



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Western Pacific Region

AIRFRAME AND ENGINE EXAMINATION (Rev A)

WPR17LA148

Accident Date: July 10, 2017
Exam Date: July 26, 2017

This document contains 36 embedded images

A. ACCIDENT

Location: New River, Arizona
Date: July 10, 2017
Aircraft: Arion Lightning, N273DB, Serial # 171
NTSB IIC: Michael Huhn

B. EXAMINATION PARTICIPANTS:

Michael Huhn
Air Safety Investigator
NTSB
Western Pacific Region

Scott Hutson
FAA Airworthiness Inspector
Scottsdale, AZ

C. SUMMARY

On July 10, 2017, about 0745 Mountain standard time, an experimental light sport Arion Lightning airplane, N273DB, was substantially damaged in a forced off-airport landing near New River, Arizona. The builder/owner/private pilot was not injured, and reported that the engine sustained a substantial loss of power when he attempted a cruise-climb about 10 minutes after takeoff.

An FAA inspector conducted a partial examination of the airplane on-scene a few hours after the accident. The airplane was recovered to a secure facility later that day. Examination of the airframe and engine was conducted at the secure facility by the NTSB IIC and the same FAA inspector who responded to the accident on July 10, 2017. No evidence of any preimpact mechanical malfunction was noted during the examination.

D. EXAMINATION DETAILS

1.0 General

The wings had been unbolted and removed for recovery, but otherwise the aircraft was not disassembled or cut for the recovery. The fuselage remained essentially intact, and the cockpit was not compromised. The left fixed main landing gear remained intact, but the right strut was partially displaced, and wheel and tire assembly was liberated from the strut. The nose gear assembly and mount was crumpled, and folded aft and up. The engine remained attached to its mount, and the mount to the firewall, but several of the engine mount tubes were bent, buckled, or fractured. The 2-blade composite propeller remained attached to the engine, and both blades were fracture-separated from the hub. There was no indication of any fire or thermal damage to the airframe or engine.

2.0 Engine

The engine was a Jabiru model 3300A, serial number 33A 2708. This is a 6 cylinder, horizontally opposed, normally aspirated, air-cooled engine. The engine showed no external indications of internal or thermal distress, or impact damage. All components, except for the propeller, spinner, and engine mounts, were essentially undamaged. All through-bolts and through-bolt nuts were checked for security, and no anomalies were observed.

The exhaust system was new in appearance, and all joints were secure. The muffler was removed, tilted and rotated, shaken, and 'rapped', and no evidence of any internal corrosion, deterioration, or other internal mechanical failures was observed.



Figure 1 - Engine Left Side



Figure 2 - Engine Front Left

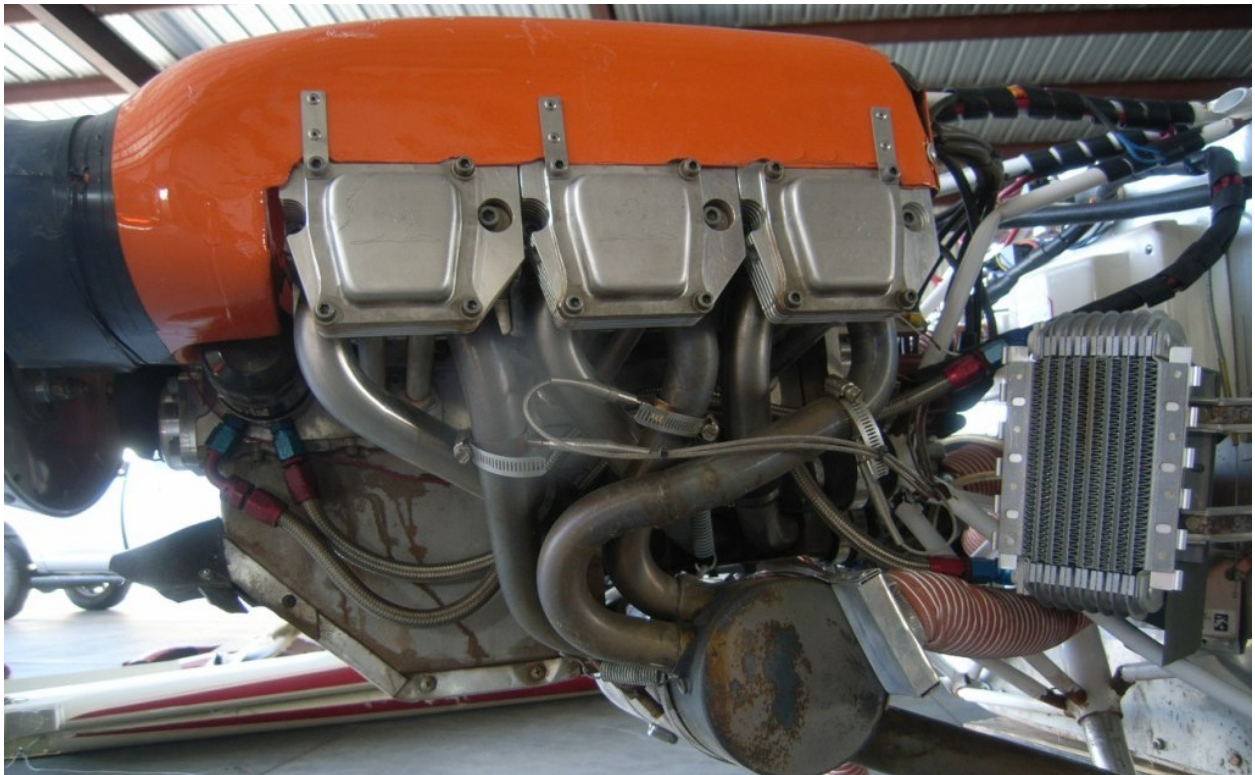


Figure 3 - Engine Left Lower Side



Figure 4 - Engine Front Right



Figure 5 - Engine Lower Right

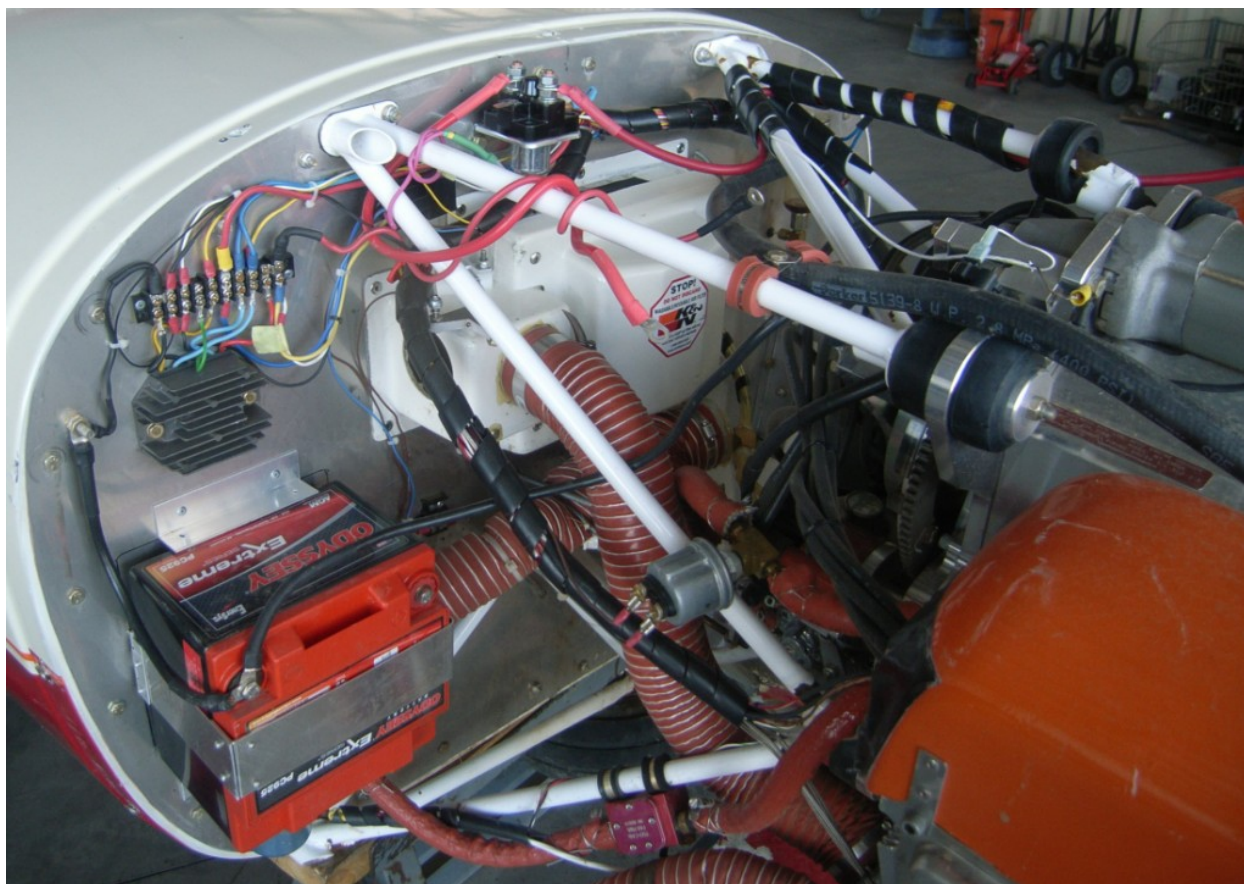


Figure 6 - Firewall

3.0 Fuel System

The builder/pilot/owner had provided a hand-drawn fuel system schematic to the investigation, and the airplane configuration matched the schematic. No lines, fittings, or components of the fuel system exhibited any signs of fuel leakage. The system was not tested for integrity.

Each wing was equipped with an integral fuel tank, each with a pilot-reported capacity of 20 gallons. The fuel tanks were intact and securely capped, and the FAA inspector who responded to the accident had confirmed the presence of significant fuel in each tank at the accident site. While at the accident site, the left and right seat bottoms were removed to access some fuel lines and the two transparent, in-line fuel filters (one per tank). Each tank was plumbed to an in-line filter in the fuselage, and both filters were observed to contain fuel. The FAA inspector reported that the fuel in the tanks and filters was clean. The carburetor bowl was removed and contained very little (estimated ½ oz) fuel. The inspector did not observe any fuel screens in the fuel tanks.

According to the Jabiru Installation Manual (IM), "The fuel tank must be fitted with an outlet strainer of between 8 and 16 mesh per inch, with a minimum total mesh area of 5 cm². Ensure the fuel tank is properly vented." The pilot reported that a mesh fuel screen was installed in each tank outlet.

Each of the lines from the two in-line filters was plumbed to its own ON-OFF valve in the center cockpit console, and then the two lines were joined by a "T" to a single line. That single line ran to an electric, cockpit switch-controlled pump on the aft (cockpit) side of the firewall, and then serially in sequence to:

- Gascolator
- Fuel flow transmitter
- Engine-mounted, engine-driven fuel pump (EDP)
- Fuel pressure sensor/transmitter
- Carburetor

The fuel lines from the tanks to the gascolator were black, flexible, cloth-reinforced material, with an inside diameter of ¼ inch, secured by worm-type clamps.

The two in-line fuel filters were transparent, and no contamination was visible in either. Both were securely attached to their respective lines, oriented in the proper flow direction.

The Jabiru IM stated that "A Fuel filter capable of preventing the passage of particles larger than 0.1mm (100um) must be installed between the fuel tank outlet and the fuel pump. The filter must be present in the system for the fuel flow test. The size of the filter should give consideration to allow adequate flow with a used filter." No manufacturer identification or part numbers were observed on the installed filters, and their filtration limits were not determined.



Figure 7 - Left In-Line Fuel Filter

The electric fuel pump was tested and operated normally. The pump also allowed liquid to flow freely through it when it was not operating. The flow rate (power ON or OFF) was not measured.



Figure 8 - Setup to Test Electric Fuel Pump

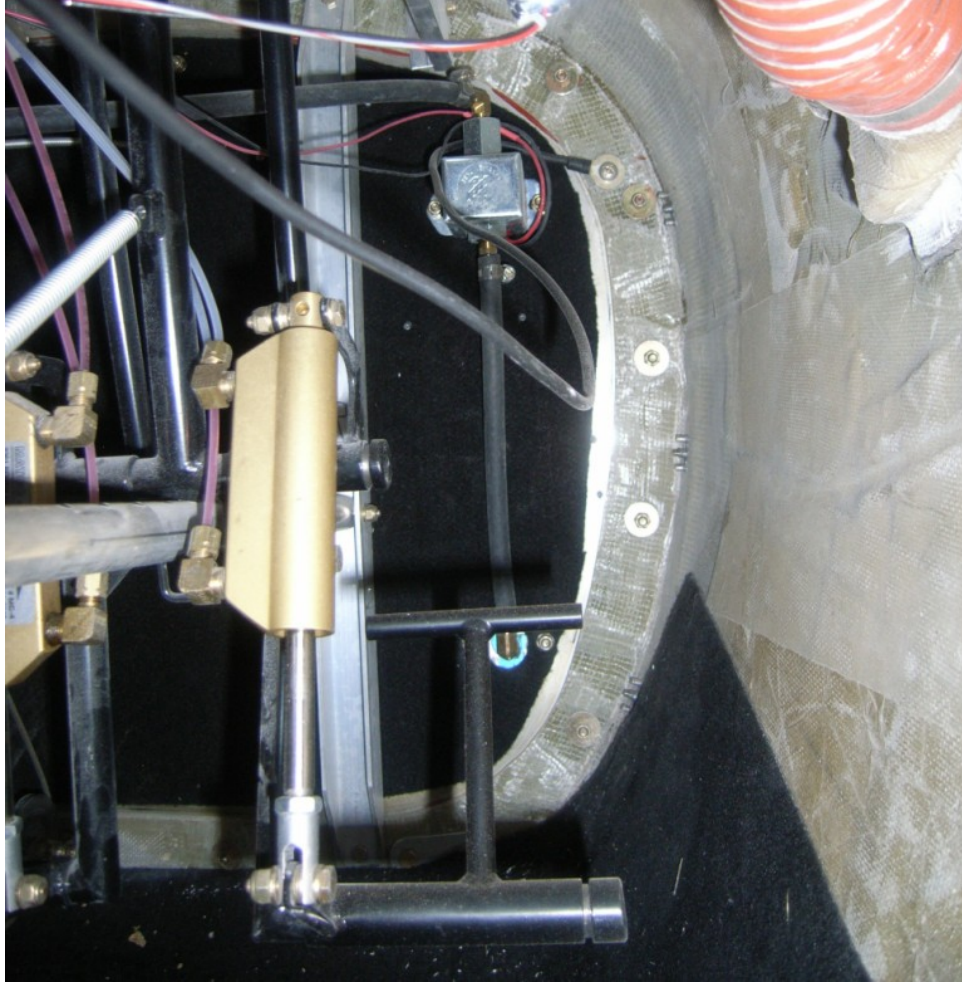


Figure 9 - Aft Face of Firewall (with electric fuel pump)

The gascolator allowed liquid to flow through it. It was removed and opened, and the chamber and screen were both observed to be pristine, with no evidence of contamination or corrosion.

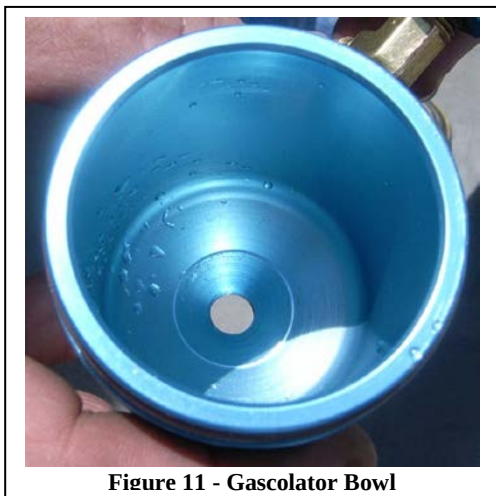


Figure 11 - Gascolator Bowl



Figure 10 - Gascolator Screen

The Jabiru IM stated that "Fuel lines are nominally 6mm [0.236 inches] bore." The IDs of all fuel lines were not measured, but the ID of the gascolator fittings was 5/32" (0.156 inches).

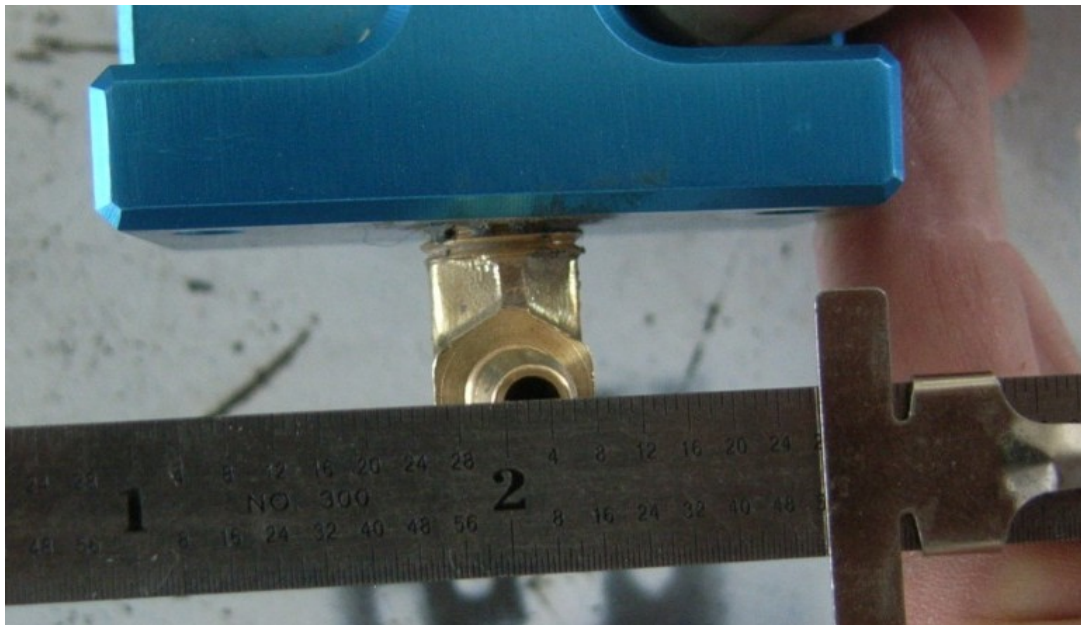


Figure 12 - Gascolator Outlet ID

All fuel lines forward of the firewall were shrouded in fire-resistant sheathing. The Electronics International FT-60 fuel flow transmitter was found to allow liquid to pass through it, but the flow capability was not measured or otherwise quantified. According to the Jabiru Installation Manual (IM), "Where a Fuel Flow Meter is to be installed to the aircraft Jabiru Aircraft recommend that the flow transducer is not installed on the engine side of the firewall. Most transducers are made of either plastic or light aluminium and are not fire resistant. Regulations and common sense both require that every part of the fuel system on the engine side of the firewall must be fire resistant."



Figure 13 - FT60 Fuel Flow Transmitter

The EDP bore no part number, but based information from the Jabiru Overhaul Manual, this was a "Type 1" pump. The EDP was disconnected and removed from the engine. There was a paper gasket and a nylon/plastic spacer between the pump and the engine case; the gasket abutted the EDP, and the spacer abutted the engine case.

The pump was a rocker/diaphragm type, driven by a pushrod that was actuated by a cam on the crankshaft. The pump rocker was undamaged, well-lubricated, and free to pivot. The pushrod was free to translate and rotate in its bore, was well lubricated, straight, with no visible scoring or damage. The crankshaft cam for the EDP pushrod was well lubricated, with no visible scoring or damage. The EDP was set aside for additional examination and testing.

The pushrod protruded from the case throughout its cam-driven actuation cycle. The following dimensions were noted:

Parameter	Measuring Device	Measured Value (in)	Calculated Value (in)
Pushrod minimum protrusion from case	6" scale	7/32	0.218
Pushrod maximum protrusion from case	6" scale	5/16	0.3125
Spacer thickness	6" scale	11/64	0.171
Pushrod length	6" scale	2 - 7/8	2.875
Pump rocker travel (manual actuation)	Visual estimate	~1/8	N/A
Space between EDP rocker and outer face of gasket (rocker below/depressed from gasket)	Feeler gauge	0.005	0.005
Pump rocker pre-set depression (installed, pushrod actuation)	Calculated	N/A	0.042
Pump rocker travel (installed, pushrod actuation)	Calculated	N/A	0.0945

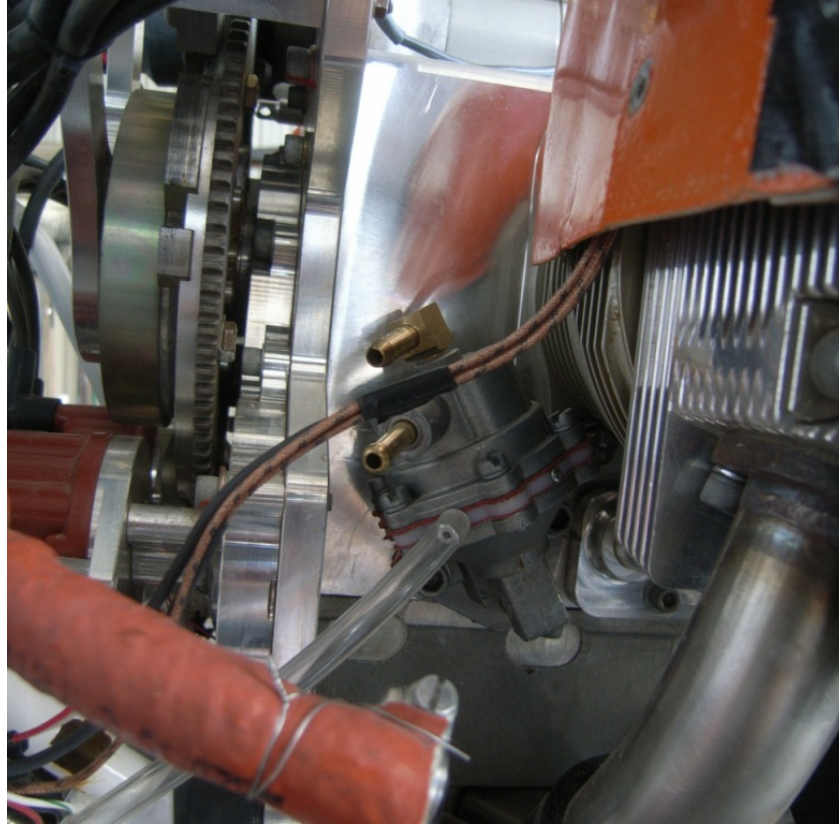


Figure 14 – EDP (In situ)

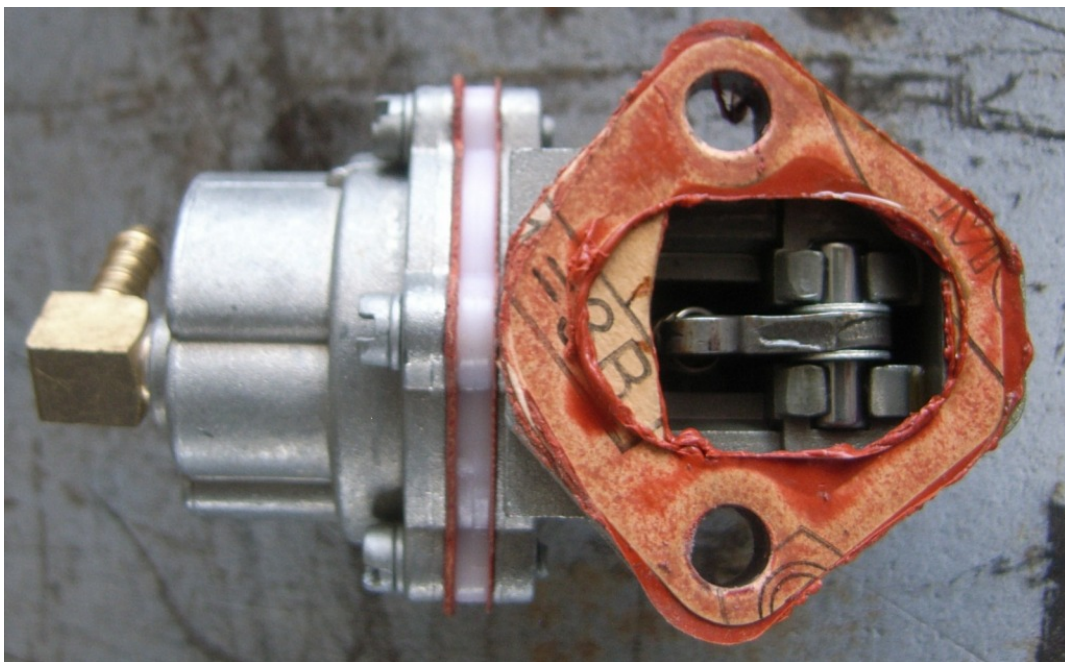


Figure 15 - EDP Removed (rocker visible)

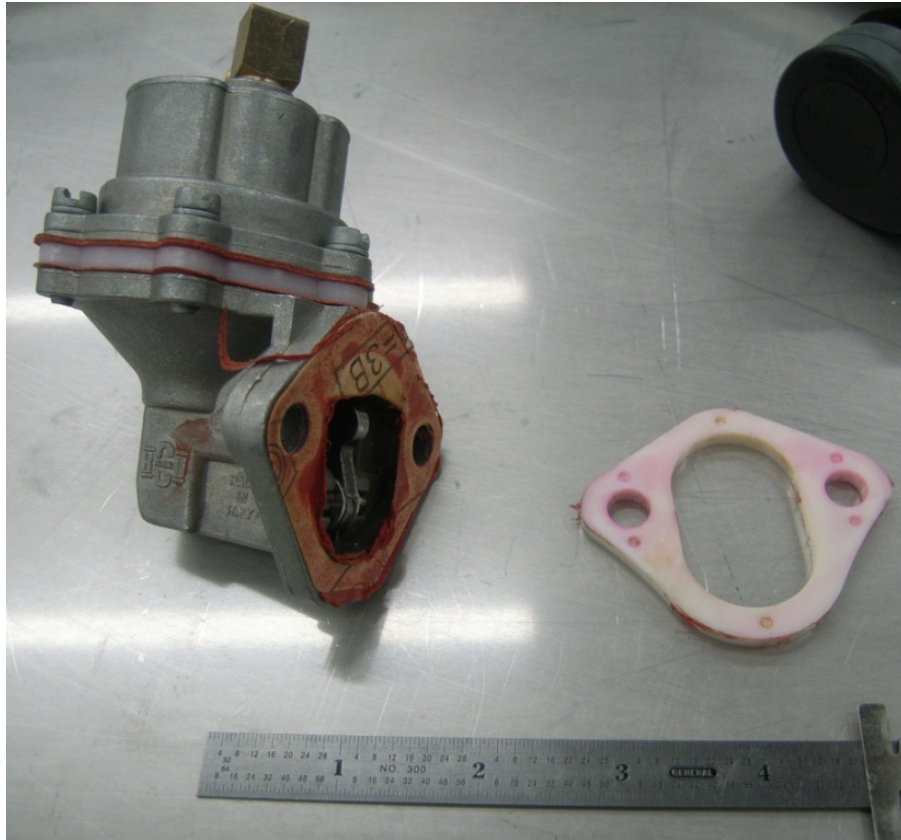


Figure 16 - EDP with Gasket and Spacer

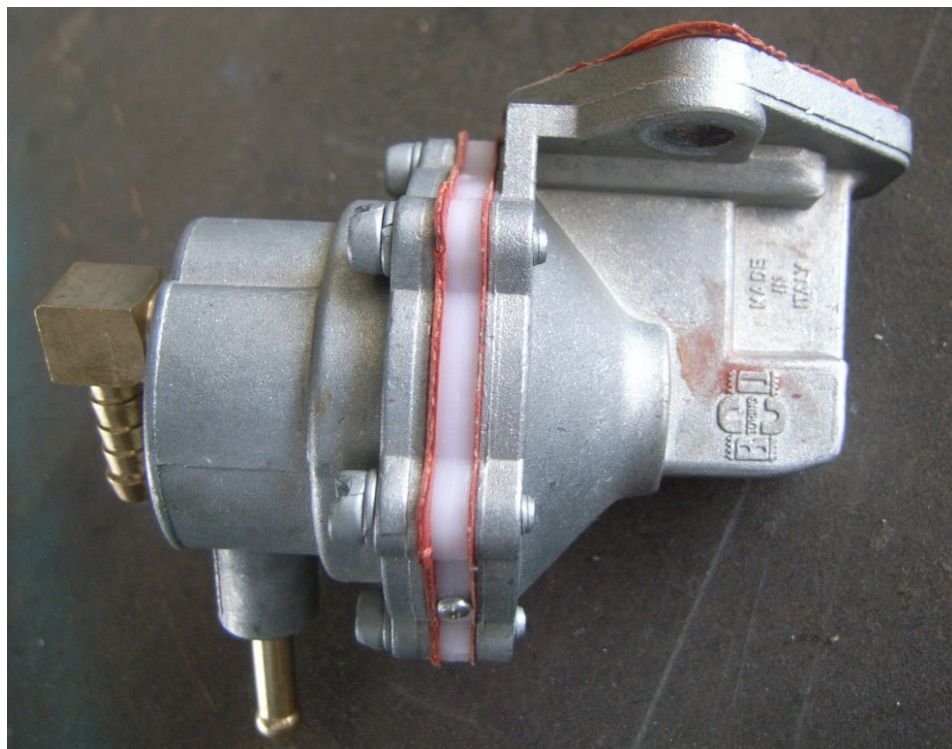


Figure 17 - EDP

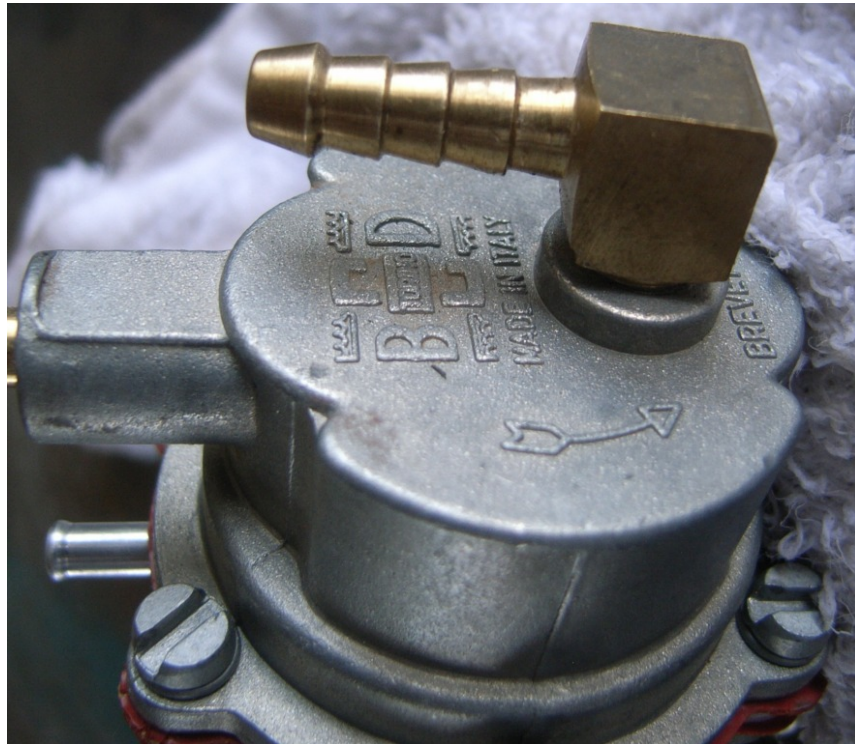


Figure 18 - EDP with Stamped Case Top



Figure 20 - EDP Pushrod End 1



Figure 19 - EDP Pushrod End 2

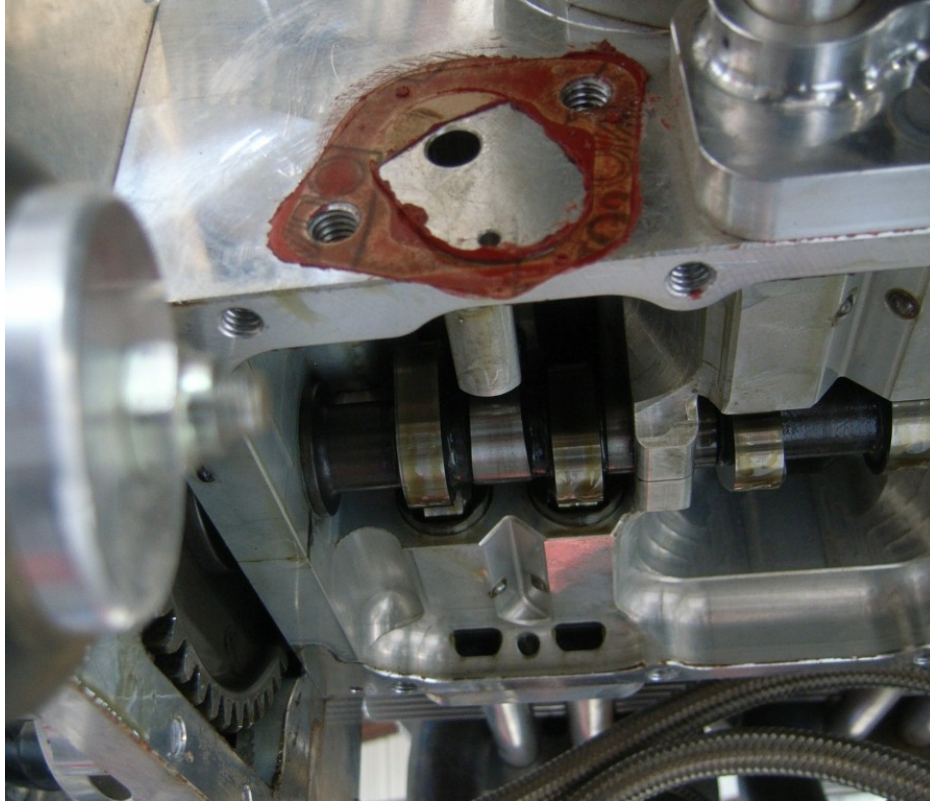


Figure 21 - EDP Mount Pad and Pushrod Cam on Crankshaft



Figure 22 - EDP Pushrod Cam on Crankshaft

The EIS LPS-02 fuel pressure sensor/transmitter was installed on a line "T," and therefore could not interfere with fuel flow; the device was not removed, examined, or tested.

The Jabiru IM stated that a Bing constant-depression type 90/94 carburetor was to be used. The carburetor was a Bing model, and bore an engraved "41559" or "41SS9," plus a stamped "94/40/148." The IM stated that "This carburettor has a minimum delivery pressure of 5 kPa (0.75 Psi) and a maximum pressure of 20 kPa (3 psi). To confirm that the fuel system is capable of delivering this pressure a fuel flow test must be performed." The investigation was unable to determine the fuel system delivery pressure capability. The carburetor was set aside for additional examination and testing.

The Jabiru IM contained a section regarding the carburetor Balance tube, which stated:

The Bing carburettor has a Balance tube (also known as a "sense tube") which connects the carburettor to the air box. The tube runs from a nipple on the carburettor to the airspace in the air box on the "clean" side of the air filter. This tube is part of a system or ports which "tells" the carburettor how hard the engine is working and controls how the carburettor varies the fuel / air mixture delivered to the engine. Tuning issues and poor running will result if this tube is blocked or connected to the wrong spot. ... Note that the balance tube must not be connected to the air box in a location where the air is moving fast – rapid flows produces pressure changes and boundary layer effects which mean the balance tube gives the carburettor "bad" information, which can cause poor mixture control and running issues.

The balance tube was not installed in accordance with the IM. Instead, an aftermarket cockpit control device (labeled "Mixture"), and its associated plumbing, was connected to the carburetor and cockpit. The device was known as a "HACman" (for high altitude compensation-manual). The plumbing consisted of several sections of clear plastic flexible lines arbitrarily designated as A through D for this investigation and discussion.

- Line A was routed from a port on the lower right front of the carburetor (adjacent to the bowl-body juncture) to the bottom (90°) port on the HACman. This carburetor port could not be definitively associated with a port or nipple in the Jabiru IM (Fig 23). This line was comprised of two sections of tubing joined by a plastic connector located about 12" from the carburetor end. Overall length of the two sections was about 49".
- Line B was routed from a carburetor port just above and aft of the choke linkage pivot point on the carburetor body to one in-line end of a brass and plastic T fitting. This carburetor port appears to be the "balance tube nipple" depicted in the Jabiru IM (Fig 23). Line B was about 10" long.
- Line C was routed from the long leg of the T to the air filter airbox sense port. Line C was about 3" long.
- Line D was routed from the other in-line end of the T to the in-line end of the HACman device. Line D was about 35" long.

Lines A and B were secured on their carburetor ports by plastic tie-wraps. None of the other line ends were secured on their attach points by any external hardware.

The HACman device was labeled (by the device manufacturer) as a "mixture" control. This control was a Vernier-type bleed adjustment intended to manually regulate the pressure in the carburetor float bowl, and was advertised to provide better performance and reduced fuel burn.

The Jabiru North America representative stated that Jabiru was aware of these HACman devices, and they reportedly smoothed engine operation when operating at altitudes above 6,000 to 8,000 feet, where the carburetor tends to run slightly rich. The representative also reported that at lower altitudes, improper setting (in the lean direction) could result in a fuel/air mixture that would not support engine operation.

The pilot stated that the HACMan/mixture was full rich during the flight. Its was not sufficiently documented to determine its exact post-accident position/setting.

The HACman port (one end of Line C) that was installed on the "clean" side of the air filter box did not appear to be mounted in accordance with the IM; while the IM recommended a location that was in slow-moving air, the actual port was installed adjacent to the filter exit, in a region that would likely be relatively fast-moving airflow. (Figs 24 & 31)

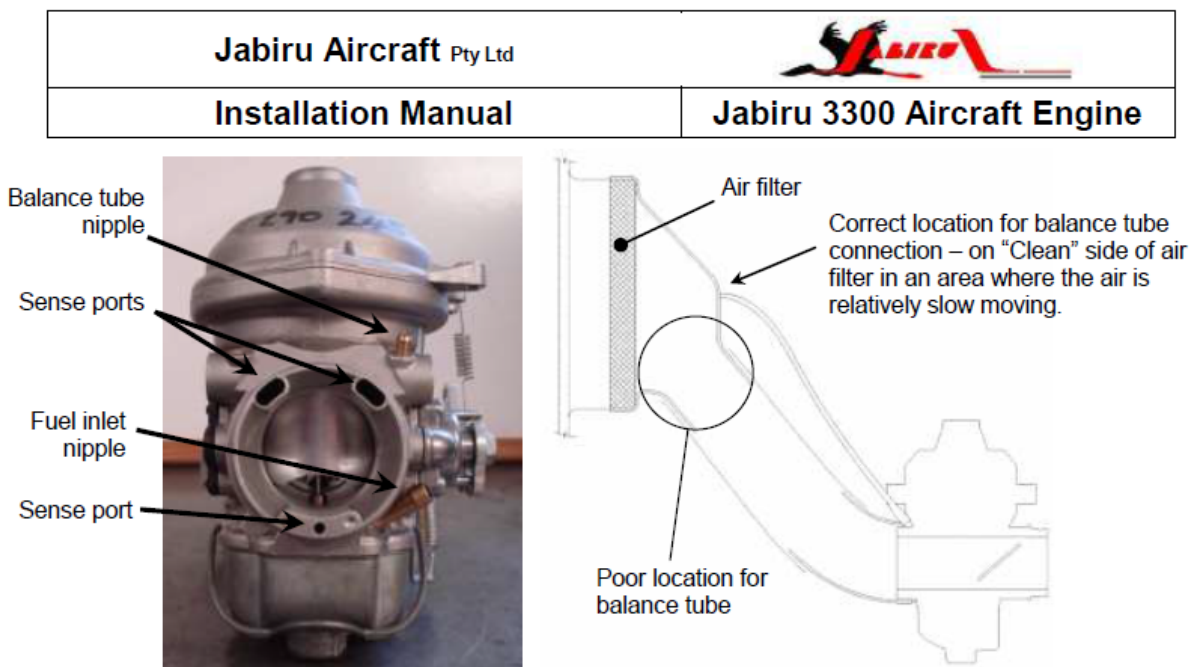


Figure 23 - IM Excerpt re Balance Tube Port Location

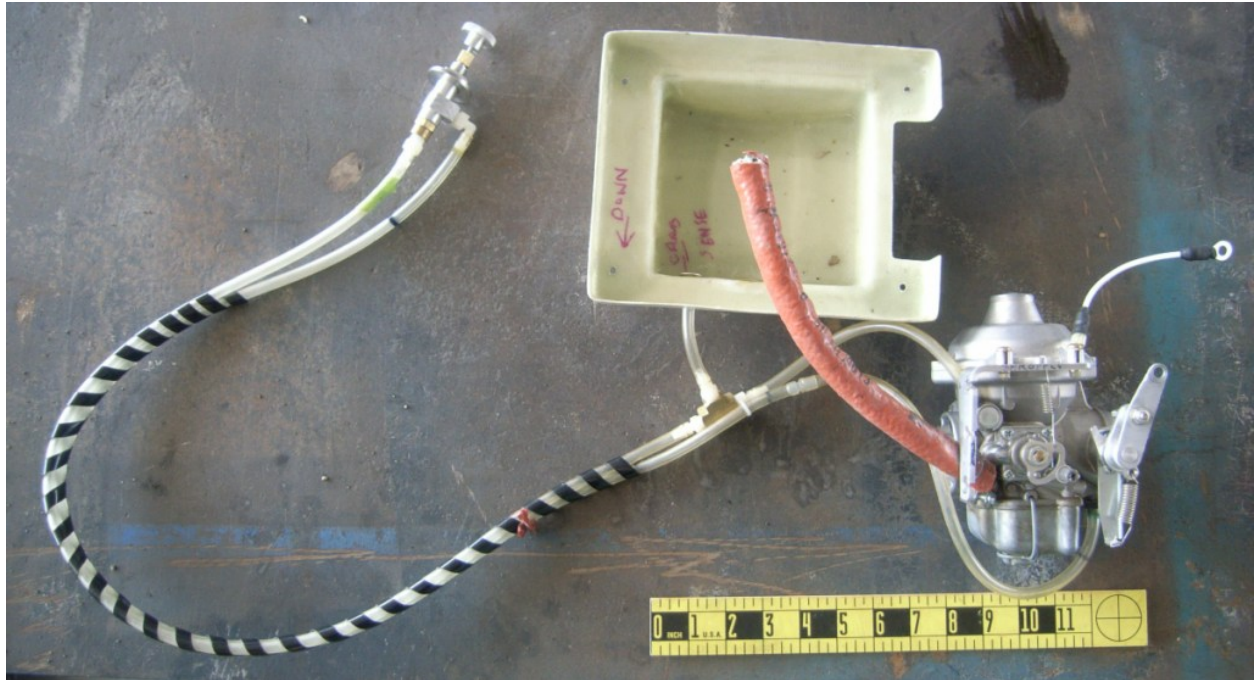


Figure 24 - Carburetor, Airbox Cover, and HACman

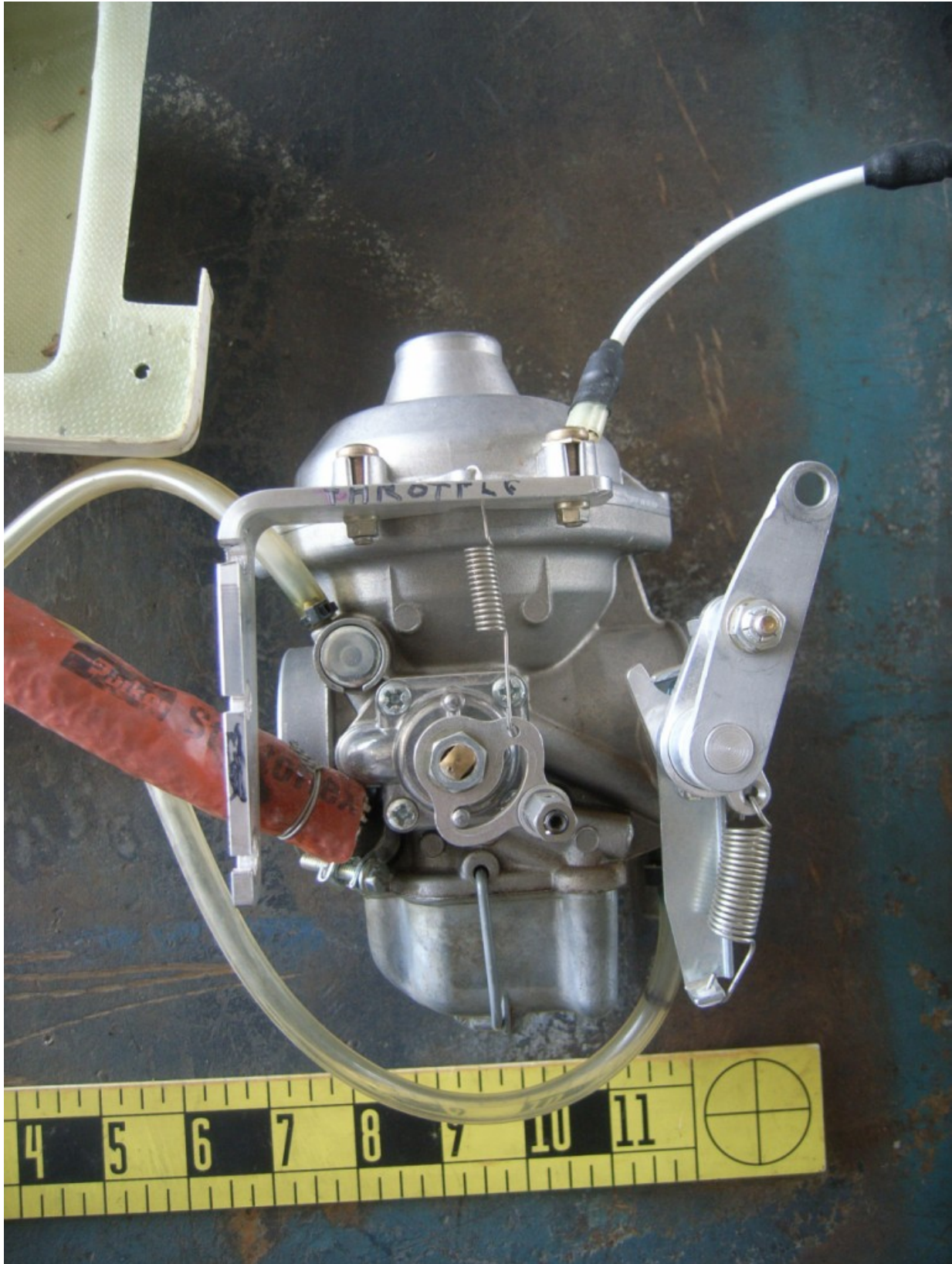


Figure 25 - Carburetor (right side)

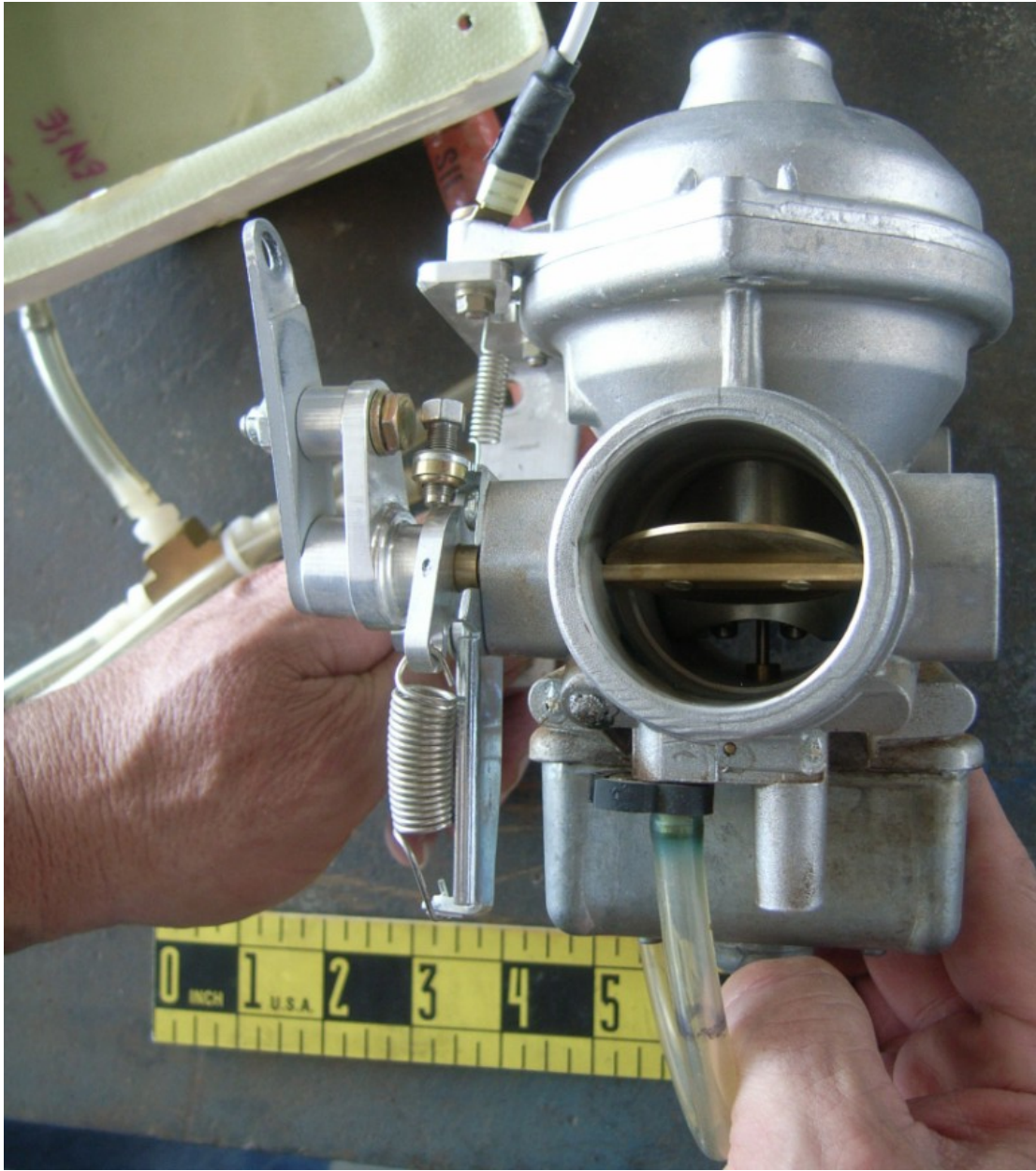


Figure 26 - Carburetor (forward side; mates to engine)



Figure 27 - Carburetor (left side)



Figure 28 - Carburetor Engraved ID Number



Figure 29 - Carburetor Stamped ID Number



Figure 30 - Air Filter

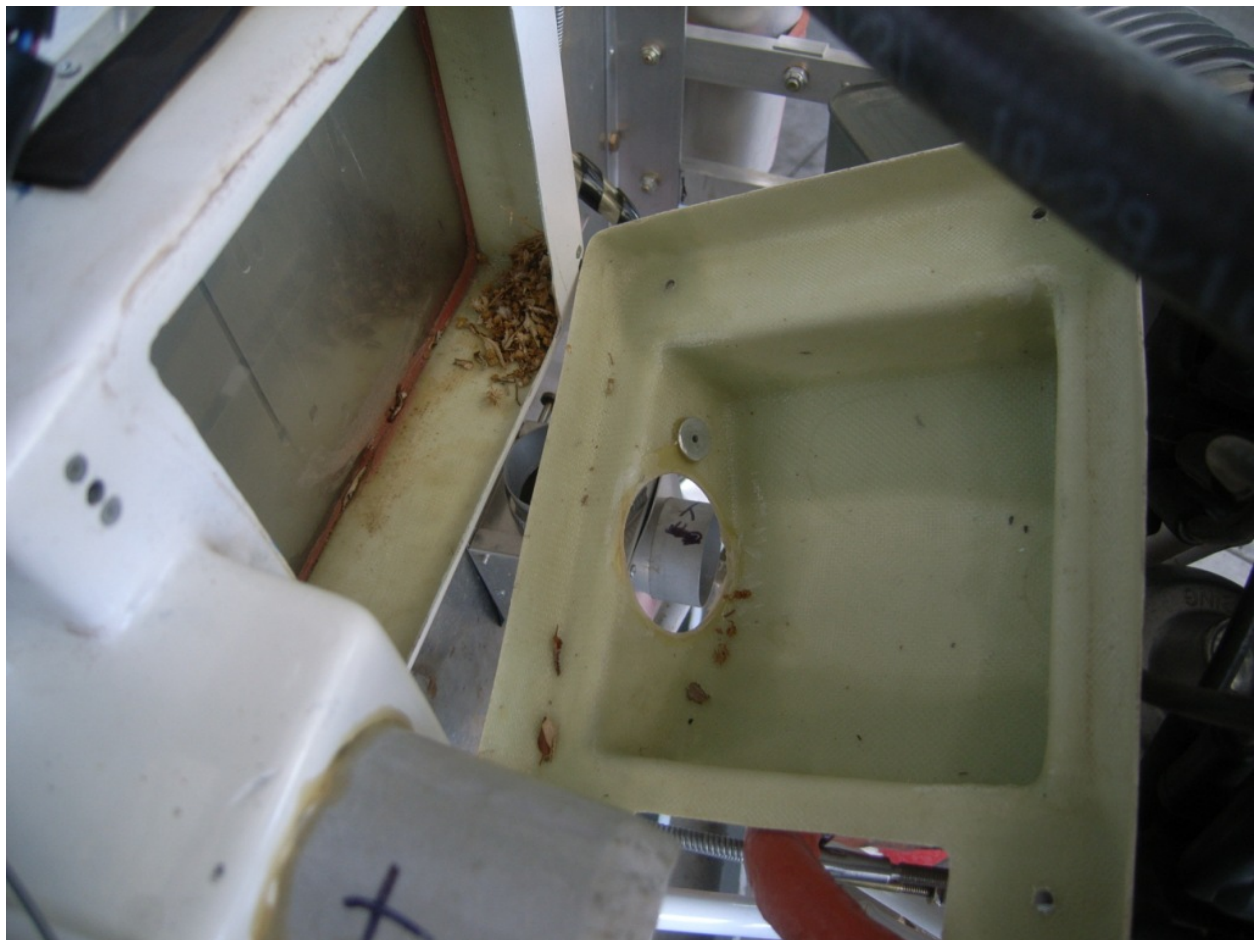


Figure 31 - Air Filter Airbox with Sense Port (small silver disc)



Figure 32 - Center Console



Figure 33 - HACman (full rich setting)

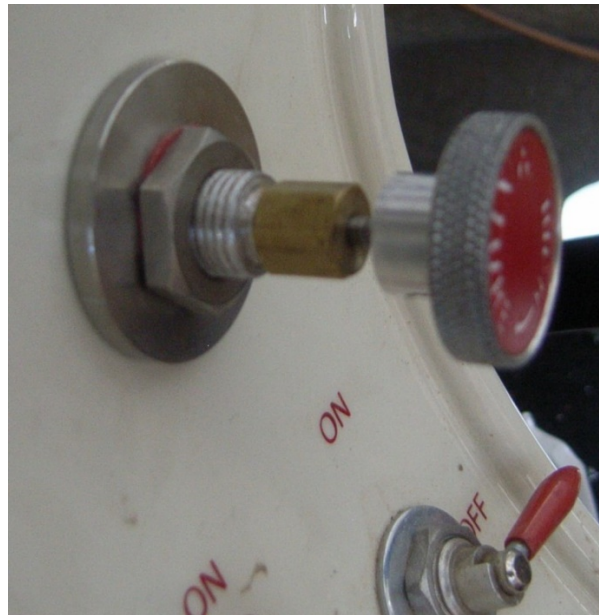


Figure 34 - HACman (leaned setting)

4.0 Ignition System

The engine was equipped with a dual breakerless transistorized ignition system with the magnets mounted on the flywheel and the coils mounted on the alternator mount plate. High voltage electricity was distributed to two spark plugs per cylinder, via two distributor cap and rotor assemblies. The ignition timing was fixed at 25° BTDC; timing is set by the position of the flywheel magnets relative to the crankshaft.

The ignition system was visually examined but not functionally tested. All components and leads were observed to be securely and properly installed. One spark plug from each cylinder was removed, and all electrodes appeared normal. The spark plugs were NKG brand model D9EA, which were as specified by Jabiru. Both distributor caps were removed, and the cap terminals and rotor ends all appeared normal.

With the spark plugs removed, the engine was rotated freely by hand, and thumb compressions were obtained on all cylinders.



Figure 35 - Spark Plugs

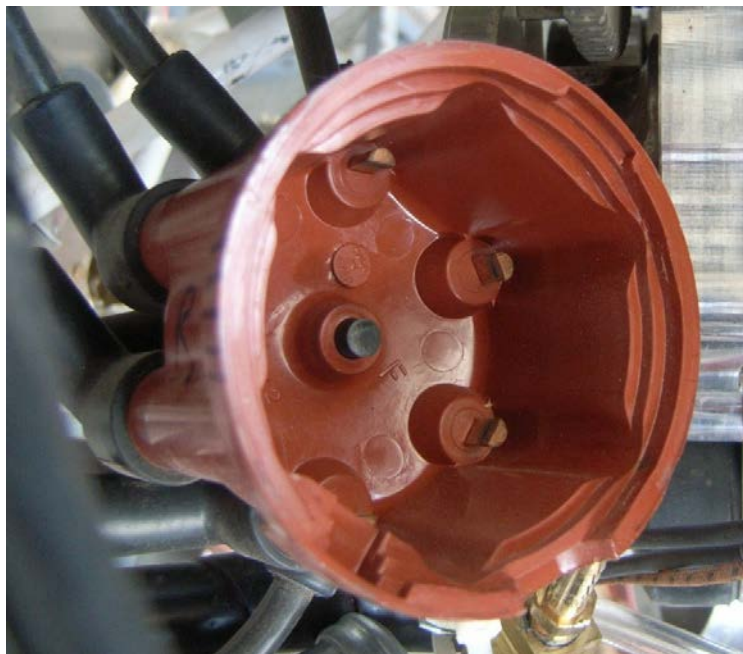


Figure 36 - Distributor Cap (typical)

5.0 Lubrication System

The engine was a wet-sump design, and was equipped with an internal oil pick-up screen, a spin-on external oil filter, an oil cooler, and a quick-drain valve. All components were intact and securely installed. About 1-2 quarts of clean oil were recovered from the sump. Removal of the sump allowed inspection of the crankshaft and other internal components; no evidence of oil starvation or thermal distress was observed. No debris was found in the sump.

The Jabiru IM stated that oil system capacity was 3.5 litres (~3.7 qts). The reason for the difference between the sump capacity and the amount of oil recovered from the sump was not determined.