magnet 35 amp alternator, lightweight starter, and dual ignition. The compact alternator and starter allow for a streamlined and aerodynamic cowl which improves the fuel efficiency of an experimental aircraft. The Aeromax aircraft engine is an opposed six-cylinder, air-cooled, and direct drive. Being a six-cylinder engine, it has smooth operation. The Aeromax engines are known for their heat dissipation qualities, provided the proper amount of cooling air is provided.

It features a crank extension supported by a massive integral front bearing (IFB) and bearing housing. These engines start out as a GM Corvair automobile core engine. These basic core engines are disassembled and each component that is reused is refurbished and remanufactured. The crankshaft in the Areomax 100 IFB aircraft engine is thoroughly inspected, including a magnaflux inspection. After ensuring the crank is free of any defects, it is extended by mounting the crank extension hub on its front. Then, the crank is ground true, with all five bearings' surfaces (four original and the new extended crank's front bearing), being true to each other and perpendicular to the crank's prop flange. *[Figure 11-19]*

All radiuses are smooth with no sharp corners where stress could concentrate. Every crankshaft is nitrated, which is a heat-chemical process that hardens the crank surfaces. The crank reinforcement coupled with the IFB is required to counter the additional dynamic and bending loads introduced on the crank in an aircraft application. The engine case is totally refurbished and checked for wear. Any studs or bolts that show wear are replaced. The engine heads are machined to proper specifications and all new valves, guides, and valve train components are installed. A three-angle valve grind and lapping ensure a good valve seal.

Once the engine is assembled, it is installed on a test stand, pre-lubricated, and inspected. The engine is, then, run several times for a total of two hours. The engine is carefully inspected after each run to ensure it is in excellent

Specifications: Jabiru 2200cc 85 HP Aircraft Engine	
Engine Features	Four-stroke
	Four-cylinder horizontally opposed
Opposed	One central camshaft
	Push rods
	Overhead valves (OHV)
(OHV)	Ram air-cooled
	Wet sump lubrication
	Direct propeller drive
	Dual transistorized magneto ignition
Magneto Ignition	Integrated AC generator 20 amp
Generator 20 amp	Electric starter
	Mechanical fuel pump
	Naturally aspirated - 1 pressure compensating carburetor
Pressure Compensating Carburetor	Six bearing crankshaft
Displacement	2,200 cc (134 cu. in.)
Bore	97.5 mm
Stroke	74 mm
Compression Ratio	8:1
Directional Rotation of Prop Shaft	Clockwise - pilot's view tractor applications
Ramp Weight	132 lb complete including exhaust, carburetor, starter motor, alternator, and ignition system
Ignition Timing	25˚ BTDC
Firing Order	1–3–2–4
Power Rating	85 hp @ 3,300 rpm
Fuel Consumption at 75% power	4 US gal/hr
Fuel	AVGAS 100 LL or auto gas 91 octane minimum
Oil	Aeroshell W100 or equivalent
Oil Capacity	2.3 quarts
Spark Plugs	NGK D9EA - automotive

Figure 11-16. *Jabiru 2200cc specifications.*

operating condition. At the end of test running the engine, the oil filter is removed and cut for inspection. Its internal condition is recorded. This process is documented and kept on file for each individual engine. Once the engine's proper performance is assured, it is removed and packaged in a custom built crate for shipping. Each engine is shipped with its engine service and operations manual. This manual contains information pertaining to installation, break–in, testing, tune-up, troubleshooting, repair, and inspection procedures. The specifications for the Aeromax 100 engine are outlined in *Figure 11-20*.

Direct Drive VW Engines

Revmaster R-2300 Engine

The Revmaster R-2300 engine maintains Revmaster's systems and parts, including its RM-049 heads that feature large fins and a hemispherical combustion chamber. *[Figure 11-21]* It maintains the earlier R-2200 engine's top

Jabiru 3300cc Aircraft Engine	
Displacement	3,300 cc (202 cu.in.)
Bore	97.5 mm (3.838")
Stroke	74 mm (2.913")
Aircraft Engine	Jabiru 3,300 cc 120 hp
Compression Ratio	8:1
Directional Rotation of Prop Shaft	Clockwise - Pilot's view tractor applications
Ramp Weight	178 lbs (81 kg) complete including exhaust, carburetor, starter motor, alternator and ignition system
Ignition Timing	25˚ BTDC fixed timing
Firing order	1–4–5–2–3–6
Power Rating	120 hp @ 3,300 rpm
Fuel Consumption at 75% power	26 l/hr (6.87 US gal/hr)
Fuel	AVGAS 100 LL or auto gas 91 octane minimum
Oil	Aeroshell W100 or equivalent
Oil Capacity	3.51 (3.69 quarts)
Spark Plugs	NGK D9EA - automotive

Figure 11-17. *Jabiru 3300cc aircraft engine.*

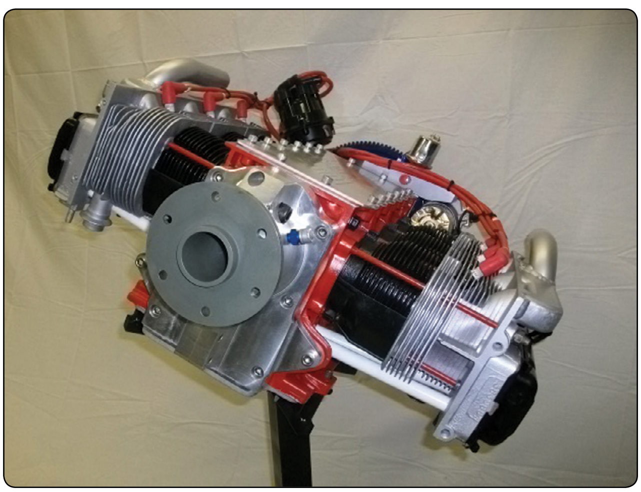

Figure 11-18. *Aeromax direct drive, air-cooled, six-cylinder engine.*

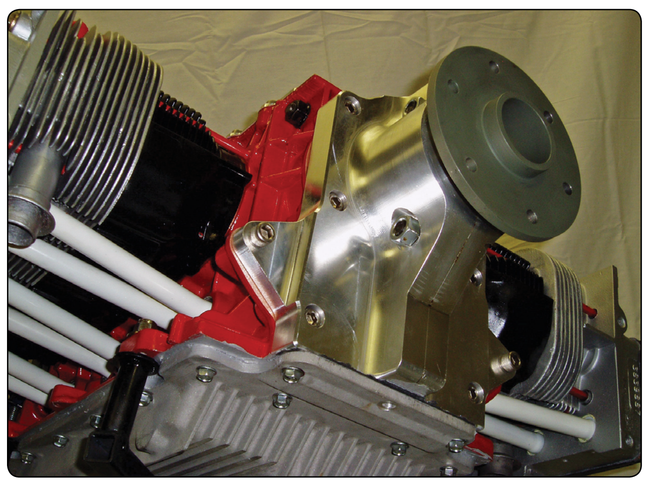

Figure 11-19. *Front-end bearing on the 1000 IFB engine.*

horsepower (82) at 2,950 rpm continuous. *[Figure 11-22]* Takeoff power is rated at 85 at 3,350 rpm. The additional power comes from a bore of 94 mm plus lengthening of the R-2200's connecting rods, plus increasing the stroke from 78 to 84 mm. The longer stroke results in more displacement, and longer connecting rods yield better vibration and power characteristics. The lower cruise rpm allows the use of longer propellers, and the higher peak horsepower can be felt in shorter takeoffs and steeper climbs.

The Revmaster's four main bearing crankshaft runs on a 60 mm center main bearing, is forged from 4340 steel, and uses nitrided journals. Thrust is handled by the 55 mm #3 bearing at the propeller end of the crank. Fully utilizing its robust #4 main bearing, the Revmaster crank has built in oil-controlled propeller capability, a feature unique in this horsepower range; non-wood props are usable with these engines.

Moving from the crankcase and main bearings, the cylinders are made by using centrifugally cast chilled iron. The pistons are forged out of high quality aluminum alloy, machined and balanced in a set of four. There are two sizes of pistons, 92 mm and 94 mm, designed to be compatible with a 78 mm to 82 mm stroke crankshafts. The cylinder set also contains

Aeromax 100 Engine Specifications	
Power Output: 100 hp continuous at 3,200 rpm	Air-cooled
Displacement: 2.7 L	Six cylinders
Compression: 9:1	Dual ignition–single plug
Weight: 210 lb	Normally aspirated
Direct Drive	CHT max: 475° F
Rear Light weight. Starter and 45 amp alternator	New forged pistons
Counterclockwise rotation	Balanced and nitrated crank shaft
Harmonic balancer	New hydraulic lifters
Remanufactured case	New main/rod bearings
Remanufactured heads with new guides, valves, valve train, intake	New all replaceable parts
Remanufactured cylinders	New spark plug wiring harness
New light weight aluminum cylinder - optional	Remanufactured dual ignition distributor with new points set and electronic module
New high torque cam	New oil pump
New CNC prop hub and safety shaft	New oil pan
New Aeromax top cover and data plate	Engine service manual

Figure 11-20. *Aeromax 100 engine specifications.*

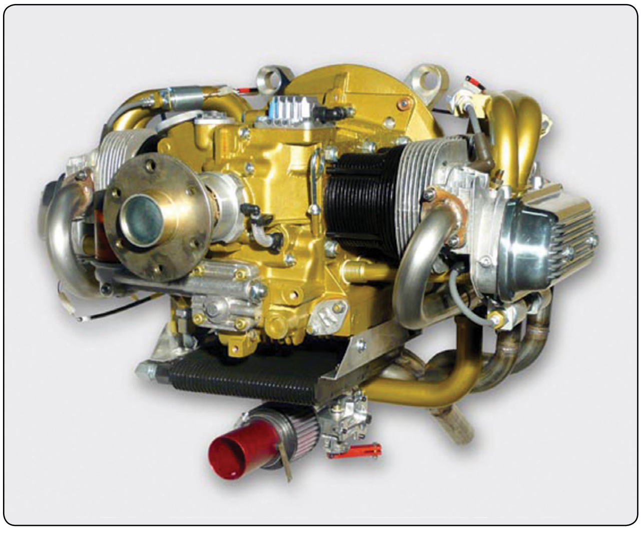

Figure 11-21. *Revmaster R-2300 engine.*

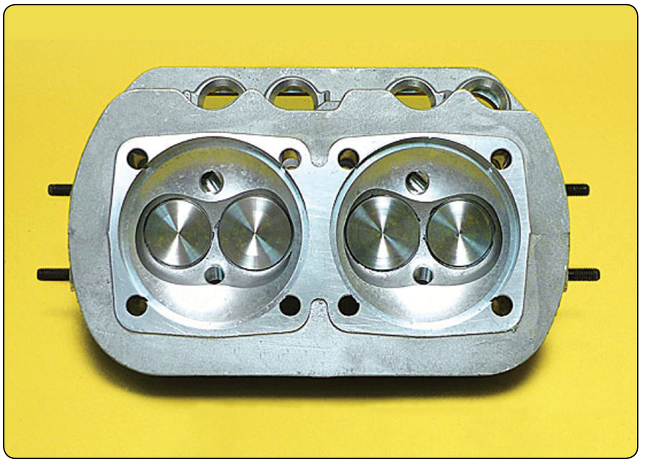

Figure 11-22. *Hemispherical combustion chamber within the Revmaster R-2300 Heads.*

piston rings, wrist pins, and locks. The direct-drive R-2300 uses a dual CDI ignition with eight coil spark to eight spark plugs, dual 20-amp alternators, oil cooler, and its proprietary Rev-Flo carburetor, while introducing the longer cylinders that do not require spacers. The automotive-based bearings, valves, valve springs, and piston rings (among others) make rebuilds easy and inexpensive.

Great Plains Aircraft Volkswagen (VW) Conversions

Great Plains Aircraft is one company that offers several configurations of the Volkswagen (VW) aircraft engine conversion. One very popular model is the front drive long block kits that offer a four-cycle, four-cylinder opposed engine with horsepower ranges from approximately 60-100. *[Figure 11-23]* The long block engine kits, which are the complete engine kits that are assembled, in the field or can be shipped completely assembled, are available from 1,600 cc up through 2,276 cc. All the engine kits are built from

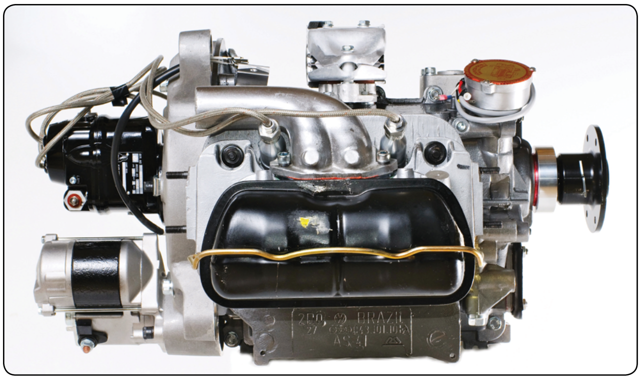

Figure 11-23. *Great Plain's Volkswagen conversion.*

proven time tested components and are shipped with a Type One VW Engine Assembly Manual. This manual was written by the manufacturer, specifically for the assembly of their engine kits. Also included are how to determine service and maintenance procedures and many tips on how to set up and operate the engine correctly. The crankshaft used in the 2,180 cc to 2,276 cc engines is a 82 mm crankshaft made from a forged billet of E4340 steel, machined and magnafluxed twice. The end of the crankshaft features a ½-inch fine thread versus a 20 mm thread found on the standard automotive crank.

Teledyne Continental 0-200 Engine

The 0-200 Series engine has become a popular engine for use in light-sport aircraft. The 0-200-A/B is a four-cylinder, carbureted engine producing 100 brake hp and has a crankshaft speed of 2,750 rpm. *[Figure 11-24]* The engine has horizontally opposed air-cooled cylinders. The engine cylinders have an overhead valve design with updraft intake inlets and downdraft exhaust outlets mounted on the bottom of the cylinder. The 0-200-A/B engines have a 201 cubic inch displacement achieved by using a cylinder design with a 4.06-inch diameter bore and a 3.88-inch stroke. The dry weight of the engine is 170.18 pounds without accessories. The weight of the engine with installed accessories is approximately 215 pounds. Developed specifically for light aircraft, the 0-200-D engine has a dry weight with installed accessories of approximately 199 pounds. The engine is provided with four integral rear engine mounts. A crankcase breather port is located on the 1-3 side of the crankcase forward of the number 3 cylinder.

The engine lubrication system is a wet sump, high-pressure oil system. The engine lubrication system includes the internal engine-driven pressure oil pump, oil pressure relief valve, pressure oil screen mounted on the rear of the accessory case, and pressure instrumentation. A fitting is provided at the 1-3 side of the crankcase for oil pressure measurement. The oil sump capacity is six quarts maximum. The 0-200-A/B induction system consists of an updraft intake manifold with the air intake and throttle mounted below the engine. Engine

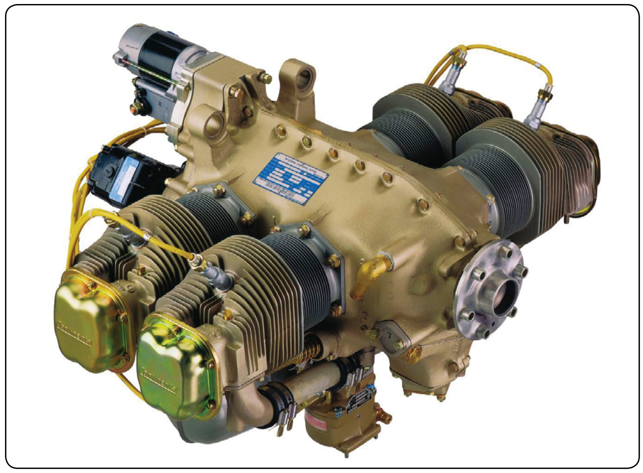

Figure 11-24. *0-200 Continental Engine.*

manifold pressure is measured at a port located on the 2-4 side of the intake air manifold. The 0-200-A/B is equipped with a carburetor that meters fuel flow as the flight deck throttle and mixture controls are changed.

Lycoming 0-233 Series Light-Sport Aircraft Engine

Lycoming Engines, a Textron Inc. company, produces an experimental non-certificated version of its 233 series light-sport aircraft engine. *[Figure 11-25]* The engine is light and capable of running on unleaded automotive fuels, as well as AVGAS. The engine features dual CDI spark ignition, an optimized oil sump, a streamlined accessory housing, hydraulically adjusted tappets, a lightweight starter, and a lightweight alternator with integral voltage regulator. It has a dry weight of 213 pounds (including the fuel pump) and offers continuous power ratings up to 115 hp at 2,800 rpm. In addition to its multi-gasoline fuel capability, it has proven to be very reliable with a TBO of 2,400 hours. The initial standard version of the engine is carbureted, but fuel injected configurations of the engine are also available.

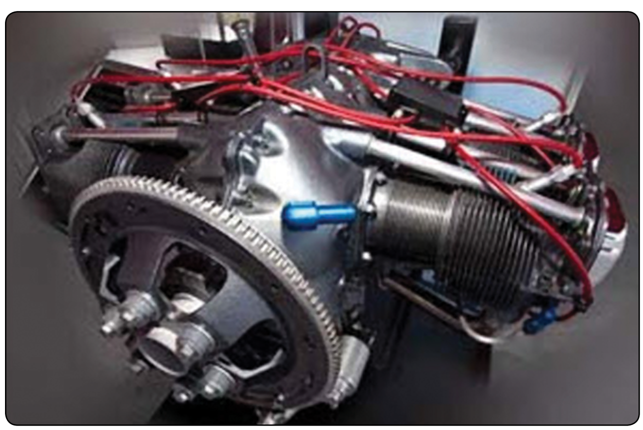

Figure 11-25. *Lycoming 0-233 engine.*

General Maintenance Practices on Light-Sport Rotax Engines

Some specific maintenance practices that differ from conventional certificated engines is covered for background and educational acquaintance purposes only. Always refer to the current manufacturer's information when performing maintenance on any engine.

Safety regulations must be adhered to ensure maintenance personnel safety when performing maintenance and service work on any engine installation. The following information should be followed while performing maintenance.

The ignition should be off and the ignition system grounded with the battery disconnected. Secure the engine against unintentional operation. During maintenance work that requires ignition on and battery connected, secure the propeller against unintentional turning by hand, and secure and observe a propeller safety zone. This precautionary measure serves to avoid any injuries in case of an unintentional start of the engine, which can result in injuries or death. Remember, as long as the ground-cable (plead) is not properly connected to ground, the ignition is switched ON (hot).

Prevent contamination, such as metal chips, foreign material, and/or dirt, from entering the cooling, lubricating, and fuel system during maintenance. Severe burns and scalds may result if the engine is not allowed to cool down to outside air temperature before starting any work. Before reusing disassembled parts, clean with a suitable cleaning agent, check, and refit per instructions. Before every re-assembly, check for missing components. Only use adhesives, lubricants, cleaning agents, and solvents listed for use in the maintenance instructions. Observe the tightening torques for screws and nuts; overtorque or too loose connection could cause serious engine damage or failure.

The following are some general maintenance practices that provide for safety and good technique:

- Work only in a non-smoking area and not close to sparks or open flames.
- Always use the specified tools.
- During disassembling/reassembling the removal of any safety items (e.g., safety wiring, self-locking fastener) each part must be followed with the replacement of a new one.
- Once loosened, always replace self-securing (locking) nuts.
- Use clean screws and nuts only and inspect face of nuts and thread for damage.
- Check the contact faces and threads for damage and replace if any damaged is detected.
- At reassembly of the engine, replace all sealing rings, gaskets, securing elements, O-rings, and oil seals.
- At disassembly of the engine, mark the engine's components as necessary to provide for locating the original position of the part.
- Parts should be replaced in the same position upon reassembly.
- Any used components have wear patterns that should be replaced or matched if reused. Ensure that these marks are not erased or washed off.

To perform maintenance, the technician must follow the manufacturer's instructions. Obtain, read, and understand the information pertaining to servicing of the light-sport or experimental engine.

Maintenance Schedule Procedures & Maintenance Checklist

All stated checks are visual inspections for damage and wear, unless otherwise stated. All listed work must be carried out within the specified period. For the intervals between maintenance work, a tolerance of + or – 0 hour is permissible, but these tolerances must not be exceeded. This means that if a 100 hour check is actually carried out at 110 hour, the next check is due at 200 hour + or – 10 hour and not at 210 hour + or – 10 hour. If maintenance is performed before the prescribed interval, the next maintenance check is to be done at the same interval (e.g., if first 100-hour check is done after 87 hours of operation, the next 100-hour check must be carried out after 187 hours of operation).

Checks are carried out per the maintenance checklists, where type and volume of maintenance work is outlined in key words. The lists must be photocopied and filled out for each maintenance check. The respective check (e.g., 100-hour check) must be noted on the top of each page of the maintenance checklist. All the maintenance work carried out must be initialed in the signature area by the aircraft mechanic performing the task. After maintenance, the completed checklists must be entered in the maintenance records. The maintenance must be confirmed in the log book. All discrepancies and remedial action must be recorded in a report of findings to be generated and maintained by the company authorized to carry out maintenance work. It is the responsibility of the aircraft operator to store and keep the records. Replacement of equipment (e.g., carburetor, fuel pump, governor) and execution of Service Bulletins must be entered in the log book, stating required information.

Carburetor Synchronization

For smooth idling, synchronization of the throttle valves is necessary. When synchronizing, slacken both Bowden cables, and detach the resonator hose (3) of the compensating tube (2) to separate the two air intake systems. *[Figure 11-26]* In this condition, no significant difference in the engine running should be noticeable. If adjustment is needed for synchronous basic throttle adjustments (mechanical synchronization), proceed as follows. *[Figures 11-27* and *11-28]*

Adjust the two Bowden cables for simultaneous opening of the throttle valves. Remove the cable fixation (4) on the throttle lever (1). Next, release the return spring (5) from its attachment on the throttle lever (1), and return the throttle lever (1) to its idle stop position (3) by hand. There should be no resistance during this procedure. Unscrew the idle speed adjustment screw (2) until it is free of the stop. Insert a 0.1 mm (0.004 in) feeler gauge (gap X) between the idle speed adjustment screw (2) and the carburetor idle stop (3), then gently turn the idle screw clockwise until contact is made with the 0.1 mm (0.004 in) feeler gauge. Pull out the feeler gauge and turn each idle speed adjustment screw (2) 1.5 turns in clockwise direction. Gently turn each idle mixture screw (6) clockwise until it is fully inserted and, then, open by 1½ turns counterclockwise. Hook the return spring (5) back up to the throttle lever (1) in its original position. Check that the throttle valve opens fully, automatically. Carry out the above procedure on both carburetors.

Note: The mechanical carburetor synchronization is sufficiently exact.

At this point, place the throttle lever in the flight deck to the idle stop position. Ensure that the throttle lever remains in this position during the next steps of the synchronization process. With the throttle lever in the idle stop position, move

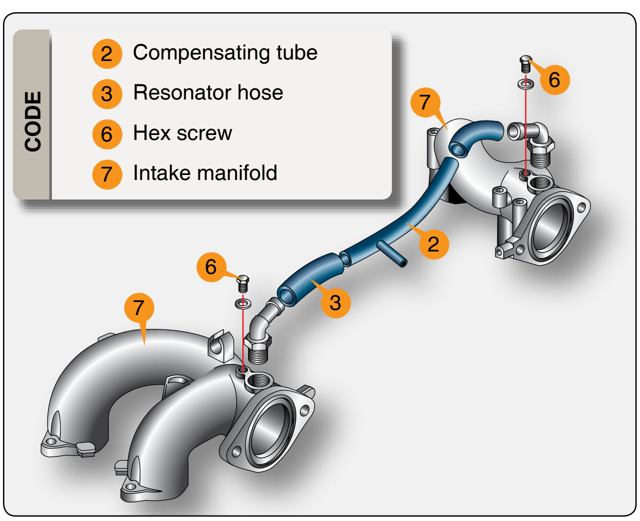

Figure 11-26. *Resonator hose and compensating tube.*

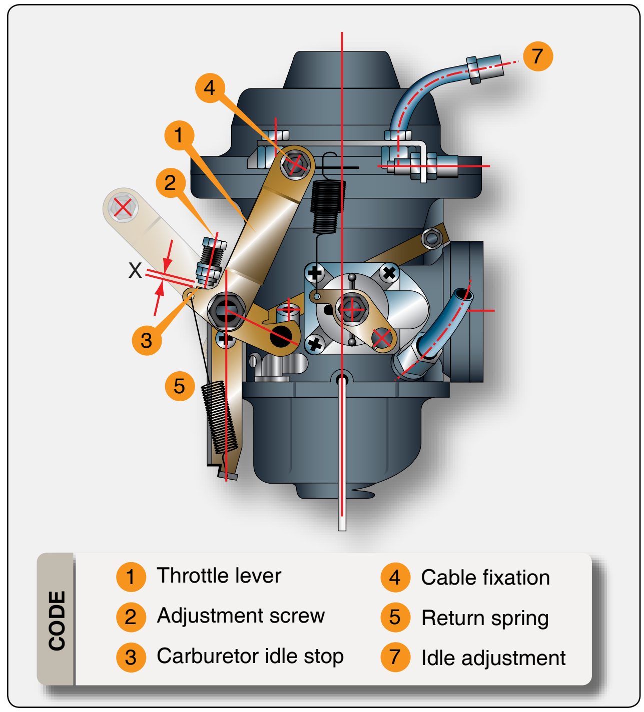

Figure 11-27. *Carburetor throttle lever.*

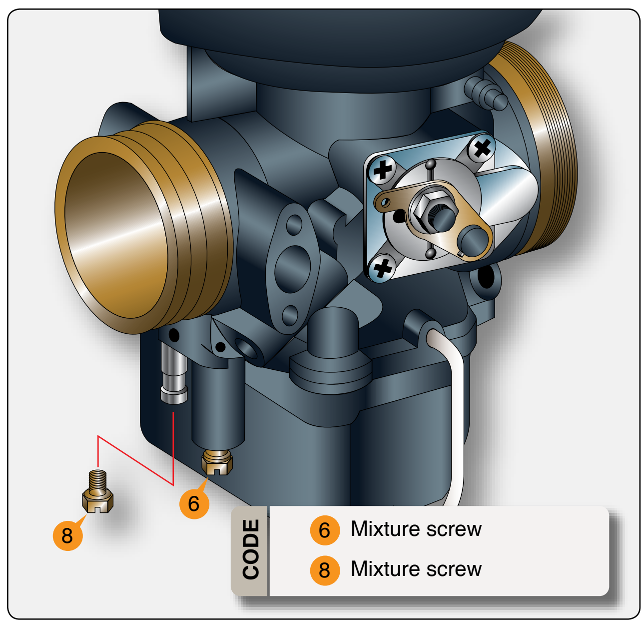

Figure 11-28. *Idle mixture screw.*

the throttle lever (1) to the carburetor idle stop position, using the cable fixation (4), and secure the Bowden cable accordingly. As soon as the two carburetor Bowden cables are installed (throttle lever idle position), check that the idle speed adjustment screw (2) rests fully on the idle stop (3) without pressure.

Caution: An idle speed that is too low results in gearbox damage, and if an idle speed is too high, the engine is harder to start. Start the engine and verify the idle speed. If the idle speed is too high or too low, adjust accordingly with idle speed adjustment screw (2). Check the operational idle mixture of the engine. If necessary, adjust with the idle mixture screw (6).

Pneumatic Synchronization

Mechanical synchronization should have already been accomplished. The two carburetors are adjusted to equal flow rate at idling by use of a suitable flow meter or vacuum gauges (1).

There are two possible methods to connect test equipment. One option is to remove the hex screw (6) M6 x 6 from the intake manifold (7) and connect the vacuum gauge(s). *[Figure 11-26* and *Figure 11- 29]* Remove the compensating tube (2) with attached hoses (12) (connection between intake manifolds) and plug the connections in the intake manifolds. The other hook up option is to remove the compensating tube hose (2) from the push-on connection (5) after removing the tension clamp (4). Using the push-on connection (5), install a flexible rubber hose (8) leading to the vacuum gauge (1), using the balance tube (4). Install the other flexible rubber hose leading to the vacuum gauge. *[Figure 11-29]* Before proceeding any further, secure the aircraft on the ground using wheel chocks and ropes.

Warning: Secure and observe the propeller zone during engine operation.

Start the engine, verify the idle speed, and make any necessary corrections. If a setting correction of more than ½ turn is required, repeat mechanical synchronization to prevent too high a load on the idle stops. If the idle speed is too high, the maximum the idle screw can be unscrewed is a complete turn. If no satisfactory result can be achieved, inspect the idle jets for contamination and clean if necessary.

Caution: Also check for translucent, jelly-like contamination. Inspect for free flow.

Once the proper idling speed has been established, it is necessary to check the operating range above the idle speed. First, establish that the engine is developing full takeoff performance or takeoff rpm when selected in the flight deck. Then, the setting of the operating range (idle to full throttle) can be checked or adjusted.

Start and warm up engine as per the operator's manual.

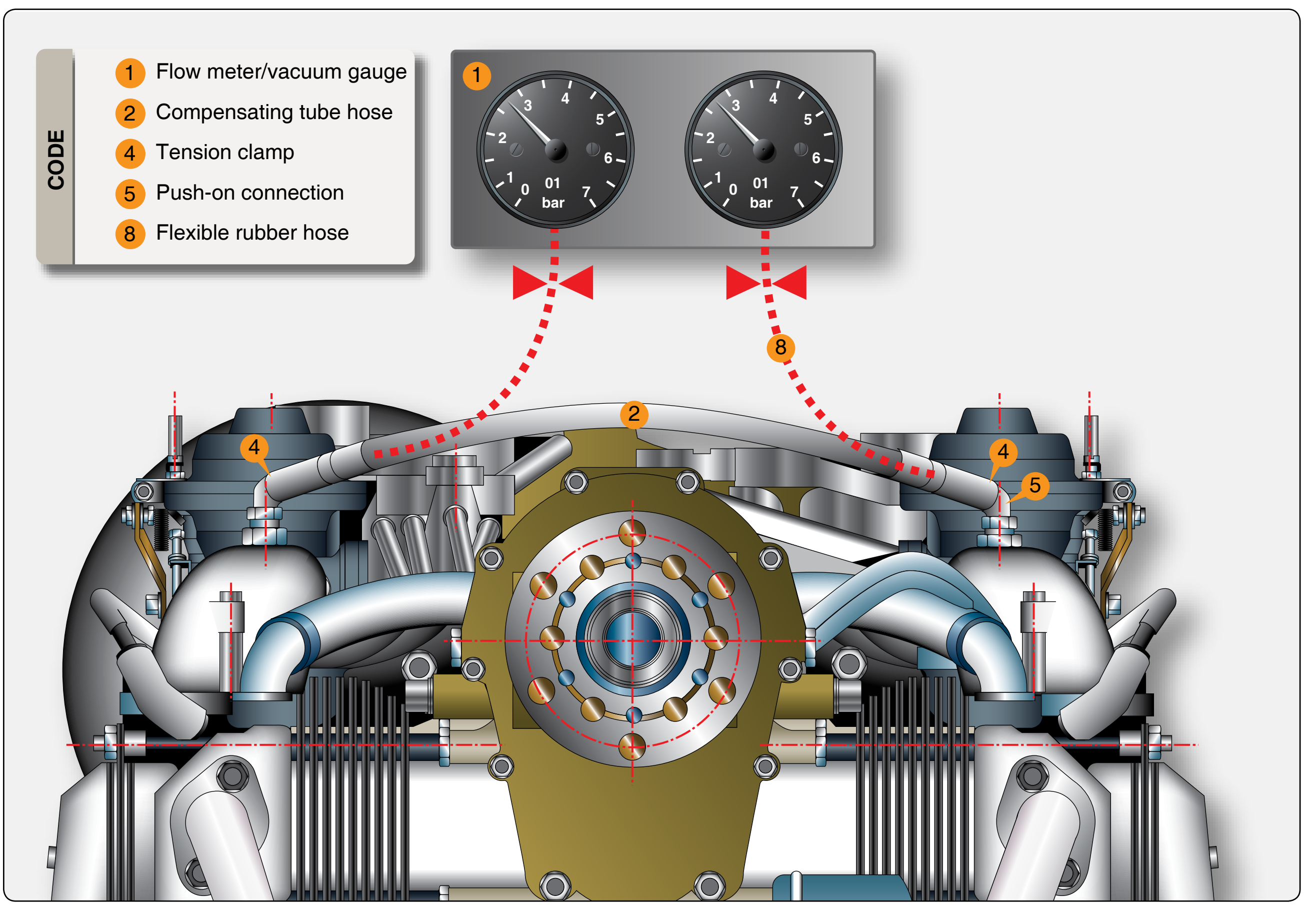

Figure 11-29. *Gauges attached to the engine.*

Select full power and check that both pressure gauges are registering the same readings. If the same reading is not made on both gauges, shut down the engine and check that carburetor actuation has full travel and that the chokes are in the full off-position. If necessary, fit/modify the carburetor actuation as required to achieve full power on both carburetors. Once full power has been established on both carburetors, retard the throttle and observe the pressure gauge settings. The pressure gauges should show the same reading for both carburetors. Discrepancies must be compensated for by adjusting the off idle adjustment (7). *[Figure 11-27]* The carburetor with the lower indication must be advanced to match the higher one. This is done by shutting down the engine and loosening the locknut on the Bowden cable and screwing the off idle adjustment in by ½ turn, then tightening the locknut and retesting the engine. Final idle speed adjustment may be required by resetting the idle speed adjustment screws (2). *[Figure 11-27]* Equal adjustment must be made on both carburetors.

Any major adjustments require retesting to verify all parameters mentioned in this procedure are within limits. Install compensation tube assembly on the engine in reverse sequence of removal. Any minor differences in balance at idle speed is compensated for. Always follow the instructions of the instrument manufacturer.

Idle Speed Adjustment

If satisfactory idle speed adjustment cannot be achieved, inspection of the idle jet or additional pneumatic synchronization is necessary. Always carry out idle speed adjustment when the engine is warm. Basic adjustment of the idle speed is first accomplished by using the idle speed adjustment screw (2) of the throttle valve. *[Figure 11-27]*

Optimizing Engine Running

Optimizing the engine run is necessary only if not accomplished at carburetor synchronization. Close the idle mixture screw (6) by turning clockwise to screw in fully and, then, opening again by 1½ turns counterclockwise. *[Figures 11-27* and *11-28]* Starting from this basic adjustment, the idle mixture screw (6) is turned until the highest motor speed is reached. The optimum setting is the middle between the two positions, at which an rpm drop is noticed. Readjustment of the idle speed is carried out using the idle speed adjustment screw (2) and, if necessary, by slightly turning the idle mixture screw again. Turning the idle mixture control screw in a clockwise direction results in a leaner mixture and turning counterclockwise in a richer mixture.

Checking the Carburetor Actuation

The Bowden cables should be routed in such a way that carburetor actuation is not influenced by any movement of the engine or airframe, thus possibly falsifying idle speed setting and synchronization. *[Figure 11-30]* Each carburetor is actuated by two Bowden cables. At position 1, connection for throttle valve and at position 2, make the connection for the choke actuator. The Bowden cables must be adjusted so that the throttle valve and the choke actuation of the starting carburetor can be fully opened and closed. Bowden cables and lever must operate freely and not jam.

Warning: With carburetor actuation not connected, the throttle valve is fully open. The initial position of the carburetor is full throttle. Never start the engine with the actuation disconnected. Inspect Bowden cables and levers for free movement. Cables must allow for full travel of lever from stop to stop. Adjust throttle cables to a clearance of 1 mm (0.04 in). Inspect and lubricate linkage on carburetor and carburetor joints with engine oil. Inspect return springs (3) and engagement holes for wear.

Lubrication System

Oil Level Check

Always allow engine to cool down to ambient temperature before starting any work on the lubrication system. Severe burns and scalds may result from hot oil coming into contact with the skin. Switch off ignition and remove ignition key. To assure that the engine does not turn by the starter, disconnect the negative terminal of aircraft battery. Before checking the oil level, make sure that there is not excess residue oil in the crankcase. Prior to oil level check, turn the propeller

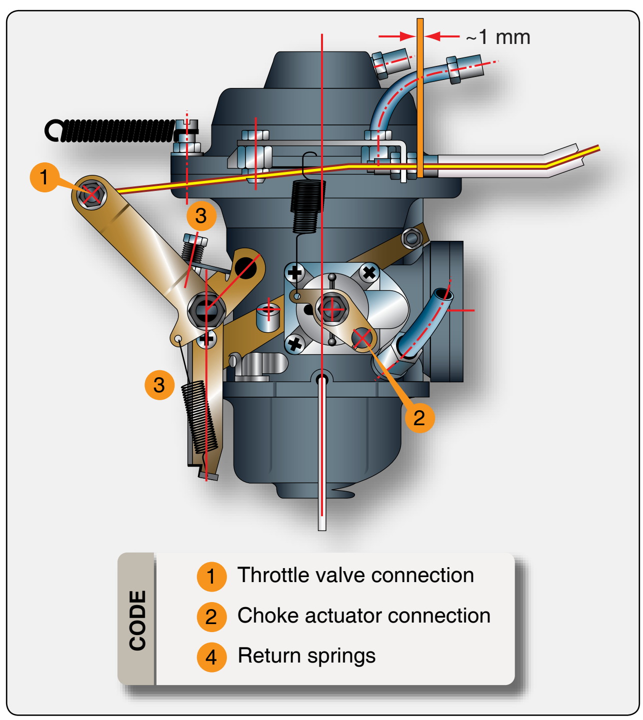

Figure 11-30. *Bowden cable routing.*

several times by hand in the direction of engine rotation to pump all the oil from the engine to the oil tank. This process is completed when air flows back to the oil tank. This air flow can be perceived as a gurgling noise when the cap of the oil tank is removed. The oil level in the oil tank should be between the two marks (maximum/minimum) on the oil dipstick, but must never fall below the minimum mark. *[Figure 11-31]* Replenish oil as required, but for longer flights, replenish oil to maximum mark to provide for more of an oil reserve. During standard engine operation, the oil level should be mid-way between the maximum and minimum marks a higher oil level (over servicing). Oil can escape through the venting (breather) passage.

Oil Change

It is advisable to check the oil level prior to an oil change, as it provides information about oil consumption. Run engine to warm the oil before beginning the procedure. Taking proper precautions, crank the engine by hand to transfer the oil from the crankcase. Remove the safety wire and oil drain screw (1) from the oil tank, drain the used oil, and dispose of as per environmental regulations. *[Figure 11-32]* Remove and replace oil filter at each oil change. It is not necessary to remove oil lines and other oil connections. Draining the suction lines, oil cooler, and return line is not necessary and must be avoided, as it results in air entering the oil system. Replacement of the oil filter and the oil change should be accomplished quickly and without interruption to prevent a draining of the oil system and the hydraulic tappets. Compressed air must not be used to blow through the oil system (or oil lines, oil pump housing, oil bores in the housing). Replace the oil drain screw torque and safety wire. Only use the appropriate oil in accordance with the latest operator's manual and service instruction. The engine must not be cranked when the oil system is open. After the oil change is accomplished, the engine should be cranked by hand in the direction of engine rotation (approximately 20 turns) to completely refill the entire oil circuit.

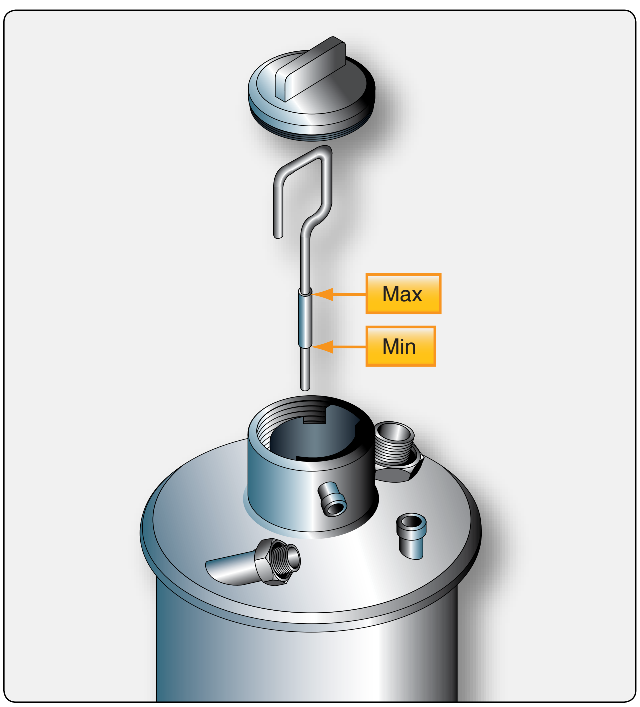

Figure 11-31. *Oil dipstick minimum and maximum marks.*

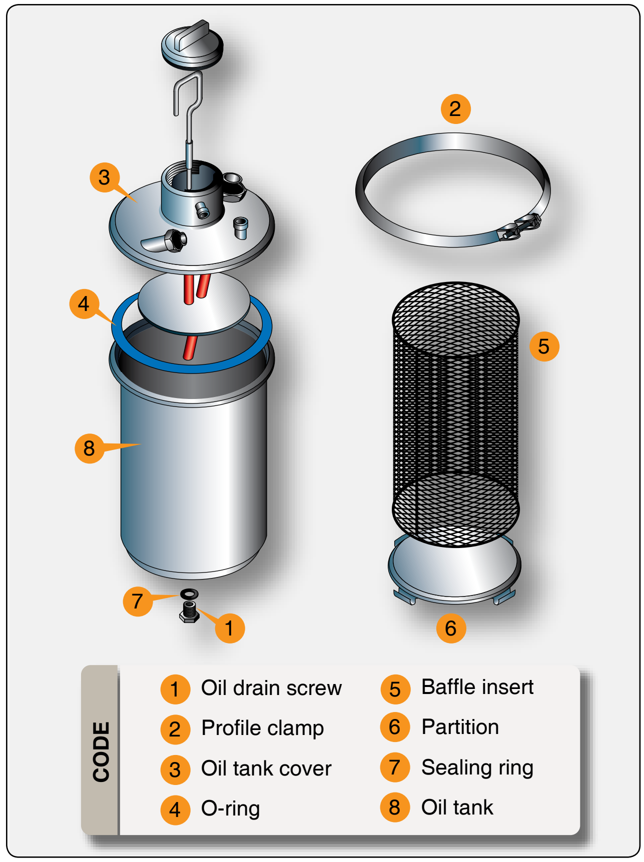

Figure 11-32. *Oil tank.*

Cleaning the Oil Tank

Cleaning the oil is optional and requires venting of the oil system. It is only necessary to clean the oil tank and the inner parts if there is heavy oil contamination. The procedure for cleaning the oil tank is shown in *Figure 11-32.* Detach the profile clamp (2) and remove the oil tank cover (3), together with the O-ring (4) and the oil lines. Remove the inner parts of the oil tank, such as the baffle insert (5) and the partition (6). Clean oil tank (8) and inner parts (5, 6), and check for damage. Be aware that incorrect assembly of the oil tank components can cause engine faults or engine damage. Replace the drain screw with a new sealing ring (7) and tighten to 25 Newton meters (Nm) (18.5 ft/lb) and safety wire. Reassemble the oil tank by following the same steps in reverse order.

Inspecting the Magnetic Plug

Remove the magnetic plug and inspect it for accumulation of chips. *[Figure 11-33]* The magnetic plug (torx screw) is located on the crankcase between cylinder 2 and the gearbox. This inspection is important because it allows conclusions to be drawn on the internal condition of the gearbox and engine, and reveals information about possible damage. If a significant amount of metal chips are detected, the engine must be inspected, repaired, or overhauled. Steel chips in low numbers can be tolerated if the accumulation is below 3 mm (0.125 in). *[Figure 11-33]* In the case of unclear findings, flush the oil circuit and fit a new oil filter. Afterwards, conduct an engine test run and inspect the oil filter once more. If there are larger accumulations of metal chips on the magnetic plug, the engine must be repaired or overhauled in accordance with the manufacturer's instructions for continued airworthiness. A detailed inspection of affected engine components must be performed. If the oil circuit is contaminated, replace the oil cooler and flush the oil circuit, then trace the cause and remedy the situation. If the magnetic chip is found to have no metal, then clean and reinstall. Tighten the plug to a torque of 25 Nm (18.5 ft/lb). Safety wire the plug and inspect all systems for correct function.

Checking the Propeller Gearbox

The following free rotation check and friction torque check are necessary only on certificated engines and on engines with the overload clutch as an optional extra. Engines without the overload clutch (slipper clutch) still incorporate the torsional shock absorption. This design is similar to the system with overload clutch, but without free rotation. For this reason, the friction torque method cannot be applied on engines without the overload clutch.

Checking the Friction Torque in Free Rotation

Fit the crankshaft with a locking pin. *[Figure 11-34]* With the crankshaft locked, the propeller can be turned by hand 15 or 30 degrees, depending on the profile of the dog gears installed. This is the maximum amount of movement allowed by the dog gears in the torsional shock absorption unit.

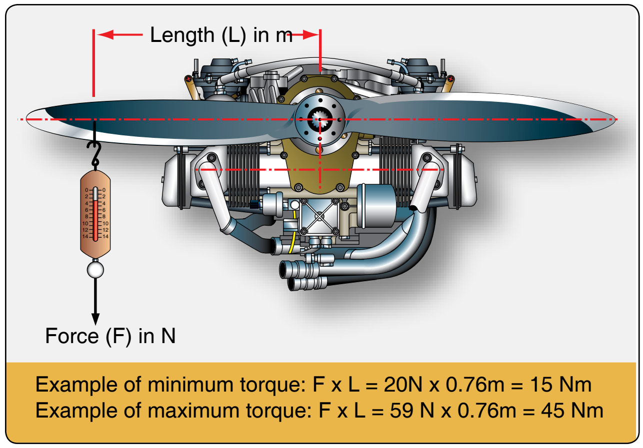

Figure 11-34. *Checking propeller gearbox.*

Warning: Ignition OFF and system grounded. Disconnect negative terminal of aircraft battery.

Turn the propeller by hand back and forth between ramps, taking into consideration the friction torque. No odd noises or irregular resistance must be noticeable during this movement. Attach a calibrated spring scale to the propeller at a certain distance (L) from the center of the propeller. Measure the force required to pull the propeller through the 15 or 30 degree range of free rotation. Calculate friction torque Nm by multiplying the force Newton's (N) or pounds (lb) obtained on the spring scale by the distance the scale is attached from the center of the propeller (L). The distance measurement and torque measurement must be in the same units either standard or metric and cannot be mixed up. The friction torque must be between a minimum of 25 Nm and maximum of 60 Nm (18.5 to 44.3 ft/lb). A calculation example is as follows:

Friction Torque (FT) = Length (meters) x Torque (Newtons)
FT = 0.5 meters x 60 Newtons
FT = 30 Nm

Remove crankshaft locking pin and reinstall plug with new gasket. Reconnect negative terminal of aircraft battery. If the above mentioned friction torque is not achieved, inspect, repair, or overhaul the gearbox in accordance with the manufacturer's instructions for continued airworthiness. Testing the propeller flange is not normal maintenance but can be carried out if defects or cracks are suspected.

Daily Maintenance Checks

The following checklist should be used for daily maintenance checks. Repair, as necessary, all discrepancies before flight.

1. Verify ignition OFF.

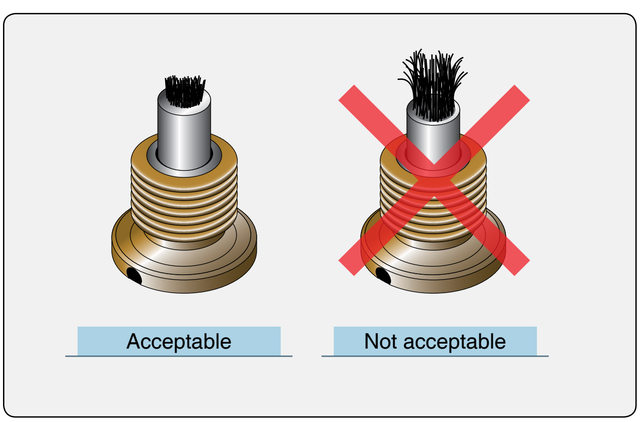

Figure 11-33. *Inspecting the magnetic plug.*

2. Drain water from fuel tank sump and/or water trap (if fitted).
3. Inspect carburetor rubber socket or flange for cracks and verify secure attachment.
4. Inspect carburetor float chamber for water and dirt.
5. Verify security and condition of intake silencer and air filter.
6. Verify security of radiator mounting. Inspect radiators for damage and leaks.
7. Verify coolant level in overflow bottle and security of cap.
8. Verify coolant hoses for security, and inspect for leaks and chafing.
9. Inspect engine for coolant leaks (cylinder head, cylinder base, and water pump).
10. Verify oil content for rotary valve gear lubrication and security of oil cap.
11. Verify oil hoses for security, and inspect for leaks and chafing (rotary valve gear lubrication system and oil injection system).
12. Verify ignition coils/electronic boxes for secure mounting, and check ignition leads and all electrical wiring for secure connections and chafing.
13. Verify electric starter for secure mounting, and inspect cover for cracks.
14. Verify engine to airframe mounting for security and inspect cracks.
15. Verify fuel pump mounting for security, and inspect all fuel hose connections (filters, primer bulbs, and taps for security, leakage, chafing and kinks).
16. Verify fuel pump impulse hose for secure connections, and inspect for chafing and kinks.
17. Verify safety wiring of gearbox drain and level plugs.
18. Inspect rubber coupling for damage and aging (C type gearbox only).
19. Rotate engine by hand and listen for unusual noises (first, double verify ignition OFF).
20. Check propeller shaft bearing for clearance by rocking propeller.
21. Inspect throttle choke and oil pump lever cables for damage (end fittings, outer casing, and kinks).

Pre-flight Checks

The following checklist should be performed for all pre-flight checks. Repair, as necessary, all discrepancies and shortcoming before flight.

1. Verify ignition OFF.
2. Check fuel content.
3. Inspect for coolant leaks.
4. Verify oil tank content (oil injection engines).
5. Verify spark plug connectors for security.
6. Inspect engine and gearbox for oil leaks.
7. Inspect engine and gearbox for loose or missing nuts, bolts, and screws, and verify security of gearbox to engine mounting.
8. Inspect propeller for splits and chips. If any damage, repair and/or rebalance before use.
9. Verify security of propeller mounting.
10. Check throttle, oil injection pump, and choke actuation for free and full movement.
11. Verify that cooling fan turns when engine is rotated (air-cooled engines).
12. Inspect exhaust for cracks, security of mounting, springs, and hooks for breakage and wear, and verify safety wiring of springs.
13. Start engine after assuring that area is clear of bystanders.
14. Single ignition engines: check operation of ignition switch (flick ignition off and on again at idling).
15. Dual ignition engines: check operation of both ignition circuits.
16. Check operation of all engine instruments during warm up.
17. If possible, visually check engine and exhaust for excessive vibration during warm up (indicates propeller out of balance).
18. Verify that engine reaches full power rpm during takeoff roll.

Troubleshooting & Abnormal Operation

The information in this section is for training purposes and should never be used for maintenance on the actual aircraft. Only qualified personnel (experienced two-stroke technicians) trained on this particular type of engine are allowed to carry out maintenance and repair work. If the following information regarding the remedy of the malfunction does not solve the malfunction, contact an authorized facility. The engine must not be returned to service until the malfunction is rectified. As described earlier in the text, engines require basically two essentials to run: spark and correct air-fuel mixture. The majority of problems quite often are a simple lack of one or the other.

Troubleshooting

Follow an organized method of troubleshooting. This facilitates the identification of discrepancies or malfunctions.

- Fuel—start by checking the supply (tank), fittings (loose), filter (plugged), and float chamber (fouled).
- Spark—check for spark at the spark plugs.

Problems of a more complex nature are best left to an engine technician. The following are examples of engine troubles and potential fixes.

Engine Keeps Running With Ignition OFF

Possible cause: Overheating of engine.
Remedy: Let engine cool down at idling at approximately 2,000 engine rpm.

Knocking Under Load

Possible cause: Octane rating of fuel too low.
Remedy: Use fuel with higher octane rating.
Possible cause: Fuel starvation, lean mixture.
Remedy: Check fuel supply.

Abnormal Operation

Exceeding the Maximum Admissible Engine Speed

Reduce engine speed. Any overage of the maximum admissible engine speed must be entered by the pilot into the logbook, stating duration and extent of over-speed.

Exceeding Maximum Admissible Cylinder Head Temperature

Reduce engine power, setting to the minimum necessary, and carry out precautionary landing. Any exceeding of the maximum admissible cylinder head temperature must be entered by the pilot into the logbook, stating duration and extent of excess-temperature condition.

Exceeding Maximum Admissible Exhaust Gas Temperature

Reduce engine power, setting to the minimum necessary, and carry out precautionary landing. Any exceedence of the maximum admissible exhaust gas temperature must be entered by the pilot into the logbook, stating duration and extent of excess-temperature condition.

Engine Preservation

If the engine is not going to be used for an extended period of time, certain measures must be taken to protect engine against heat, direct sun light, corrosion, and formation of residues. In particular, the water bonded by the alcohol in the fuel causes increased corrosion problems during storage. After each flight, activate choke for a moment before stopping engine. Close all engine openings like exhaust pipe, venting tube, and air filter to prevent entry of contamination and humidity. For engine storage of one to four weeks, proceed with preservation prior to engine stop or on the engine at operating temperature. Let the engine run at increased idle speed. Shut the engine down and secure against inadvertent engine start. Remove air filters and inject approximately 3 cubic cm of preservation oil or equivalent oil into the air intake of each carburetor. Restart the engine and run at increased idle speed for 10–15 seconds. Shut engine down and secure against inadvertent engine start. Close all engine openings, such as exhaust pipe, venting tube, and air filter, to prevent entry of contamination and humidity.

For engine storage of engine for longer than four weeks and up to one year, proceed with preservation prior to engine stop and on the engine at operating temperature. Let the engine run at increased idle speed. Remove air filters and inject approximately 6 cubic cm of preservative oil or equivalent oil into the air intake of each carburetor. Stop the engine. Remove spark plugs and inject approximately 6 cubic cm preservation oil or equivalent oil into each cylinder and slowly turn crankshaft 2 to 3 turns by hand to lubricate top end parts. Replace and re-torque the spark plugs. Drain gasoline from float chambers, fuel tank, and fuel lines. Drain coolant on liquid cooled engines to prevent any damage by freezing. Lubricate all carburetor linkages using the proper lubricates. Close all openings of the engine, such as exhaust pipe openings, venting tube, and air intake, to prevent entry of any foreign material and humidity. Protect all external steel parts by spraying with engine oil.

General Maintenance Practices for the Light-Sport Jabiru Engines

Note: Some specific maintenance practices that differ from conventional certificated engines is covered for background and educational acquaintance purposes only. Always refer to the current manufacturer's information when performing maintenance on any engine.

Engine & Engine Compartment Inspection

Check for oil, fuel exhaust, and induction leaks and clean the entire engine and compartment before inspection. Check flywheel screw tensions to 24 foot pounds. Check the carburetor air filter and clean it by removing it from the intake housing and blowing compressed air against the direction of the intake flow. For operation in heavy dust conditions, clean air filter at shorter intervals than recommended for normal conditions. A clogged filter reduces engine performance, as well as promotes premature engine wear. The engine baffles and air ducts should be checked for condition and functionality.

Two methods can be used to check the cylinders compression. The compression gauge method is used to measure compression using a compression tracer. Readings are taken with a fully open throttle valve at engine oil temperature between 30 °C and 70 °C (90 °F to 160 °F). If readings are below 6 bar (90 psi) a check of the pistons, cylinders, valves, and cylinder heads must be undertaken.

The second method uses the pressure differential test. Check cylinder compression for a maximum allowable pressure loss of 25 percent. As an alternative to a compression test, a pressure differential test (leak down) can be accomplished. This is a much better test of the condition of rings, bore, head sealing, and valves. This is the normal test used in aviation and requires specific equipment. The test is carried out with the engine in warm to hot condition. Input pressure is best set at 80 psi; a second gauge reads the differential. This is done with the piston on TDC on the firing stroke.

Note: The propeller needs to be restrained. A differential of lower than 80/60 (generally a 25 percent loss) indicates a problem.

Problems can be better identified by observing where air is escaping from the cylinder, blow-by. Some examples are as follows:

1. Blow-by through the crankcase vent indicates worn rings or bore.
2. Leaking from carburetor indicates a poor intake valve seal.
3. Leaking from exhaust indicates a poor exhaust valve seal.
4. Head leak indicates poor head to cylinder seal.

With the problem identified, the malfunction can then be corrected. Poor compression can be an indication of a serious problem. For example, continued operation with poor compression due to a poorly sealing valve can lead to eventual valve failure and heavy damage to the piston, connecting-rod, barrel, and head.

Lubrication System

The oil should be changed as required by the manufacturer. When changed, the oil filter should also be changed. Change the oil filter at every 50 hourly inspection. Drain the oil while engine is still warm and visually check for leaks. Fill the engine with oil (approximately 2.3 liters) and check oil level. Never exceed the maximum mark. Use only registered brand oils meeting the correct specifications. Do not drain the oil cooler during a normal oil change. The cooler holds only a small amount of old oil that has negligible effect on the new oil. Taking the hoses on and off the cooler can prematurely age the oil lines and lead to hoses slipping off the cooler.

Carburetor Adjustment & Checks

To adjust the engine's idle speed, adjust the idle stop screw (7 mm screw) against throttle lever. Standard idle mixture screw position is 1¼ turns out from the seated position. Fine adjustment may be necessary to give a smooth idle.

The mixture is set by selecting jet sizes. As supplied, the engine has jets to suit a majority of installations; however, the mixture may be affected by operation with a propeller that does not meet the requirements listed in the installation manual or by ambient temperature extremes. If an engine is to be used in these situations, an exhaust gas temperature (EGT) gauge should be fitted and monitored against the limits specified above. Do not change carburetor settings if EGT readings fall outside the range given without consulting with Jabiru Aircraft or the local authorized representative. The carburetor automatically adjusts the mixture to account for altitude. Visual inspection should include checks for carburetor joint degradation and carburetor linkage for full and free movement, correct positioning of stops and security.

Spark Plugs

When plugs are removed from a warm engine, the inspection of the tip of the spark plug can be used to indicate the health of the engine. If the tip of the plug is a light brown color, the plug is operating correctly. A black velvet, sooty looking plug tip generally is an indication of an overly rich mixture (check the choke, air filter, and intake). If the firing end tip is covered with oil, it is an indication of too much oil in the combustion chamber (check for worn piston rings and cylinder walls). When servicing the spark plugs, do not use steel or brass brushes for cleaning, and never sandblast plugs. Clean the spark plugs with a plastic brush in a solvent. Check electrode gap and, if necessary, adjust to 0.55–0.6mm (0.022 in–0.024 in) by carefully bending the electrode. Use the recommended Plugs (NGK D9EA) and place a suitable anti-seize compound on threads of the plug before installing them in the engine. Tighten spark plugs when the engine is cold and adjust engine to the correct torque value. Reconnect the ignition lead.

Exhaust System

Visually check the exhaust system for security of mounting, damage, rubbing, leaks, and general condition. Check nuts and bolts for tightness and condition; re-torque and replace if necessary.

Head Bolts

Check the head bolt torque after five hours of operation, and again after ten hours of operation. The bolts should, thereafter, be checked annually. Head bolts torque when cold to 20 ft/lb.

Tachometer & Sender

Many apparent engine problems can be caused through inaccurate tachometers. Where engine performance is observed to be outside limits, the tachometer should be checked against a calibrated instrument. Tachometer sender gap is 0.4mm (0.016 inches). The sender must have at least 60 percent covered by the tags fitted to the gearbox side of the flywheel. Ensure both tags are equal distance from sender.

Engine Inspection Charts

Note: Read all inspection requirement paragraphs prior to using these charts. *[Figure 11-35]*

Propeller	Engine and Engine Compartment
Spinner * *	Check flywheel screw tensions to 24 foot pounds*
Spinner flange * *	Carburetor air filter * *
Spinner screws * *	Engine baffles and air ducts *
Propeller * *	Cylinders *
Propeller bolts/nuts - Tension *	Crankcase & front crankcase seal *
Spinner/prop tracking * *	Hoses, lines and fittings * *
	Intake and exhaust systems *
	Ignition harness, distributor caps & rotors *
	NOTE: Check for oil, fuel exhaust and induction leaks, then clean entire engine and compartment before inspection.
Annual Inspection **Each 100 Hours***	

Figure 11-35. *Engine inspection charts.*