

Drafted by Scott Norsworthy, Aero Sport Power.

Also see the Pre-Exam Discussion notes by Stephen Stein that were considered in the Sept. 4th, 2024 conference call between Stephen Stein (NTSB), Bruce Hanson (FAA), Bruce Reed (Backcountry Super Cubs), Robert Paisley (EFii), and representatives from Aero Sport Power and Progressive Air Group of Companies.

A couple of my questions not answered during the conference call were:

- The absolute minimum fuel pressure required for the EFii fuel system to operate properly.
- The bank angle of the aircraft during the fuel pressure loss incident. Stephen said they'd have to look at the data provided by the Garmin Avionics to get that information.
- Also useful would be the pitch angle and G loads on the aircraft during any maneuvers. +1 G would be required to keep fuel at the fuel supply ports of the fuel tanks during any roll or pitch maneuvers.

The engine was test run at Aero Sport Power after it was at our shop. We used the following customer's components:

- ECU#1
- ECU#2
- Throttle body
- Hoses
- Injectors

We used the following components that are attached to our test stand:

- EFii fuel pumps
- Fuel pressure regulator
- Spark plugs
- Spark plug wires
- EFii wiring harness
- Cockpit Controller (referred to as the Controller for the rest of these notes)

Sept. 10th, 2024. On-site evaluation:

The Garmin avionics had been re-installed before the evaluation.

Both batteries had been disconnected and the fuel selector valve had been shut off after the incident for safety reasons.

The cowl was removed to access the engine, components, and wiring to inspect their condition and verify there were no obvious signs of failure.

The cowling, propeller, spinner & backplate, cabin heater intake pipes & heater SCAT hoses were found to be damaged due to impact with the ground.

The broken propeller was removed from the crankshaft.

Little or no damage was noted on the engine, engine mount, engine accessories, or exhaust.

The air filter was slightly deformed from the cowl movement during the impact but not enough to create issues with test running the engine.

All connections to the electrical components of the EFii engine management system were found to be serviceable.

The automotive style bottom spark plugs were removed. The internally threaded posts that the spark plug wires attach to of the B1 and B2 spark plugs were found to be barely finger tight. They were still assembled all the way on to their threaded posts ends. With the spark plug wire boots pressed onto the posts it would be unlikely that the posts would have become loose during operation as the silicone boots push over the ceramic end of the plugs with an interference fit and would not allow them to rotate.

The crankshaft was rotated over 720° CCW when viewed from the front (normal engine rotation) and CW (backwards engine rotation) to check for indications of damage. No defects were found.

A cold differential cylinder compression test was performed on all 4 cylinders.

First round of tests on each cylinder:

- #1 45/80 psi.
- #2 12/80 psi. Air was heard escaping from the end of the exhaust pipe.
- #3 72/80 psi.
- #4 64/80 psi.

The engine was spun in the direction of normal rotation a few times and the compression tests were performed on cylinders 1 & 2:

- #1 68/80 psi. #2 18/80 psi. & air was heard at the exhaust pipe again.

(It was decided to continue with the engine test run and test the compression of #2 cylinder at that time. The result of post run testing of the #2 cylinder found the compression to be 78/80.)

The oil quantity was checked with the aircraft sitting on all 3 wheels. The oil quantity on the dipstick showed 6 quarts. This is a normal quantity of oil for this engine.

The spark plugs and wires were reinstalled in the cylinders.

A fuel sampler cup was used, and samples were taken from the LH and RH tanks and inspected. Both samples were clean, blue, and showed no signs of water.

The manufacturer's fuel quantity of each tank is 24 gallons. The fuel remaining in each tank was not an accurate measurement since the aircraft ended up inverted on the runway. At that time an unknown quantity of fuel had drained from both the LH and RH fuel cap vents.

Fuel was drained from each tank to check the amount left in each one.

- LH tank: Less than ½ gallon.
- RH tank: Less than 1 cup.

A fixed pitch ground adjustable prop was installed on the engine. Blade tracking was measured back to the landing gear and found to be less than 1/8" different between both blades.

5 gallons of fuel were added to both tanks. The fuel selector was placed in the RH tank position.

The engine was started and tested at multiple rpm settings up to approximately 1800 rpm. Attached are pictures and video of the tests.

During the test run the ECU 1 and ECU 2 were cycled on and off and readings were documented. The EFii fuel trim on the Controller was left as found at 26%.

While testing I noticed that the fuel pressure indication on the Garmin was displayed all in white. Most other gauges had their limits set to indicate white, yellow, green, and red ranges of their displayed values. I was told that the owner said he was planning to contact Robert Paisley of EFii to get these values to be able to set the display limits for each colour of the fuel pressure display.

I also asked about the fuel flow readings displayed on the EFii Controller. I was told the owner wanted minimal ground run time because he was concerned the additional time spent ground running and setting up the K-Factor of the fuel flow transducer would affect the engine break-in procedure. The K-Factor is how the fuel flow transducer is calibrated to show the correct fuel flow information on the Controller.

During the test run with both ECUs switched on the engine was stabilized at 1530 rpm and 29° IGN (ignition timing) indicated on the Controller. The ECU 1 indicator on the controller was blue and the ECU 2 indicator was green. The ECU FUEL INJ switch was left in the #1 position for these tests.

ECU 1 was switched off. The Controller ECU 1 indicator displayed red. ECU 2 displayed green. The engine was smooth at 1500 rpm indicated and 29° Ignition timing. ECU 1 was then switched back on and the engine continued to run smoothly.

ECU 2 was switched off. The rpm dropped to 1270 rpm. The IGN timing indication was 21°. The ECU 1 indicator displayed blue on the Controller, and the ECU 2 indicator displayed red. ECU 2 was turned back on and the rpm rose back up to 1520 rpm and ran smoothly. (After going through my pictures and cleaning up the excess ones I must have accidentally deleted this one, John may have a picture of it).

The engine was run between 1000 and 1800 rpm with the fuel trim set at 26° with no rough indications.

The Fuel Trim was set to 0% during parts of the testing.

The FUEL PUMP was switched from 1/AUTO to 2 during parts of the testing.

The FUEL INJ switch was switched from ECU 1 to ECU 2 during parts of the testing.

No indications during the rest of the testing indicated engine roughness or loss of power.

The engine was shut down and the aircraft was brought back into the hangar.

It was decided to run the EFii electric fuel pump while the fuel was drained from the RH tank with the selector still in the RH tank position to see what would happen to the fuel pressure indication while the tank was emptied.

We turned the electric pump on and opened the RH tank drain (see video). The fuel pressure remained steady at 28.7 psi until the sound of the electric pump started to change as the fuel from the tank got to a point where we assume the tank port was no longer under the level of the fuel in the tank.

I took a picture at that time and the fuel pressure indication dropped to 28.3 psi. I then started taking video to see how the fuel pressure reading reacted. I commented in the video that I was expecting the fuel pressure to drop to about 6 psi from information given during the Sept. 4th conference call with Stephen. At that point John commented that the fuel pump sound was changing more at that point. He looked over at the fuel draining from the tank and at 1:45 in the video says, "We're empty here." while the pressure on the gauge reads 6.3 psi. It dropped to 6.1 psi before I panned the camera to view the remains of the fuel draining into the funnel. The fuel drain is below the rear fuel tank feed tube to the engine.

We concluded that there were no more tests or procedures that we could perform that would provide us with information pertinent to the investigation.