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SERVICE LETTER / NOTIFICATION - FEB 2018

Issue Date
February 05 2018, Rev. 0

Subject/Purpose
Fuel system

Affected Models
All Chris Heintz (CH) designs

Compliance Time
Within the next 50 hours - or immediately if you are having fuel flow issues.

Inspection Frequency
Annual (on-going)

Background
Chris Heintz designs for amateur builders plans and kits, leaving the selection of the engine (powerplant) and fuel system up to the builder of the aircraft, and the plans (blueprints and manuals) only provide very basic information on their installation and operation. It is the builder's responsibility to ensure that the fuel system installed will be compatible with the engine installed, and that the fuel system is tested (by the builder) for adequate fuel flow in all configurations. By default, Chris Heintz designs use simple fuel systems that work in most applications and with most powerplants. However, the builder (and/or subsequent owners and pilots) should follow the steps prescribed below to verify that their fuel system, as installed in their particular aircraft, is adequate.

Subject/Purpose

Zenair Ltd received several comments regarding aircraft fuel systems. Additionally, as per the FAA's fact sheet (FAA News - Fact Sheet – General Aviation Safety of July 26, 2017 https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=21274), fuel starvation is the fourth most frequent cause of fatal accidents. Zenair Ltd is therefore recommending that all CH (Chris Heintz) aircraft builders, owners and pilots take a closer look at their fuel systems, inspecting and/or evaluating the following:

1. Fuel flow
2. Fuel caps and venting
3. Fuel lines in airframe
4. Fuel lines near engine
5. Fuel pumps
6. Fuel selector valves
7. Regular recurrent fuel system inspections

The technical drawings for CH aircraft designs typically do not provide detailed instructions on fuel systems since builders install a variety of different engines and have a variety of different fuel system requirements. Remember that the builder of an amateur-built experimental aircraft is in effect the aircraft manufacturer. Second owners of amateur-built aircraft must understand that they purchased a unique, one-of-a kind aircraft and should not assume that the original builder was an expert. Regularly inspect the aircraft and all its systems.

Inspection:

1. Fuel flow

For certificated airplanes. 14 CFR 23.955 (see page 8 below) states that fuel flow must be demonstrated. You do not have to run the engine to satisfy this requirement but you need to demonstrate adequate fuel flow in the aircraft's most critical attitude.

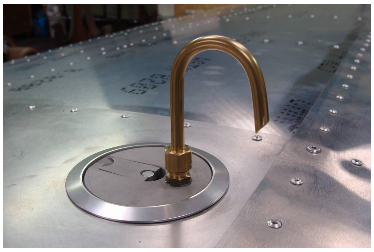
While 23.955 arguably does not directly apply to an amateur-built experimental aircraft (especially a kit built aircraft) the test is simple to conduct and can be very educational. Please view the FAA's Experimental/Amateur-Built Flight Testing and download the FAA manuals in the Resource area.

https://www.faa.gov/news/safety_briefing/2014/media/SE_Topic_11_2014.pdf

AC 90-89A. SECTION 11, 1-e for setting up the fuel flow test. There is a lot of excellent information in this manual. Read and understand the complete manual.

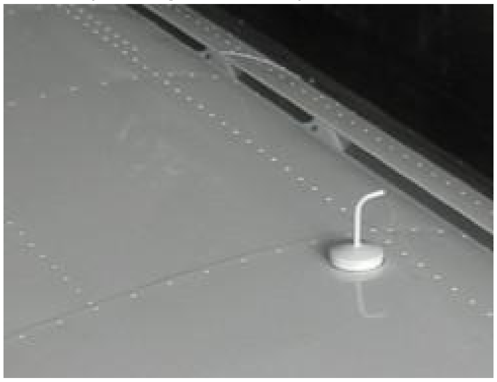
2. Fuel caps and venting

Aircraft with a sealed cap and separate vent tube: If the tanks are very full and/or the wings are not level, it is possible that some fuel may exit through the vent tubes under the wings. If you want to prevent this from happening, Homebuilt.com help has a simple solution. Please see http://homebuilthelp.com/Tip_of_Week/Tip_11.htm



Above photos are from Zenith customers. Note the small hole in the gooseneck bend. Once installed properly, you can then seal the vent tubes that exit under the wings.

For gas caps that vent at the cap, it is also possible that a small amount of fuel may exit through the cap if the tank is very full. To avoid this, you can install the goose neck tube and block the breather holes in the cap - or purchase Aircraft Spruce cap #05-08077 or WagAero Ram Air Pressure Cap E-476-200 and bend the tube with a tube bender. This cap is sealed and comes with a tube that you bend (facing forward).



Above photos are from Zenith builders. Photo on the right shows the welding of the gooseneck tube and the plugging of the air vents in the cap.

This photo of a fuel cap is for a Piper Cub with 180HP.
http://www.fadodge.com/fuel-cap-for-180hp-piper/

WAG AERO fuel cap E-476-200
Vent tube to be bent facing forward.

For gas caps that vent at the cap: They have been used on CH designs for 30+ years, with the CH 701 probably having the most extreme angles of attack. Having said that, some still feel that on their aircraft, the standard vented cap is marginal. Or, with a fuel line connecting both tanks and with one ON/OFF valve, that the tanks do not drain evenly. Some have also said that with one tank empty, fuel flow stops on the other tank. Completing in-flight tests during Phase 1 should determine if the fuel system is functioning properly.
In the event that additional fuel flow is desired, you can install a simple gooseneck tube to the fuel cap(s) as shown above. This will force air into the tank to increase fuel flow. Or, if you notice that fuel is not flowing evenly from both tanks with a simple ON/OFF valve, your fuel lines and valve can be changed so that you can select fuel from just LEFT, RIGHT or BOTH.
Again, you need to properly check your fuel system during Phase 1 of your flight test program to ensure it is functioning properly. If you are not sure (especially if you are the second owner), perform a fuel flow test on the ground and complete a flight test for all different fuel management configurations.

3. Fuel lines in airframe (in wings, fuselage & cabin area).

Older rubber fuel lines may not be compatible with newer fuel additives, including ethanol. Inspect your fuel lines carefully (especially around hose clamps) looking for signs of aging (notably cracking). Bend a fuel line and look for signs of deterioration. Inspect the gascolator mesh screen for any rubber (black) debris. Replace the fuel lines if they show any signs of aging. Replacement lines should be made from Parker Super-Flex 397 fuel line hose which may be ordered from Aircraft Spruce.

Water in fuel typically flows downward to the lowest point. At the lowest point in the fuel system, you need a way to remove any water accumulation. This can be accomplished with a valve or a gascolator. If you have a low point in the fuel system that cannot be drained, you need to add a drain or alter the fuel line routing. Please also see http://homebuilthelp.com/Tip_of_Week/Tip_47.html regarding leaking fuel drains and fuel hoses.

4. Fuel Lines near engine (in the engine area / firewall forward area)

As fuel lines need to be protected from heat or from a potential fire, it is recommended that fire sleeves be installed over the fuel lines in the engine area. Fuel lines close to the muffler system or that touch a sharp edge should have extra protection or should be re-routed. Fuel lines should be installed snug. Ensure that your firewall is sealed so that potential fumes or smoke do not enter the cabin area. Sealing the firewall holes with a high temperature caulking sealer works well.

5. Fuel pumps.

Typically aircraft will have a mechanically-powered engine fuel pump and an electrically-powered back-up fuel pump. For the fuel flow test, the back-up pump is used. A common pump is the Facet solid-state electric fuel pump (available from Aircraft Spruce and many automotive supply stores). The back-up pump must function properly. When performing the fuel flow test, it is important to disconnect the fuel line at the carburetor. A manifold is typically used to split the fuel lines so if the engine pump is blocked, the electric fuel pump still supplies fuel to the engine. For fuel injected engines there are typically two high pressure fuel pumps, a primary pump and a backup pump. This can be checked during the fuel flow test. Please also see http://homebuilthelp.com/Tip_of_Week/Tip_47.html regarding leaking fuel drains and more information about fuel systems.

6. Fuel selector valves.

When drawing fuel from both tanks simultaneously, it is not uncommon for fuel flow to be uneven. There are different reasons for this such as uneven venting, unlevel wings, uneven fuel lines, filters, etc. If your aircraft has a single ON/OFF fuel selector valve, the wing tanks may not drain evenly on the ground and/or in the air, resulting in one tank emptying first. To ensure the engine always gets adequate fuel (even with one tank empty), complete fuel flow tests on the ground as well as in flight (close to the airport!). Conduct tests with one tank empty and fuel in the other, then repeat the tests with fuel in the other tank. If you have a fuel selector valve with LEFT/RIGHT/BOTH, you need to do the fuel flow tests for all available selector settings. It is important to fully test the system to make sure fuel always flows properly to the engine.

7. Regular recurrent fuel system inspections

At the fuel tank(s): Your fuel line exiting the fuel tank should be connected to a finger screen to minimize large debris from blocking the fuel line. Inspect the tank with a flashlight and mirror. If you see debris/dirt, drain the tank and remove or add an access panel under the wing so that you can remove the finger screen. If inspection by flashlight does not work, regularly drain the tank(s).

Fuel drain valves: There are fuel drain valves at the tanks and possibly under the fuselage. Remove them and pass fuel through the system to remove any debris.

Gascolator: Open the gascolator and inspect. Remove any debris in the bowl and on the fine mesh screen. Any sign of debris is cause for concern, so inspect everything upstream carefully.

Firewall forward area: If you have a fuel filter in the engine area, replace it on a regular basis. Also, a lot of carburetors have a fine mesh screen - make sure it is clean. Carburetor bowls can accumulate debris so inspect that as well. See your engine manual for inspection procedures.

Based on the installation you have, there could be many additional things to inspect. Make sure you understand your fuel system and what to inspect at the 50 and 100-hour annual inspections.

Note that on a new aircraft it is very important to flush the complete fuel system out before starting the engine. A lot of debris can accumulate during the building process.

Properly document your fuel system so that it can be properly inspected and maintained (especially important for subsequent owners of your aircraft).

Header Tank

In the event that you are not satisfied with your present fuel system, an option is to add a header tank. Here is what Jonathan Porter posted on January 24, 2013.

- **Posted by** Jonathan Porter **on January 24, 2013 at 7:34pm**

In our line of operations we often experience a lot of turbulence at low level (we are approved to operate below 500' for aerial dispersal and supply drops). We also get some long, at times fast, descents. With this combination of events we have decided that we really want a header tank for a variety of reasons... We have simulated 'uncovered ports' in ground tests, and do not like the VERY unlikely possibility that it could cause. By taking the 'Tee'ing of tanks to a low point 'air being sucked' can be limited, but better still a header tank can solve the challenge altogether, provided you are happy with the weight, extra complexity and engineering necessary to fit it into the system! Also, if you need a return line, as is more and more common, a header tank can avoid you running lines all the way back to the wing tanks... (each individual installation is different and each builder must make their own decisions on what is right for them, and following the original plans is the preferred solution in most cases - we take no responsibility for anybody copying our approach). For the blog and following comments, see **View Blog**

For those of you who want to see what Rotec did when developing the firewall forward package for the CH750, see http://www.rotax-owner.com/en/videos-topmenu/builder/425-750-4

If you decide to add a header tank, complete the fuel flow test after the installation.

Fuel flow test details:

Use FAA AC 90-89A. SECTION 11, 1-e for setting up the fuel flow test.

Additional suggested information.

Empty your fuel tank(s). Disconnect the fuel line at the carburetor and put the line into an empty fuel container. Remember to turn on the fuel pump before starting the test if needed to operate the engine.

Pour fuel into one of the aircraft's empty fuel tank until a steady flow is coming out of the line into the fuel container. The amount poured into the fuel tank before a steady flow of fuel is established into the fuel container is the unusable fuel volume. Repeat for other tank(s). Your total fuel per tank could be 14 USG and your unusable fuel could be 1 USG for a total usable fuel of 13 USG. Make sure that your own readings are recorded into the Flight Manual / POH. Usable fuel should be labeled beside the fuel valve in the cabin.

Now that you have the unusable fuel in each tank, pour one gallon of fuel into a tank with the fuel selector in the OFF position. Turn ON and with a stopwatch, time how long it takes for the fuel to fill 1 gallon (mark a fuel can at the 1 gallon mark). The test should be run with the fuel cap(s) on all the tank(s). Ensure that the fuel tank vents (whether part of the cap or as separate vent tubes) are unobstructed as plugged or partially closed vents can slow or stop the fuel flow. Based on the time it takes one gallon to pass through the system we can calculate the fuel flow in gallons per hour and compare that to our engine requirements.

Test each tank individually and both together, depending on the type of fuel selector valve installed. These tests should also be repeated for a gravity-fed system that uses a back-up electric fuel pump. Make sure that adequate fuel flow is obtained for all possible configurations.

Even if a fuel pump is installed, the fuel flow to the engine should be at least 1.5 times the fuel flow that the engine will require at 100% throttle. For example, if an engine burns 8 gallons per hour maximum, our test should show a minimum flow rate of 12 gallons per hour. By performing this simple test, one can be confident that the engine will receive the fuel it needs making flying safer and more rewarding.

Some engines (such as the Rotax 912iS) require the installation of a header tank. Doing the fuel flow tests is more complex with a header tank installed, however, you still need to check fuel flow for each tank. First complete tests to determine adequate fuel flow from the main tanks to the header tank. Then confirm you have adequate fuel flow from the header tank to the engine. Remember that throughout the test, your fuel system must be able to provide at least 150% of the full-throttle fuel flow rate. Repeat the test for all available tank configurations and fuel selector settings.

Note: It is also a good time to calibrate the fuel-gauge sender-units in the tanks at this time.

Once complete, make a log book entry.

14 CFR 23.955 (Now removed due to the FAR 23 rewrite but still applicable to your aircraft)

§23.955 Fuel flow.

(a) *General.* The ability of the fuel system to provide fuel at the rates specified in this section and at a pressure sufficient for proper engine operation must be shown in the attitude that is most critical with respect to fuel feed and quantity of unusable fuel.
These conditions may be simulated in a suitable mockup. In addition—

(1) The quantity of fuel in the tank may not exceed the amount established as the unusable fuel supply for that tank under §23.959(a) plus that quantity necessary to show compliance with this section.

(2) If there is a fuel flowmeter, it must be blocked during the flow test and the fuel must flow through the meter or its bypass.

(3) If there is a flowmeter without a bypass, it must not have any probable failure mode that would restrict fuel flow below the
level required for this fuel demonstration.

(4) The fuel flow must include that flow necessary for vapor return flow, jet pump drive flow, and for all other purposes for
which fuel is used.

(b) *Gravity systems.* The fuel flow rate for gravity systems (main and reserve supply) must be 150 percent of the takeoff fuel consumption of the engine.

(c) *Pump systems.* The fuel flow rate for each pump system (main and reserve supply) for each reciprocating engine must be 125 percent of the fuel flow required by the engine at the maximum takeoff power approved under this part.

(1) This flow rate is required for each main pump and each emergency pump, and must be available when the pump is operating as it would during takeoff;

(2) For each hand-operated pump, this rate must occur at not more than 60 complete cycles (120 single strokes) per minute.

(3) The fuel pressure, with main and emergency pumps operating simultaneously, must not exceed the fuel inlet pressure limits of the engine unless it can be shown that no adverse effect occurs.

(d) *Auxiliary fuel systems and fuel transfer systems.* Paragraphs (b), (c), and (f) of this section apply to each auxiliary and transfer system, except that—

(1) The required fuel flow rate must be established upon the basis of maximum continuous power and engine rotational speed, instead of takeoff power and fuel consumption; and

(2) If there is a placard providing operating instructions, a lesser flow rate may be used for transferring fuel from any auxiliary tank into a larger main tank. This lesser flow rate must be adequate to maintain engine maximum continuous power but
the flow rate must not overfill the main tank at lower engine powers.

(e) *Multiple fuel tanks.* For reciprocating engines that are supplied with fuel from more than one tank, if engine power loss becomes apparent due to fuel depletion from the tank selected, it must be possible after switching to any full tank, in level flight, to obtain 75 percent maximum continuous power on that engine in not more than—

(1) 10 seconds for naturally aspirated single-engine airplanes;

(2) 20 seconds for turbocharged single-engine airplanes, provided that 75 percent maximum continuous naturally aspirated
power is regained within 10 seconds; or

(3) 20 seconds for multiengine airplanes.

(f) *Turbine engine fuel systems.* Each turbine engine fuel system must provide at least 100 percent of the fuel flow required by the engine under each intended operation condition and maneuver. The conditions may be simulated in a suitable mockup. This flow must—

(1) Be shown with the airplane in the most adverse fuel feed condition (with respect to altitudes, attitudes, and other conditions) that is expected in operation; and

(2) For multiengine airplanes, notwithstanding the lower flow rate allowed by paragraph (d) of this section, be automatically
uninterrupted with respect to any engine until all the fuel scheduled for use by that engine has been consumed. In addition;

(i) For the purposes of this section, "fuel scheduled for use by that engine" means all fuel in any tank intended for use by a specific engine.

(ii) The fuel system design must clearly indicate the engine for which fuel in any tank is scheduled.

(iii) Compliance with this paragraph must require no pilot action after completion of the engine starting phase of operations.

(3) For single-engine airplanes, require no pilot action after completion of the engine starting phase of operations unless means are provided that unmistakenly alert the pilot to take any needed action at least five minutes prior to the needed action; such pilot action must not cause any change in engine operation; and such pilot action must not distract pilot attention from essential flight duties during any phase of operations for which the airplane is approved.

[Doc. No. 4080, 29 FR 17955, Dec. 18, 1964, as amended by Amdt. 23-7, 34 FR 13093, Aug. 13, 1969; Amdt. 23-43, 58 FR 18971,
Apr. 9, 1993; Amdt. 23-51, 61 FR 5136, Feb. 9, 1996]

Note: Completing a flight test will ultimately determine if the fuel system is functioning properly.

For additional information go to www.newplane.com or contact Zenair Ltd.

For additional continued airworthiness documentation, make sure you are a registered owner and have access to the Builder Resource web site at www.zenithair.com

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FUEL FLOW REPORT

____________________ ____

Aircraft registration Name of signatory (print)

This functional test of the aircraft fuel system is required to ensure adequate fuel is constantly supplied to the engine in all flight attitudes. It also tests the integrity of the fuel supply circuit from fuel tank(s) to power plant.

Note: *The complete fuel tank system of ventilation should be tested before performing the fuel flow test to ensure that leakage and /or obstructions are not falsifying the fuel flow results or cause an accident in the future.*
The complete fuel tank ventilation system has been tested and found leak and obstruction free (Y)

This test must be carried out on both gravity and pump systems, with all fuel lines and fittings airworthy. The quantity of fuel in the tank may not exceed the unusable fuel supply plus that quantity necessary to perform the test.
Gravity systems. The fuel flow rate must exceed 150 percent of the takeoff fuel consumption of the engine.
Pump systems. The fuel flow rate must exceed 125 percent of the takeoff fuel consumption of the engine.

The builder must ensure that the test results meet or exceed the requirements of **CAR 523.955 *Fuel Flow* (a), (1), (2), (3), (4), (b), (c) and (1)** while accurately reflecting the fuel flow capability of his aircraft. If a large discrepancy exists between the test results and the fuel flow capability of the aircraft, it may be an indication of a hidden flaw in the aircraft fuel system. The builder must repeat the fuel flow test until the final results are a credible and accurate reflection of the fuel flow capability of the aircraft.

For this test the aircraft should be positioned in the MAXIMUM ANGLE OF CLIMB and only have the minimum fuel as per the weight and balance report. (MD-RA Form C17E).

Note: *In the past, this report has identified defects such as: dirt lodged inside fuel lines, fuel valves and gascolators with restricted ports, incorrect diameter fuel lines, and faulty electric pumps.*

Method

Results

Date: ____________ Signature ____

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