GLASTAR SERVICE BULLETIN 43

MANDATORY

Note This is Revision B. It supersedes Revision A of this bulletin.

Subject: Fuel system design and usable fuel quantity

Applicability: All GlaStar kits

Discussion: New Glastar LLC has undertaken a complete review of the GlaStar fuel system, Service Bulletins, prior tests performed by Stoddard-Hamilton Aircraft and the Header Tank Installation Kit P/N 038-03500-01 that is currently shipped with all kits. In the six months prior to their bankruptcy, Stoddard-Hamilton had been shipping the above-mentioned Header Tank Installation Kit to all kit owners as the solution to fuel system design and the concerns regarding the usable fuel quantity. If you have these header tanks installed, then you are in compliance with this Service Bulletin. If you have not installed them, then you must mark your usable fuel as prescribed at the end of this Service Bulletin. These conclusions, both of which have important implications for safety of flight, are discussed below.

1. Differential Fuel Tank Drain Rates and Slips

Most flying GlaStars, including the prototype (N824G), the company demonstrator airplane N498CF and the customer-built aircraft we have used at various times as demonstration aircraft (N160FM, N269JL and N918V), have exhibited uneven rates of fuel drain from the two main tanks. We believe this phenomenon (which is not uncommon, even in some certificated aircraft), can be attributed to differential pressures in the vent lines and restrictions in fuel lines after a tank outlet has un-ported. Such a differential might be caused by slight differences in the length and/or shape of the ends of the vent lines under the wingtips, as well as by slight out-of-rig conditions or pilot techniques that cause uncoordinated flight.

A common solution to this problem in other aircraft is to cross-vent the two main tanks, thereby assuring equal vent pressure. However, this solution is complicated in the GlaStar by **a)** the large amount of dihedral relative to some other aircraft and **b)** the folding wing feature. The former characteristic would produce a significant local low spot in any cross-tank vent line, while the latter would necessitate circuitous vent line routing and/or some sort of complicated and potentially unreliable connection/disconnection system for the vent line. Both difficulties could probably be surmounted, but the question is whether the benefit would be worth the cost. Stoddard-Hamilton did not believe that it would be, and nothing in our analysis to date has changed this belief.

In our experience of more than 1,300 hours in the prototype and several hundred hours in other GlaStars, this uneven fuel drain characteristic has not posed any operational problems. The main

concern, of course, is whether the fuel supply to the engine could possibly be interrupted if one tank were run substantially dry before the other tank began to feed. However, while a very slight vent pressure differential may be enough to cause one tank to drain much faster than the other, it would in theory require a vent pressure in the empty tank greater than the head pressure of the fuel in the relatively full tank to prevent the latter from feeding the instant the empty tank ran dry. We have flown many times until one tank has read completely empty without experiencing any interruption in fuel supply.

However, our analysis of the fuel system revealed one flight condition in which the differential drain rate characteristic could pose a safety risk. If one tank were empty or nearly so and the aircraft were flown in a slip with the "empty wing" high, it is conceivable that the fuel supply could be interrupted, even though a significant amount of fuel might remain in the low wing tank. Slipping with the "empty wing" low would pose no such risk, because even if the low wing tank became unported, fuel from the high wing would be flowing (and under greater-than-normal head pressure due to its elevated position).

2. Usable Fuel Quantity

The usable fuel quantity for the GlaStar specified in the *GlaStar Owner's Manual* (27.6 gallons) was defined based on certain assumptions about aircraft attitudes in normal flight operations combined with computer-aided design (CAD) analysis of the fuel tank geometry.

FAA Advisory Circular 23.959-1, "Unusable Fuel Test Procedures for Small Airplanes," was used as a guideline during our re-evaluation of this issue. This publication specifies six critical flight conditions that represent the "most adverse fuel feed conditions" typically encountered in small general aviation aircraft. In defining these conditions, the advisory circular explicitly excludes "radical or extreme maneuvers not likely to be encountered in operation."

One of the six critical conditions applies only to multi-engine aircraft. The five relevant to the GlaStar are: a) level flight at maximum recommended cruise power; b) maximum power climb at best angle-of-climb speed (Vx); c) power-off glide at maximum flap extended speed (Vfe); d) power-off glide at 1.3 times full-flap stall speed (Vso) and transition to maximum power climb at best rate-of-climb speed (Vy); and e) power-off side slip of thirty seconds' duration at 1.3 Vso.

Given the aft location of the fuel outlets in the GlaStar main tanks, conditions a) and b) turn out not to be critical at all; in any climbing or nose-level condition, all but a very small quantity of the fuel in the tank sumps will flow to the outlets and will thus be usable. It is the nose-low conditions that render significant amounts of fuel in the GlaStar unusable by trapping it below the level of the aft-mounted outlets.

The nose-low conditions are c), d) and e). Flight testing reveals that c), a power-off glide at Vfe (75 kts.), produces a nose-down angle of 9.8°, which is considerably greater than that produced by glides at 1.3 Vso (approximately 56 kts.). Thus, the power-off glide at Vfe is the normal flight attitude that produces the most adverse fuel feed condition. It is this attitude that must be used in determining the actual amount of unusable fuel.

Substantial tests of various fuel systems were performed in 1999 by Stoddard-Hamilton engineers in order to understand what was happening once the flow of fuel was interrupted from a fuel tank. When

a tank has un-ported and the engine continues to draw the fuel in the lines forward, air follows the fuel down line towards the engine. When the flow of fuel from the wing tank resumes, this new fuel would trap the air in the line. Since this is only a low-pressure gravity supplied system, the air within the line wants to rise back toward the tank and the fuel above wants to descend. It was observed through clear fuel lines that the air would actually restrict or block the flow of fuel in that line.

We do not believe that a header tank installed on the firewall (as is common on many aircraft) is a valid solution for the GlaStar. As the fuel in the firewall mounted header tank is consumed during a prolonged descent, when the aircraft is leveled and power is resumed to a full power setting, it is possible there would not be sufficient enough fuel flow for normal operation even though the wing shows adequate fuel because of the potential of entrapped air in the lines. The tests conducted in 1999 on a vented firewall mounted header tank demonstrated this very scenario.

Note Per AC 23.959-1, the usable fuel quantity established for the optional auxiliary tanks remains unchanged. The advisory circular specifies that "a tank that is not needed to feed the engine under all flight conditions should be tested only for the flight regime for which it was designed." Since the aux tanks are designed to be used to extend range by refilling the main tanks in level cruise conditions, they need not be considered under the same adverse fuel feed conditions as the main tanks do.

3. New GlaStar LLC's response

It was these tests and observations that led to the decision by Stoddard-Hamilton to create two vented header tanks just below the fuel ports of each wing. Given the characteristics of this system, these two tanks allow virtually **all** the fuel in the main tanks to be considered usable. The location and venting of these tanks enables them to immediately begin refilling once the aircraft has leveled off and the flow of fuel has resumed.

The required capacity of the header tanks are determined by the amount of fuel the engine needs to continue operating normally for the longest period that the aircraft might reasonably be expected to fly under the most adverse fuel feed condition. As explained above, the GlaStar's most adverse fuel feed condition is the Vfe glide at idle power. In this condition, flight test reveals that the GlaStar prototype descends at 1,250 f.p.m. A worst-case scenario would involve a 180 h.p. GlaStar descending from its estimated service ceiling of 21,500 ft. to sea level at Vfe. Such a descent would take 17.2 minutes. The O-360 at idle burns, conservatively, 2 g.p.h., which means that the engine would require approximately half a gallon of fuel to complete the descent.

We are confident that the two vented header tanks as described here provides a safe, simple and wholly satisfactory solution to the fuel system problems discussed in the prior issues of this service bulletin. This system has been installed in N498CF, our GlaStar demonstrator, and has successfully met our expectations. After the system was designed, we noticed that the same system has actually been used on some certified aircraft as well.

Warning!: A firewall mounted header tank <u>does not</u> satisfy the unusable fuel limitations of S.B. 43 or the critical conditions listed above.

4. **Required Actions:** The following actions are required **prior to further flight**:

All fuselage shipments since September of 1999 have had these tanks included in the kits. Additionally, Stoddard-Hamilton Aircraft had been shipping GlaStar Header Tank Installation Kit P/N 038-03500-01 to customers of record prior to their bankruptcy in May of 2000. If you do not have these tanks installed and wish to order some, please contact New GlaStar LLC for details.

If you **have not** installed the header tanks described above, then:

1. Re-mark fuel gauges which employ an indicator needle (whether mechanically or electrically actuated) to indicate "**Empty**" when **3.6** gallons remain in each main tank. For digital gauges, install a placard reading "**3.6 Gallons per Tank Unusable**."

2. Amend the *GlaStar Owner's Manual* in ink as follows (page and section references apply to both tricycle and taildragger versions):

   a) On Page 9 of SECTION 1, "**General**," change the Fuel Capacity (usable): Main Wing Tanks (standard) from 27.6 gal. to **23.4 gal**.

   b) On Page 1 of SECTION 2, "**Limitations**," add new section 2-10A, SLIPPING MANEUVERS.

   c) On Page 10 of Section 2, "**Limitations**," add the following text: "**2-10A SLIPPING MANEUVERS**: The GlaStar is approved for slips at any flap setting. However, slips of greater than thirty (30) seconds' duration and/or slips that result in the high wing containing less than two (2) gallons of fuel are prohibited."

If you **have** installed the header tanks described herein, then:

1. The restrictions as set by the previous Revision of this Service Bulletin may be removed and the original values in the GlaStar Owner's Manual for Fuel Capacity and Limitations be restored.