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SERVICE BULLETIN: JSB 018-2

Issue: 2

Date: 7th May 2009

Subject: Jabiru Engine Tuning

Issue	Reason for Issue	Revision Status
1	Original Issue	CANCELLED
2	New Information Added	CURRENT

Operators also note: ALL Issues of Jabiru Service Letter JSL 002 have been CANCELLED.

1 Applicability

All Jabiru Engines.

Note, all Jabiru Engines have been equipped with the economy tuning kit as standard equipment from the following engine serial numbers:

2200A – S/No. 1883 on
2200B – All Engines.
2200J – S/No. 754 - 775
3300A – S/No. 722 on
5100 – S/No. 24 on

Note: For aircraft in Light Sport Aircraft categories this Bulletin is equivalent to a Manufacturer's Safety Direction.

2 Background:

2.1 General:

In December 2004 Jabiru Aircraft released a tuning kit for the Bing Carburettor used on our engines. This kit provided accurate tuning of the intake mixture to suit the engine loads, allowing fuel consumption to be reduced.

The kit also produced a cleaner burn, slowing the formation of deposits in the combustion chamber which may have otherwise affected engine efficiency. Engines equipped with the tuning kit are also easier to tune to suit different airframe / propeller combinations. Power output is not affected.

This ability to accurately tune the mixtures resulted in settings which work well in a normal Jabiru airframe, while the engine is in good condition & is using the recommended propeller. However, operational experience has shown that the mixture is affected by leaks in the head-cylinder seal as well as by leaks in the induction system. Different airframe and propeller combinations also significantly alter the mixture by changing the way the propeller load is applied to the engine

The significance of these effects have not been well understood by some owners. In some cases, cylinder-to-head leaks have caused lean running, damaging exhaust valves & causing engine failures.

2.2 Jabiru Service Letter JSL 002

Jabiru Service Letter JSL 002 "Jabiru Engine Economy Tuning" was initially released in December 2004, then re-issued in March 2007. The initial issue provided information on the Economy Tuning Kit while the second issue gave more detailed engine tuning information and revised the jet sizes used as standard in the kit.

Continued operational monitoring has shown that awareness of the Service Letter is low and that the information contained was not reaching owners. Accordingly Service Letter JSL 002 has been cancelled and this Service Bulletin issued in it's place.

2.3 Jabiru Service Bulletin JSB 018

Issue 1 of this Bulletin was released in October 2007. Issue 2 has been prepared to address typographical errors in Issue 1. Some descriptions and details within the Bulletin have also been updated to reflect the current situation. Altered passages are marked with a vertical bar on the left margin. Note that the requirements of this Bulletin have not altered – an aircraft which was modified to comply with Issue 1 of this Bulletin will not require further work to comply with Issue 2.

This Service Bulletin provides information to allow operators to better assess their carburetor settings. This information is general and so is applicable to all Jabiru Engines, including those operating without the Economy Tuning Kit – though the jet size notes below will not be applicable unless the economy needle for the engine is being used.

In October 2007 Jabiru Aircraft revised the standard parts used in the 2200 economy kit to make the system more tolerant of induction system effects. No changes were made to the 3300 engine tuning at that time or in this bulletin. Recommended allowances are retained for the jet sizes used on all engines.

2.4 Engine Serial Number Ranges & Standard Jet Sizes

Table 1 - Engine Serial Number Ranges & Standard Jet Sizes

Engine Model	Serial No. Range	Idle Jet	Needle Jet	Main Jet	Needle Part No.
2200A	32mm Carburetor 01 – 698	45	268	235	Bing. 2nd from bottom position
	40mm Carburetor 699 - 1883	35	276	250	Bing. 2nd from bottom position
	1884 - 2161	45	276	220	4A138A0D-2
	2162 – 2849	45	280	225	4A138A0D-2
	2850 – onwards	35	290	245	4A138A0D-3
2200B	01 – 02	35	276	250	Bing. 2nd from bottom position
	03 – 05	45	276	220	4A138A0D-2
	06 – 88	45	280	225	4A138A0D-2
	89 - onwards	35	290	245	4A138A0D-3
3300A	01 – 721	35	280	280	Bing. 2nd from bottom position
	722 – 870	45	278	250	4A139A0D-2
	871 – onwards	35	285	255	4A139A0D-2
5100	01 – 23	35	276	275	Bing. 3rd from bottom position
	24 – onwards	35	290	250	4A140A0D-3

Notes:

1. These jets were fitted when the engines were manufactured. If the engine has been modified or overhauled since carburetor settings may vary from those listed.
2. 2200 Needle P/No. 4A138A0D-3 differs from earlier versions of the needle (P/No. 4A138A0D-1 and 4A138A0D-2) by having a slightly larger diameter at the top of the needle. This gives a smoother idle when needle jet sizes larger than #285 are used.
3. “Standard” economy tuning is not available for engines using the 32mm carburetor.

3 Carburettor Operation:

3.1 Jets & Needle:

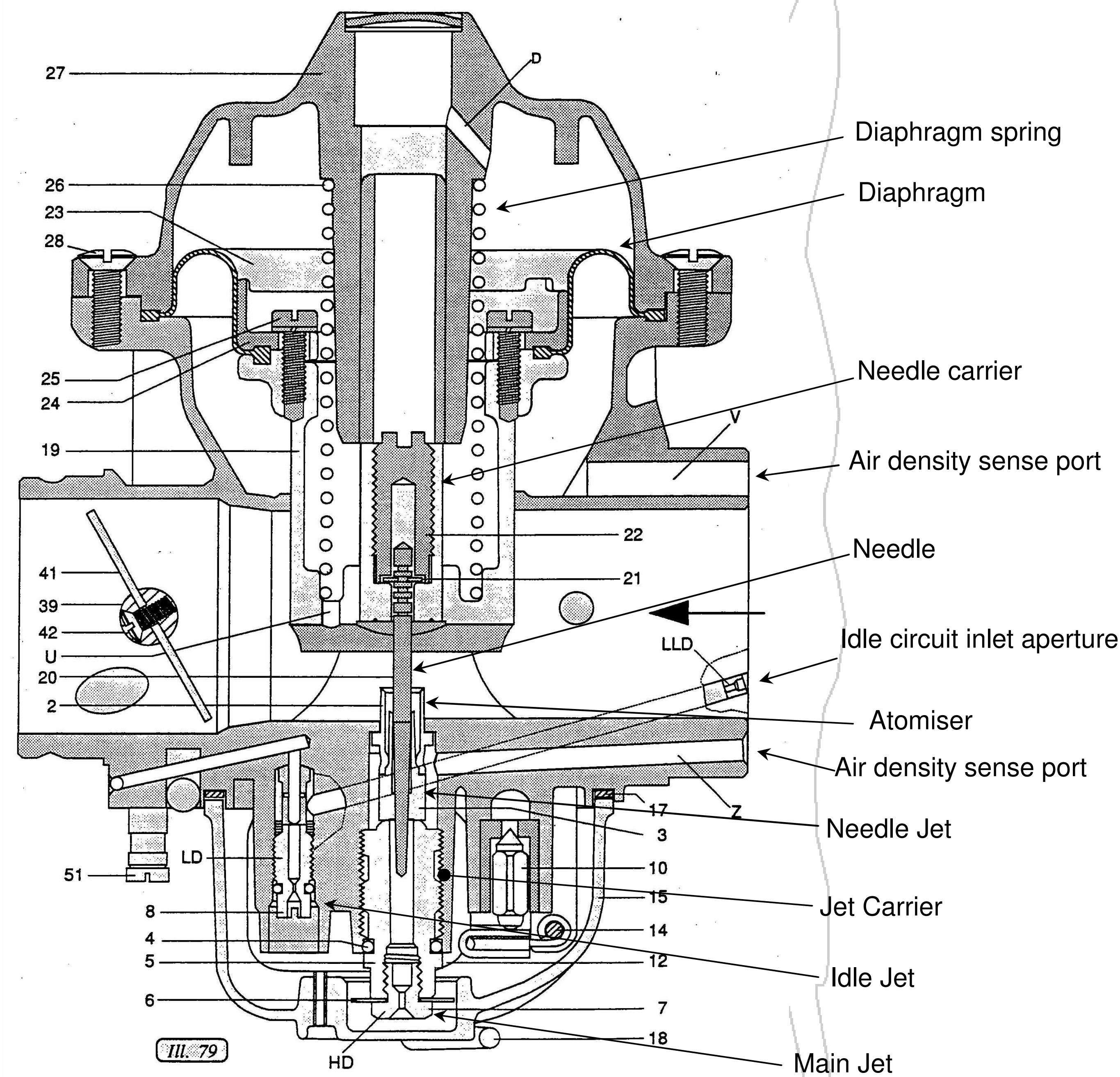

Figure 1. Carburettor Cut Away Drawing

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 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 consists of idle, needle and main jets, and a needle to suit. Table 2 shows the range of jet sizes available along with the standard parts supplied with the kit and fitted to new engines (unless requested otherwise).

Table 2 – Kit Jet Sizes & Needle Part Numbers

Item:	2200 Engine	3300 Engine	5100 Engine
Economy Tuning Kit P/No. ➔	4A172A0N	4A171A0N	4A173A0N
Idle Jet ➔	# 35 or # 45 (# 35 Standard)	# 35	# 35
Needle Jet ➔	# 280 to # 295 (#290 Standard)	# 285 to # 295 (# 285 Standard)	# 290 to # 295 (# 290 Standard)
Main Jet ➔	# 220 to #250 (# 245 Standard	# 250 to # 265 (# 255 Standard)	# 250 to # 255 (# 250 Standard)
Needle ➔	Jabiru P/No. 4A131A0D-3 (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 2 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 leaner 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 2800 – 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.

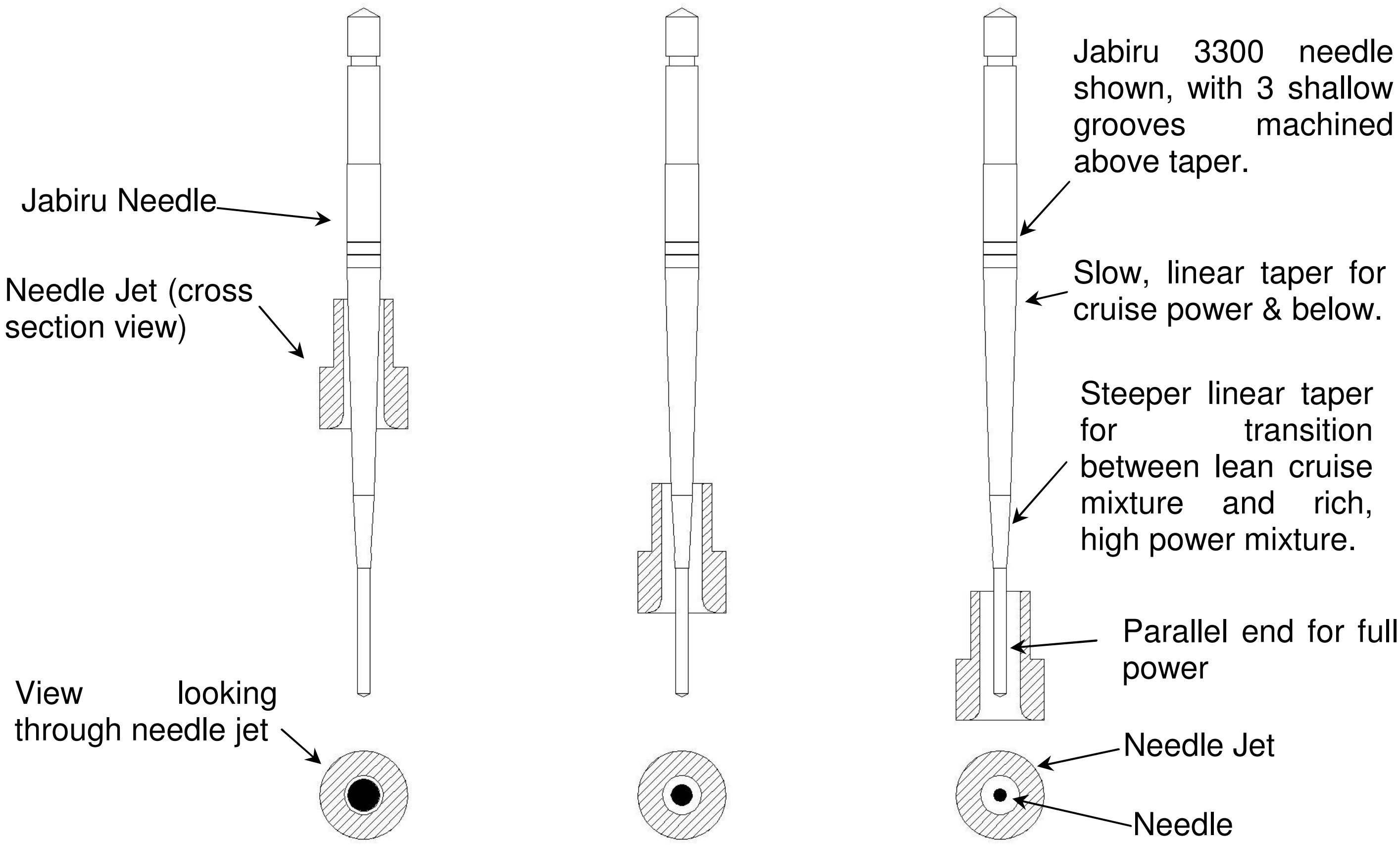

Figure 2. Needle Jet (Jabiru Needle)

3.2 General:

The tuning information contained within this bulletin assumes that the engine is installed in accordance with the appropriate Jabiru Engine Installation Manual – which include details on the carburetor float bowl vent line installation, cobra head installation, SCAT hose and airbox details. All of which can adversely affect tuning.

3.3 Float Level:

The float level affects the mixture through all air circuits. Lowering the float level will lean the mixture throughout the entire engine range, and 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.

3.4 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.

3.5 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[1]
ii. Maximum in-flight rpm between 3150 – 3300 rpm[2].

8 Cylinder propellers must meet the following requirements:

i. Minimum static RPM during ground run-up: 2400[3, 4]
ii. Maximum in-flight rpm between 2950 – 3100 rpm[5].

Using a propeller which has operating RPM's other than those listed above with the standard Jabiru economy kit may 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 strongly recommended by Jabiru that the propeller be modified or replaced by one more appropriate.

Example effects of different propeller and airframe combinations is outlined in Section 6.4 below. These effects must also be considered if a variable propeller is to be used.

When using a Jabiru engine on a non-Jabiru airframe or with a non-Jabiru propeller, it is strongly recommended that the tuning be checked. Refer to Section 6 below for details.

5 Engine Installation:

In installations where the engine is operating without cowls in very low ambient temperatures (less then 5℃ or 41℉) 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

[1] Test carried out using AVGAS fuel at sea level with 25℃ ambient temperature
[2] Test carried out using AVGAS fuel at sea level with 25℃ ambient temperature
[3] Test carried out using AVGAS fuel at sea level with 25℃ ambient temperature
[4] When using a coarse, fixed pitch propeller suited to a "slippery" airframe such as a Van's RV-6.
[5] Test carried out using AVGAS fuel at sea level with 25℃ ambient temperature

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 should be warmed in accordance with the aircraft's operating manuals before flight.

5.1 Engine Condition

Any leaks in the induction system between the carburetor and the cylinders will lean the mixture and can cause valve or piston damage. In addition, if the head-to-cylinder seal degrades this can also result in lean running.

Refer to the current Jabiru Engine manuals for servicing requirements. At the time of writing, the manuals require head bolt tension to be checked after the first 10 hours of running since the head has been fitted, then at 50 hours in service, and at an interval of 50 hours thereafter. Maintaining the correct tension in these bolts will ensure the condition of the head-cylinder seal.

In addition, during scheduled maintenance care should be taken to inspect the induction and exhaust tracts for degrading seals or signs of leaks.

6 Tuning Check:

6.1 Lambda Ratios

A portable Lambda Meter system can be used 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 3.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 – 0.99	14 : 1 – 14.7 : 1
Above 70% Power	No more than 0.8	11.5 : 1

Note that different types of Lambda sensors have different characteristics. Some are only accurate over very narrow mixture ranges and most do not work properly when used with leaded fuels (such as AVGAS). Lambda readings must be confirmed by other tuning tell-tales such as spark plug colour and fuel consumption.

6.2 EGT Gauge

EGT gauges can be used to assess the engine's operating mixture. Preferred target EGT values are given below.

Table 4. Allowable EGT Range

Power Range	EGT Allowance	Preferred Target EGT
Mid-Range / Cruise	680 – 720℃ (1256 – 1328℉)	680℃ 1256℉
Above 70% Power	640 – 680℃ (1184 – 1256℉)	640℃ 1184℉

Note that the gauge must be installed correctly, with the temperature sender located 120mm from the face of the exhaust port.

6.3 Spark Plugs

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 dark 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 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 generally 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.

Figure 3. Spark Plug Insulator Colour

6.4 Propeller / Airframe Comparison:

Figure 4 is a graph which shows three curves for Lambda Ratio vs RPM. The curve for the std J160-C is quite flat up to 2850 RPM, then quickly changes to a full-rich mixture for higher power settings. The other two curves show two flights of a different model Jabiru – a UL 500 ("Calypso" in some markets). The UL uses the same engine as the J160-C, but has a larger wingspan and, in this particular aircraft, a propeller with a much higher pitch. The larger wingspan gives higher drag at high speed, while the larger propeller increases overall engine load.

The "UL 500 1" curve shows the Lambda Ratios for the standard economy kit, while the "UL 500 2" curve is for the same aircraft when fitted with larger jets. The effect of the different propeller can be seen as the engine is under higher load at lower RPM – in this case resulting in a leaner mixture. The airframe difference appears at higher speeds (cruise speed & above) where the mixture enters the transfer region from lean to rich at a lower RPM and the mixture at full power is not as rich as on the standard aircraft. The changes shown changed fuel consumption at cruise from 13L/hr to 15L/hr.

Note that while this example shows higher propeller loads to give leaner running this is not always the case. The combined effect of propeller, airframe and installation combined affect the engine tuning – so new installations and designs must be tested individually to determine appropriate mixture settings.

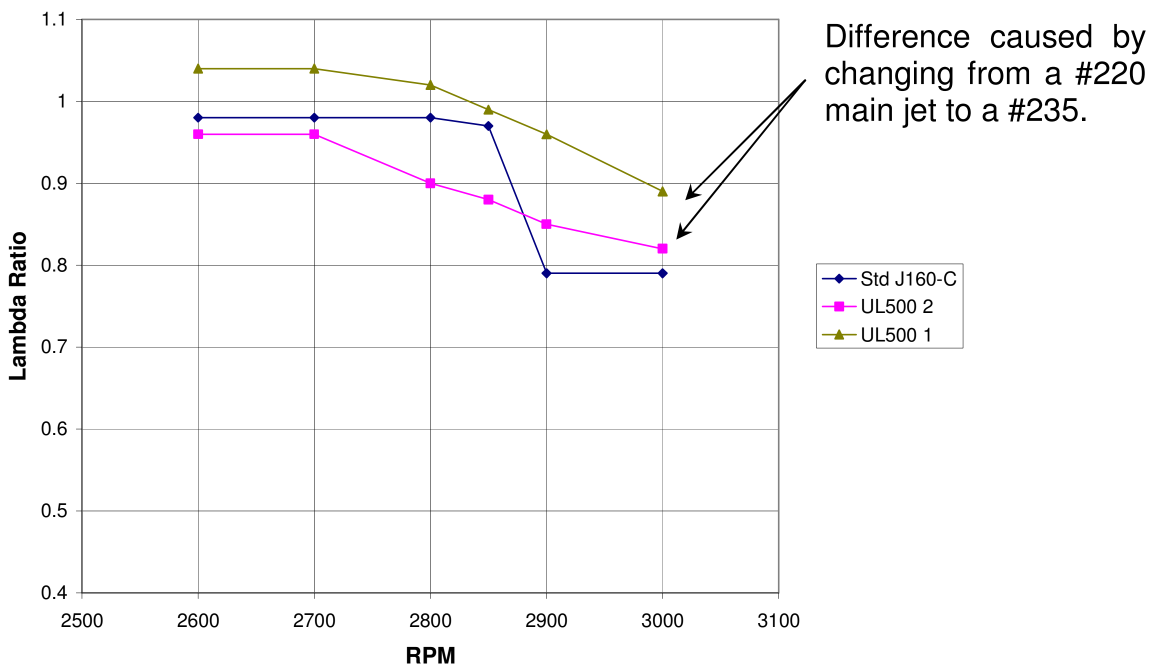

Figure 4. Lambda Ratio Comparison

6.5 General Notes

- The following assume a fixed-pitch propeller & conventional airframe are used. Variable propellers and variable drag (such as found with a retractable undercarriage) are likely to significantly vary results.
- During ground run-ups at 2000 RPM the engine mixture will normally be the same as at 2000 RPM in the air.

- Full power run-ups on the ground give engine mixture “similar” to full power in the air.

6.5.1 Using spark plug colours to check tuning:

- After a long descent at low power settings the spark plug colours may show a lean mixture. This is normal & not indicative of engine mixture in powered flight.
- Always minimize the running time between running the engine at the mixture point you want to check and the time when you see the spark plugs (i.e. avoid prolonged taxiing).

6.5.2 Solid Lifter Engines

Operational experience has shown that engines which have solid valve lifters can require slightly different tuning than engines with hydraulic valve lifters. The following table shows the jet sizes which normally work best in these engines. Operators must confirm the suitability of these jet sizes in their application.

Table 5 – Solid Lifter Engine Jet Recommendations

Engine Model	Idle Jet	Needle Jet	Main Jet	Needle Part No.
2200	45	280 282	225 235	4A138A0D-3
3300	45 35	285	255	4A139A0D-2

7 Fuel burn

- Consumption for the 4 cylinder engine approximately 15-16 Litres per hour at 2850 RPM
- Consumption for the 6 cylinder engine approximately 23-25 Litres per hour at 2850 RPM

Note: Figures for engines installed in Jabiru airframes, with Jabiru propellers

- Consumption for the 8 cylinder engine is approximately 30-31 Litres per hour when fitted in a Van’s RV-6, with a Sensenich propeller, cruising at 2600 rpm.

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 may 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 – Implementation Schedule:

9.1 Factory-Built Jabiru Aircraft

For any factory-built Jabiru Aircraft using the economy needle upgrading the tuning to current specifications (see Table 2) is mandatory. For older models which do not have the economy needle fitted installation of the tuning kit remains optional.

This work is to be carried out at the aircraft's next scheduled maintenance.

9.2 2200J and 2200B Engines

For 2200J and 2200B Engines using the economy needle when fitted in factory-built aircraft other than Jabiru Aircraft.

Due to the range of airframe and propeller variations it is impossible to mandate the use of particular jet sizes or carburetor settings. Manufacturers must evaluate the settings used on their aircraft against the information contained in this bulletin and make changes as required.

Airframe manufacturers must evaluate their settings and issue service information to operators as they see appropriate.

9.3 2200 Engines Fitted to Light Sport Aircraft.

Due to the range of airframe and propeller variations amongst LS Aircraft it is impossible to mandate the use of particular jet sizes or carburetor settings. Manufacturers and operators must evaluate the settings used on their aircraft against the information contained in this bulletin and make changes as required. Manufacturers must issue service information to their operators as they see appropriate.

9.4 Other Aircraft

Installation of the tuning kit is optional and must be based on individual manufacturer or operator's assessments.

For engines equipped with the economy needle the installation of the larger jet sizes detailed above is optional – subject to airframe, installation and propeller variations. However, Jabiru Aircraft recommend operators of these aircraft ensure they have assessed their tuning configuration and made any necessary changes.

10 Airworthiness Note:

Where required, maintenance work called for by this Bulletin must be carried out by authorised personnel. For the aircraft detailed herein this means the owner, an RA-Aus Level 2 holder or a Licensed Aircraft Maintenance Engineer (LAME) – as appropriate to the aircraft's registration and use (Private or Air Work operations).

On completion of the work, the authorised person must note the completion of the actions required by this bulletin in the aircraft's maintenance logbook. This note should note the jet sizes fitted to the aircraft, show if any parts were replaced, indicate the date of the work and the identity (including licence number where appropriate) of the person carrying out the work.