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SERVICE LETTER: JSL 002-1

Issue: 1

Date: 13th Dec 2004

Subject: Jabiru Engine Economy Tuning

1. Applicability:

All Jabiru Engines.

2. Background:

Jabiru Aircraft has developed new tuning for it's engines to improve fuel consumption at cruise power. Consumption for the 4 cylinder engine is reduced to 13-14 Litres per hour and consumption for the 6 cylinder engine is reduced to 19-20 Litres per hour (figures for engines installed in Jabiru airframes, with Jabiru propellers at typical cruise rpm). Consumption for the 8 cylinder engine is reduced to 30-31 Litres per hour (when fitted in a Van's RV-6, with a Sensenich propeller, cruising at 2600 rpm.).

The new tuning results in a cleaner burn, slowing the formation of deposits in the combustion chamber which may otherwise affect engine efficiency. The new jetting has also been found to be easier to vary to suit different airframe / propeller combinations. Power is not affected by this change.

This work should only be carried out by competent, approved persons. Poor tuning can easily result in severe engine damage caused by detonation.

3. Carburettor:

- **Jets & Needle:**

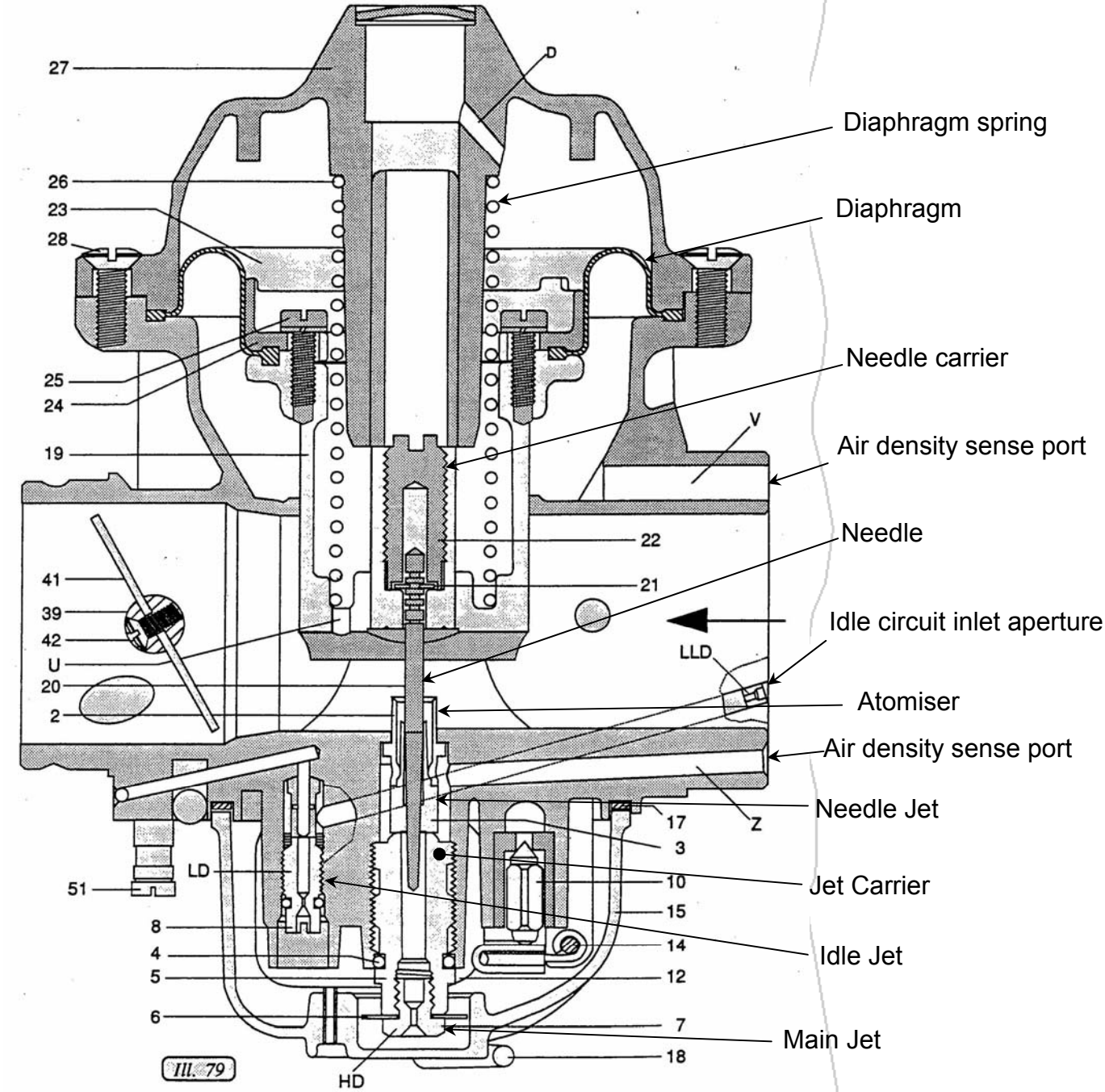

Figure 1. Carburettor Cut Away Drawing

The Bing altitude compensating carburettor used on Jabiru engines uses bowl float level and two main air circuits – the idle and the needle/main – to control the mixture. Both circuits use jets to meter the rate at which fuel is allowed to flow. The jets in the Bing carburettor are small brass parts with precisely controlled openings (both the size of the opening and the shape surrounding the opening affect the fuel flow rate) which can be changed to adjust the engine mixture. The economy tuning kit contains new idle, needle and main jets, in addition to a new needle.

Table 1 – Kit Jet Sizes & Needle Part Numbers

Item:	2200 Engine	3300 Engine	5100 Engine
Economy Tuning Kit P/No. ➔	4A172A0N	4A171A0N	4A173A0N
Idle Jet ➔	# 45	# 45	# 35
Needle Jet ➔	# 276	# 278	# 290
Main Jet ➔	# 220	# 250	# 250
Needle ➔	Jabiru P/No. 4A131A0D (2 notches on needle)	Jabiru P/No. 4A139A0D (3 notches on needle)	Jabiru P/No. 4A140A0D (5 notches on needle)

Note that the needles for the different engines can be told apart by the number of shallow grooves machined above the taper (See Figure below). The 2200 needle has two grooves, the 3300 three and the 5100 has five.

The main and idle jets have simple fixed apertures, while the effective size of the needle jet aperture varies, depending on the diameter of the needle. Figure 2 below shows three different throttle settings in the needle jet and the corresponding difference in aperture. On the left is a low power setting, where the needle jet is nearly completely blocked by the needle. The middle throttle setting corresponds approximately to a high cruise power setting. The gap between the needle and the sides of the jet is much larger. The final setting corresponds approximately to wide open throttle. The needle jet is now effectively not there, and the amount of fuel flowing is controlled by the main jet (located upstream of the needle jet in this circuit).

The shape of the taper of the needle controls the mixture at a given throttle setting. The original Bing needle has a nearly constant taper over it's length which was designed to give a consistent mixture when fitted to an engine under a steady load (i.e. the load stays fairly constant with engine speed). The Jabiru needle by comparison has been optimized for use with a propeller, which puts a very non-linear load on the engine; to double the RPM of a propeller a lot more than double the power has to be applied.

To achieve a good mixture with the type of load applied by a propeller, the Jabiru needle uses two-stage taper and a straight tip. The more gradual taper at the upper end of the needle gives a good, lean mixture in cruise and at lower RPM where the propeller is using relatively little power, while the sharper taper at the lower end ramps up rapidly to a much richer mixture at higher power settings. The straight tip of the needle is used when the throttle is wide open and the engine's mixture is being controlled by the main jet. This rich mixture at full power protects the engine from detonation.

The transition from lean, cruise mixtures to richer full-power mixture will occur at around 2900 – 3000 rpm on 4 and 6 cylinder engines, when fitted with an appropriate propeller. For most efficient operation, the transition must be above cruise rpm. The transition can clearly seen in the difference in exhaust temperatures.

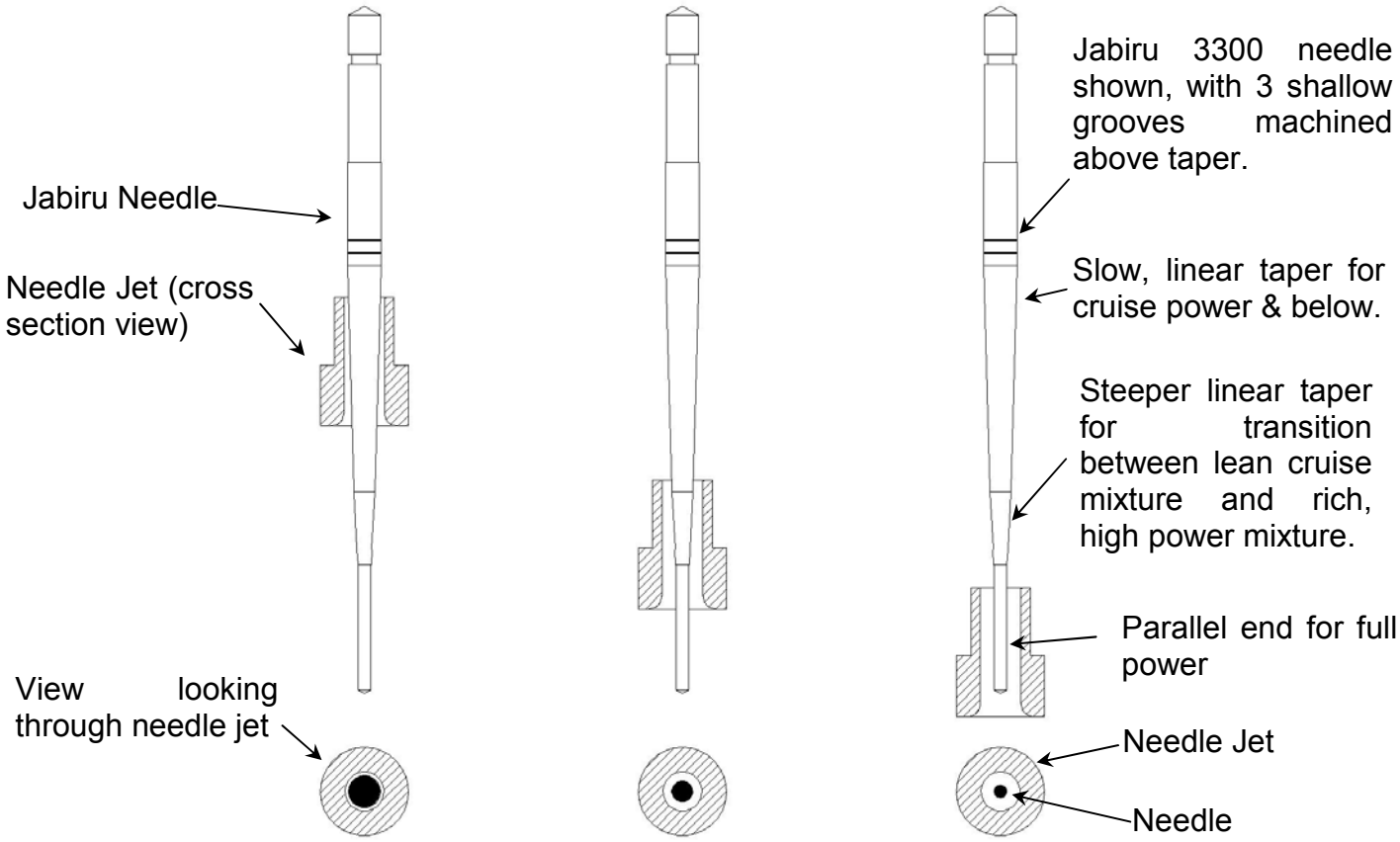

Figure 2. Needle Jet (Jabiru Needle)

- **Float Level:**

The float level affects the mixture through all air circuits, so lowering the float level will lean the mixture throughout the entire engine range, and similarly, raising the level will richen the mixture throughout the entire engine range. The float level setting works with the idle circuit to control the mixture at idle rpm. The idle circuit is always open, so changes to the idle jet and air passages will affect the mixture through the entire power range. Once above idle, the float level setting works with the needle/main jet circuit to control engine mixture.

With the economy tuning kit installed, The float level must be set so that the floats cut off fuel flow when they are level.

- **Idle Circuit Inlet**

As standard, the inlet aperture to the idle jet circuit is too small and does not flow enough air to work properly on Jabiru engines. To allow it to function as intended, the inlet aperture must be drilled out to 1.6mm diameter.

- **Air Density Compensation**

At higher altitudes where the air is thinner less fuel must be added to the intake charge to give the proper mixture, so while the effective air/fuel mixture remains the same, the amount of fuel being used is reduced. The altitude compensating carburettor uses an air density compensation system to maintain a constant mixture at different altitudes. This system does not vary the mixture during flight (such as leaning the mixture at cruise) – the mixture is controlled by the shape of the needle and the sizes of the jets.

The carburettor uses sense ports inside the carburettor inlet and a pressure sense tube to maintain a constant mixture. For the system to work properly, the ports inside the inlet must not be blocked (which can happen if bunched-up SCAT hose is attached directly to the carburettor inlet) and the sensor tube must be installed correctly as detailed in the engine installation manual.

4. Propeller:

The shape of the needles that have been developed for the 4 and 6 cylinder engines are tailored specifically for use with a propeller that meets the following requirements:

i) Minimum static RPM during ground run-up: 2800
ii) Maximum in-flight rpm between 3150 – 3300 rpm.

8 Cylinder propellers must meet the following requirements:

i) Minimum static RPM during ground run-up: 2400*
ii) Maximum in-flight rpm between 2950 – 3100 rpm.

*→ When using a coarse, fixed pitch propeller.

Using a propeller which has operating RPM's lower than those listed above with the standard Jabiru economy kit will result in a lean mixture and, in extreme cases, engine damage. While it is possible to adapt the mixture to suit a propeller which does not meet these requirements, the engine will be operating outside of it's preferred RPM range and it is very strongly recommended by Jabiru that the propeller be modified or replaced by one more appropriate.

In general, when using a Jabiru engine on a non-standard airframe or with a non-standard propeller, it is strongly recommended that the suitability of the new tuning be checked. Refer to the "Tuning Check" section below for details.

5. Engine Installation:

In installations where the engine is operating without cowls in very low ambient temperatures (less then 5°C or 41°F) the induction pipes for the engine are cooled to a very low temperature by airflow. This can lead to the air/fuel mixture condensing on the insides of the pipes, which reduces the concentration of fuel in the intake charge and leads to rough, lean running. This problem can be addressed by richening the fuel mixture (using larger needle & main jets) or by shrouding the induction pipes so that they are maintained at a warmer temperature by the engine's heat.

In general, all engines using the economy kit should be warmed in accordance with the aircraft's operating manuals before flight.

6. Tuning Check:

There are several methods to check the engine tuning. The best way is to use a portable Lambda Meter system to check the exhaust gasses to find the air/fuel ratio throughout the operating range. The table below gives appropriate target mixtures for the Jabiru engine:

Table 2.Target Lambda Probe Readings / Air/Fuel Ratios

Power Range	Lambda Probe Reading	Fuel / Air Mix
Idle	0.75 - 0.85	
Mid-Range / Cruise	0.9 – 1.05	14 : 1 – 15 : 1
Above 70% Power	No more than 0.8	11.5 : 1

If an exhaust probe system is not available, the mixture can be checked using an EGT gauge. The gauge must be installed correctly, with the temperature sender located 100mm from the face of the exhaust port. The following table shows appropriate EGT's for the Jabiru engine.

Table 3. Target EGT Readings

Power Range	EGT Reading
Mid-Range / Cruise	680 – 750°C (1256 – 1382°F)
Above 70% Power	640 – 680°C (1184 – 1256°F)

When running the engine on AVGAS, the colour of the spark plug insulator and the colour of the exhaust pipes can also provide an indication of mixture. An engine that is running well will have tan coloured spark plug insulators and an exhaust pipe that is between light tan and grey in colour. Both plug and exhaust colour are general indicators only and should only be used as a backup check on tuning to confirm the readings of the exhaust gas probe or EGT. Engines burning unleaded fuel will have darker plug and exhaust colours. It is generally not possible to judge the engine's tuning by plug or exhaust colour when using unleaded fuel.

7. Applicability:

The new configuration is in place in production engines from the serial numbers listed below:

2200 Models – S/No. 1883 on
3300 Models – S/No. 722 on
5100 Models – S/No. 24 on.

8. Installation:

Kits are available from Jabiru Aircraft which contain all of the parts required and come with comprehensive instructions.

It should be noted that after installing the kit, the “feel” of the engine may change, seeming slightly harsher or just different. This is due to the more efficient combustion, and providing the mixture and EGT’s check within the acceptable range there will be no problem with the engine. Depending on the idle mixture, the engine will be harder to start from cold without choke due to the leaner mixture. Generally, with the economy tuning kit fitted and working properly, choke will be needed every time the engine is started from cold.

9. Compliance:

While installation of the new tuning is entirely optional, it has the benefits of maintaining a cleaner combustion chamber (including rings and valve seats) in addition to reducing fuel consumption.