N7522U Fuel Selector Test

Objective

To evaluate the functionality and reliability of the fuel selector valve to supply adequate fuel to operate the engine.

Overview

There are many variants that make up the family of airplanes collectively known as the *T-6*. N7522U was built as a Harvard II for the Royal Canadian Air Force by the Canadian Car and Foundry corporation. After WWII, the manufacturer modified the aircraft to better suit the RCAF's needs in the post-war era and redesignated it a Harvard IV.

The early block of Harvard IVs (including N7522U) utilize the same fuel system as wartime aircraft; the Center Section of the aircraft contains two fuel tanks, one on the left and one on the right, each holds 55 gallons, 51 of which are considered usable. Mechanical linkages connect the front seat and back seat selector handles to the selector valve located in the wing between the tanks. Despite having only two fuel tanks, the selector valve has four positions, "LEFT," "RIGHT," "RESERVE," and "OFF."

Detail view of the front seat fuel selector handle and placard

The "OFF" and "RIGHT" positions function as one would expect; the "LEFT" and "RESERVE" are less straightforward. When the fuel selector is in the "LEFT" position fuel is drawn from a standpipe which draws fuel from approximately one-third of the way up from the bottom

of the tank. The usable fuel for this position is 33.5 gallons. In order to draw the remaining 17.5 gallons of usable fuel from the left tank, the fuel selector must be in the “RESERVE” position which draws fuel from the bottom of the left tank.

According to the Royal Canadian Air Force Pilot’s Operating Instructions for the Harvard IV, the fuel supply is “normally sufficient for 3.9 hours cruising.” (refer to RCAF manual EO 05-55A-1, revised April 1, 1953)

Setup

The components of the fuel system were removed as required and reassembled into their respective positions in the overall system to replicate functionality as best as possible and to maintain the integrity of the test. The fuel selector valve was removed from the wing and temporarily mounted to the fuselage. The fuel selector itself was not disassembled or manipulated in any way. A supply of fuel was provided to the selected inlet position of the selector and the outlet of the selector was plumbed to the fuel hand pump (wobble pump) as it was in the original configuration.

The wobble pump was undisturbed from its original mounting position on the firewall and the pre-existing plumbing between the wobble pump and the engine driven fuel pump was left intact. The engine driven fuel pump was removed from its accessory pad on the back of the engine and affixed to an electric motor which turned at 1850 RPM, exactly replicating the operating speed of the engine driven fuel pump at the airplane’s cruise power setting. On the outlet side of the engine driven fuel pump, we affixed clear tubing allowing us to observe the quality of the fuel supplying the engine. A restrictor fitting was attached to the outlet side of the clear tubing to approximate the correct flow of fuel for cruise power, which provided the correct amount of backpressure to best replicate the flow of fuel through the entire system.

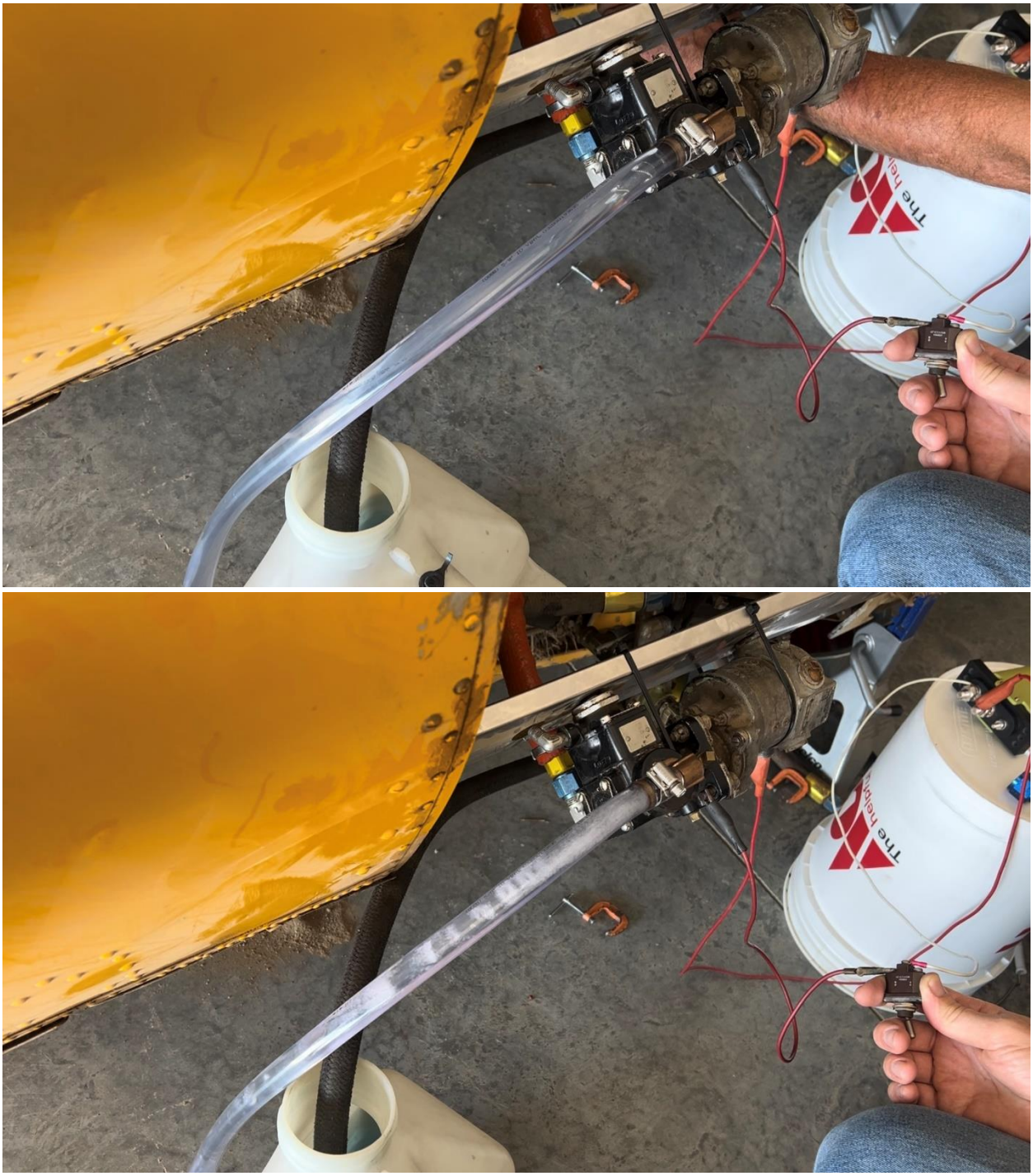
The fuel selector was wetted with fuel 24 hours prior to conducting the test in order to simulate the condition of the fuel selector at the time of the incident.

Observations

Upon arrival in Ione, the recovery team indicated that they drained an unknown quantity of fuel from one or both tanks prior to transporting the aircraft to its storage location in Ione, CA. After the airplane was unloaded in Ione, the pilot’s calibrated fuel stick was retrieved and used to examine the remaining fuel quantity in the fuel tanks, with the wing approximately in the cruise attitude. The right tank indicated nearly empty, and the left tank indicated slightly under 10 gallons of fuel.

Detail view of the calibrated dip stick reading of the left tank upon arrival in Ione

There was no observable damage to any of the components of the fuel system, however the hose connecting the outlet side of the fuel selector to the wobble pump was removed to allow separation of the fuselage from the wing to enable transportation of the aircraft. To begin the test, the fuel selector was set to the “RESERVE” position with the fuel supply plumbed to it. The supply ports to each of the other two positions (“LEFT” and “RIGHT”) were left open to ambient air. To begin the test, both unselected positions were temporarily sealed to prevent the suction of air. The pump was energized, and fuel began flowing through the clear tubing and was observed to be a steady and uninterrupted flow of fuel at approximately the correct rate. With the pump running, the temporary seals were removed from the unselected ports and the fuel observed in the clear tubing immediately became severely aerated and the flow rate of fuel decreased substantially. After observing the large air bubbles, the seals were reinstalled on the unselected ports of the fuel selector and the fuel resumed flowing steadily and uninterrupted.



“RESERVE” Position Test

Photos retrieved from video captured with fuel pump on, note steady and constant fuel flow when unselected ports are sealed (Top); and severe aeration of fuel when unselected ports of fuel selector are open to air (Bottom)

The test was repeated several times, and the results proved consistent and repeatable.

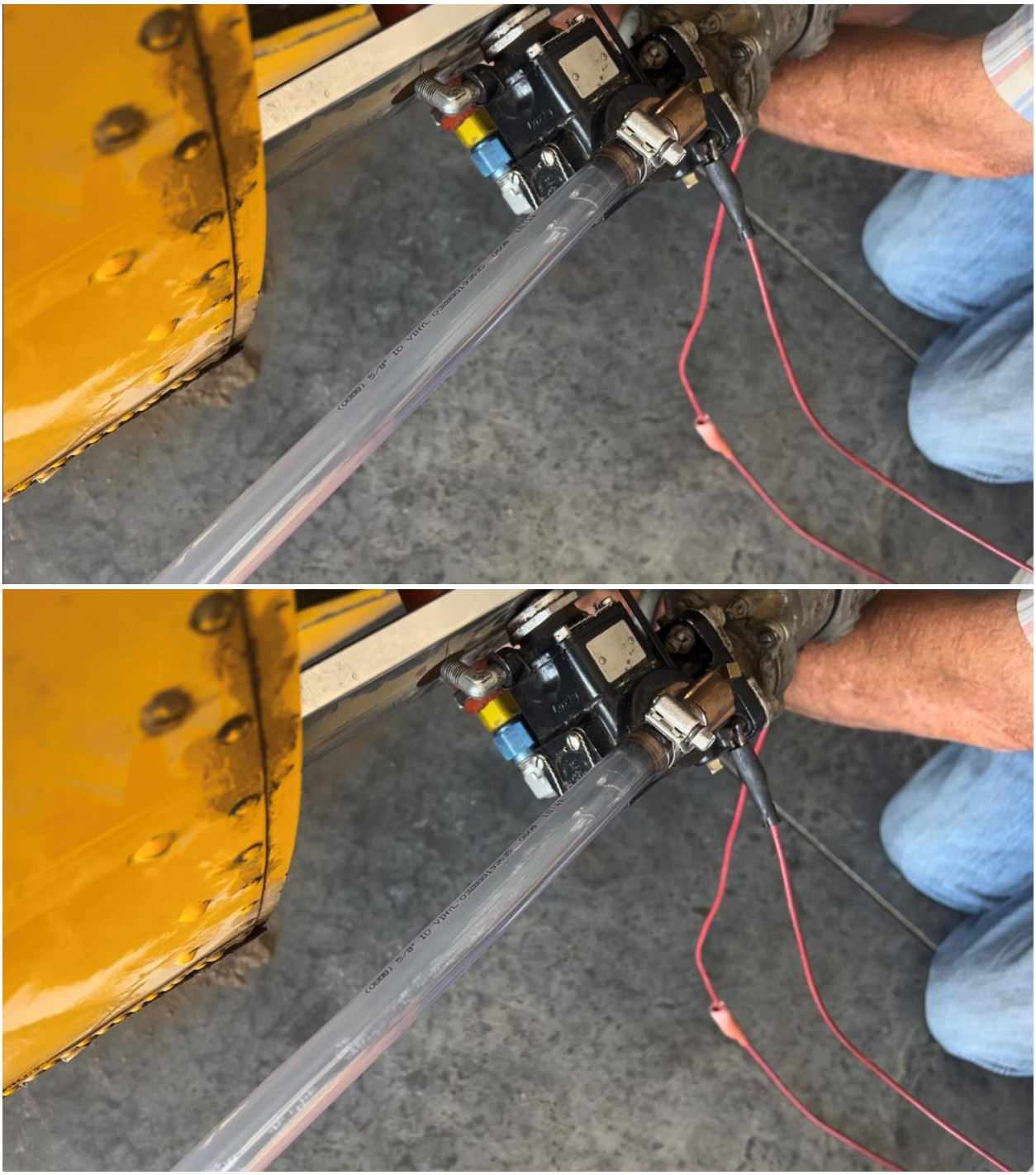
The wobble pump was operated and no observable change occurred.

The test was repeated as described above on each of the other two fuel selector positions

and similar results were observed. When the fuel selector was set to the “Right” position the fuel flow was less aerated though certainly not as steady and uninterrupted as when the unselected ports were sealed.

“LEFT” Position Test

Photos retrieved from video captured with fuel pump on, results are very similar to those of the “RESERVE” position test; unselected ports sealed (Top) and unsealed (Bottom)



“RIGHT” Position Test

Photos retrieved from video captured with fuel pump on the aeration of the fuel while the selector was in the “RIGHT” position was less severe than in the other positions but present nonetheless when unselected ports were open to air (Bottom)

Summary

The fuel selector proved to be leaking consistently between ports which resulted in significant aeration of the fuel.

Conclusion

The fuel selector failed to provide sufficient fuel flow to support operation of the engine due to cross-port leaking. The original fuel selector valve utilizes cork to seal the unselected ports to stop the draw of fluid from those tanks. The cork seal of this fuel selector failed and therefore the engine driven fuel pump drew simultaneously from all three ports, regardless of fuel selector position. If any one of these ports were subject to air, the output of the engine driven fuel pump would be so severely aerated that the engine could cease to run.

Though it is not the case for N7522U, in a hypothetical scenario of an extreme failure of this type, it is possible the engine could be starved of fuel once the standpipe (which supplies the fuel pump when the “LEFT” position is selected) is subjected to air, which happens when the fuel in the left tank is reduced to 17.5 gallons of usable fuel. Such a failure could occur with the right tank completely full as the fuel selector valve will continue to draw air through the standpipe regardless of valve position. The carburetor will receive severely aerated fuel in quantities that are likely insufficient for the engine to run despite a total of up to 68.5 gallons of usable fuel still being aboard.

There is a reasonable expectation that the fuel selector will continue to provide fuel to the engine so long as the selected tank still has usable fuel in it. The fuel selector failed in this “RESERVE” position which still had some quantity of usable fuel as was observed by the Sanders Aeronautics team. The engine likely ceased to run due to the severe aeration of the fuel which was delivered by a faulty fuel selector. The site of the landing was close enough to the Modesto airport (to which the pilot immediately deviated after experiencing the first indications of engine roughness) that the remaining usable fuel would have been sufficient to approach and land.

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