

# Chapter 8 - Engine Startup Procedures

## Lighting the Fuse!

One of the great milestones in the process of building an airplane is firing up the motor for the first time. Unless you suffered from kid-in-a-candy-shop syndrome and started your motor while still on the shipping crate, this will be the first time you've heard your e-motor sing. Even if you did have a sneak preview, it is still rewarding to see the motor run in it's proper environment. Here we go!

## Prop Prep

It is NOT necessary, or desirable, to have your prop installed during the first run. Having the prop installed just creates further safety hazards and a lot of noise and wind that you don't need right now. It does no harm to run the motor with only the PSRU (gearbox) load as long as you keep the RPM within a reasonable limit.

## Cowling Prep

It is NOT necessary, or desirable, to have your cowling installed during the first run. You want to be able to look over the motor as it is running to identify any leaks, rattles, sources of smoke, etc.

## Fuel Supply

It is NOT necessary to have your wings installed yet. You can simply choose one side of the aircraft and slip short sections of 3/8 and 5/16 fuel line over the supply and return stub lines respectively, and insert them both into a portable gas can.

- Run 87 octane automotive fuel if normally aspirated.
- Run 93 octane automotive fuel if supercharged.
- Use TCP additive if running 100LL avgas.

Set the can on a short stool or step ladder to minimize the height which the fuel pumps must draw fuel from.

If you do have the wings installed, add enough fuel to each tank to allow you to fully test the fuel selection functions. Even if you use the gas can method, it is good to switch sides at some point in order to verify proper operation and flush out any debris which may have accumulated in the lines and valves.

A shocking number of homebuilts suffer from early motor stoppage due to debris in the fuel lines and other needless errors which could easily be avoided through proper testing. Don't let this happen to you! Make sure you have fully tested and flushed out all fuel supply components.

# Fuel Pump Auto-Failover Function

For the first test run, we are not concerned with validating the Auto-Failover function of the fuel system. Therefore, it is NOT necessary to have adjusted your MANDATORY failover pressure switch. We will return to this before our second test run.

## First Test Run Duration & Location

Your first test run should be limited to no more than one minute. Without the big fan up front, there will not be enough cooling airflow for the motor, so you do not want to cause an overtemp condition. After the first test run, we will take steps to allow the motor to run for longer periods, but not now.

Except for the grin and adrenaline rush, your first test run should be no more eventful than starting a car. Still, it is a good idea to make your initial run outdoors rather than inside a garage or hangar, just in case Murphy chooses to participate. It is always a good idea to have a fire extinguisher on hand. Also, the motor can be expected to produce some smoke as a small amount of oil may be present in the exhaust ports from shipping.

Don't rush the experience. Take your time and make sure all of your systems are fully installed and properly tested. The following checklist should help you determine when the time is right for lighting the fuse.

## Pre Test 1 Checklist - Final Exam!

- Completed fuel system installation per Chapter 5.
- Completed electrical system installation per Chapter 6
- Installed both batteries, making sure they have a good charge and all cables are tight.
- Completed the checklist at the end of Chapter 6, corrected any defects and re-checked as needed.
- Checked all fuel line fittings (supply, return, and vent).
- Checked all coolant hose clamps.
- Checked for smooth operation of fuel selector valve.
- Checked the gascolator drain valve. Is it installed? Tight? Does it work?
- Checked for smooth operation of throttle and throttle cable. If it's dangling, secure it. Pull out for start and idle.
- Checked exhaust header and optional muffler for proper installation and clearance.
- Checked the O2 sensor harness to be sure it has been connected at the header pipe.
- Checked crankcase breather vent tube to be sure it is not rubbing against the hot header pipes.
- Added and verified proper amount of Mobil-1 synthetic 5w/50w oil.
- Added and verified 20 oz. of Mobil-1 synthetic gear oil in PSRU.
- Added and verified proper amount of ORANGE, Long Life anti-freeze mixed 50/50 with distilled water.
- Visually checked all engine wiring and sensors to be sure everything is installed and hooked up.
- Can't think of any other reason why I should not fire this baby up!

## Coolant Check

Your coolant level will naturally drop after the motor is run for a few seconds, and more later on as the motor is run up to full temperature. This is an expected side-effect of purging air from the various cooling and heater passages. Just keep an eye on it so the level remains at or slightly above the center line of the swirl pot. Make sure the cap is tight. If you installed the optional coolant loss sensor circuit, it would be good to test it before adding coolant. The indicator/s should be on when the swirl pot is empty, and should go off shortly after you start adding coolant. If you've included an audible warning mechanism and "silence" switch, make sure they work as expected.

## Lubrication Check

Your oil level may drop slightly after the motor is run for a few seconds. The motors were all run at the factory, but some oil may have drained from passages and the filter during shipping. As these passages fill up again, you may need to top off the oil level.

## Engine Monitoring

During the first test run, we will not be running long enough for the motor to fully warm up. Monitoring temperatures and pressures is always useful, but not strictly required for the initial short duration run. Thus, if your EFIS or EIS is not fully calibrated yet or you are not familiar with them, don't get hung up on playing with them. It is better to pay attention to the motor itself during the first test run. Look and listen for unusual noises, leaks, or sources of smoke. You don't need electronics to tell you when something is seriously wrong. The goal of the first test run is to detect seriously wrong things.

## Priming the Pumps

The very first time you add fuel to your system, it is quite possible that your fuel pumps will not prime without some help. This is because the impeller vanes inside the pumps are completely dry and there is likely to be a whole lot of trapped air pressure in the system.

To get the juices flowing, do the following steps as needed.

- 1 ) Get the fuel lines ready to go. If using a gas can, insert both the supply and return lines into the gas can and raise the can to approx where the wing tanks would be. If using the wing tanks, make sure you've got enough fuel in each tank to cover the pick-up tubes. Drain any water that may be in the wing tank sumps.
- 2) Select the correct tank source with your Fuel Select Valve.
- 3) We need to get fuel into the low-pressure side of the fuel system. This may happen on its own when the pumps are run, or you may need to give things a little boost. A simple way to do this is to remove and fill the gascolator cup with a small amount of fuel. Alternatively, you can open the gascolator drain valve and squirt some fuel into the lines until it flows from the drain. One way to do this is to raise the gas can and start a siphon flowing with a squeeze bulb or apply a VERY SLIGHT (i.e. one quick puff) amount of positive pressure to the can with an air hose. Be safe please!
- 4) Once you have fuel in the primary lines, briefly turn on your Main Fuel Pump. If it still does not prime, as should be obvious by the sound of the

pump, lack of fuel returning from the return line to the gas can, or how about that big red LOW FUEL PRESSURE warning lamp staring at you, then you probably have a large amount of air pressure in the fuel rails preventing the prime. To resolve this, simply remove a hose from the fuel filter or fuel rail supply line (not the return side) and let the pressure out. You can stick the hose into a bottle and run the pump for a moment to see that fuel is emerging. Be careful whenever opening an EFI fuel line, there is a lot of retained pressure. Protect your eyes and just tap the switch briefly. Reconnect and tighten the lines.

5) If you still have no fuel pressure, double-check the polarity of your fuel pump wiring, and contact us for assistance. Obviously, if you don't even hear the pumps running, check your fuses and breakers.

## **Critical Switch Functions & Sequences**

Familiarize yourself with the location and operation of the critical switches. These include the EXP Master, Bus Master, Pump Select, Start, IGN, and Fuel Pump switches. You might be surprised at how many people, myself included, are so startled by the first run that they momentarily forget how to shut the darn thing down! Below is a quick refresher.

### **STARTUP SWITCH SEQUENCE**

- 1) Pull throttle OUT to IDLE
- 2) All breakers IN
- 3) BUS MASTER to NORMAL (up) (Use a switch-guard or pull-out detent on this switch)
- 4) PUMP SELECT to MAIN (up)
- 5) EXP MASTER to ON (up)
- 6) EXP FUEL PUMP to ON (up) - Pump/s should be running
- 7) EXP IGN to ON (up) - ECM Caution Light should be lit
- 8) START (up then release) - ECM Caution Light should go out when motor starts
- 9) EXP ALT to ON (up) - Get those batteries charging!

### **SHUTDOWN SWITCH SEQUENCE**

- 1) Pull throttle OUT to IDLE
- 2) EXP IGN to OFF (down) - Motor stops
- 3) EXP FUEL PUMP to OFF (down) - Pumps Stop
- 4) EXP ALT to OFF (down)
- 5) EXP MASTER to OFF (down)
- 6) BUS MASTER to OFF (center)

### **EMERGENCY SHUTDOWN SWITCH SEQUENCE**

- 1) BUS MASTER to OFF (center) - Everything stops right now!

The BUS MASTER switch will stop the motor immediately. Throwing the EXP MASTER switch or the EXP IGN or EXP FUEL PUMP switches will not always stop the motor because, depending on your BUS MASTER and PUMP SELECT switch positions, this may be seen as an EXP failure and your smart electrical system may fall back on one of its redundant modes. Thus, try to commit to memory that you want to STOP ALL ELECTRICITY to stop the motor. The BUS MASTER switch will always accomplish this in a single throw.

## First Test Run

Two sets of eyes are better than one. Have somebody watching up front while you work the controls. Let them man the fire extinguisher so they feel important. Make sure you clear the area around the exhaust from anything that would blow around. Expect a few moments of pretty sky-blue smoke as the oils burn off the exhaust ports (this is another good reason for doing your initial run outdoors).

Did you forget anything? Witness? Camera? Champagne? etc... Let's rock!

- 1) All breakers in.
- 2) Throttle pulled OUT to IDLE.
- 3) BUS MASTER to NORMAL (up)
- 4) PUMP SELECT to MAIN (up)
- 5) EXP MASTER to ON (up) - Low Fuel Pressure light is ON
- 6) EXP FUEL PUMP to ON (up) - Main Pump should be running, Low Fuel Pressure light is OFF
- 7) EXP IGN to ON (up) - ECM Caution/Fault/Check-Engine Light should be ON
- 8) Open the throttle slightly. You may need to open it a little more during cranking, but get ready to close it when the motors starts. You may be startled by the sound.
- 9) Yell "CLEAR PROP" or perhaps,, "CLEAR PSRU"
- 10) START (up then release) - ECM Caution Light should go OFF when motor starts
- 11) EXP ALT to ON (up) - Get those batteries charging!
- 12) Work the throttle slightly until the motor runs smoothly and is able to maintain a nice idle. Do not over-rev the motor! It will rev up very fast without the prop installed and you can easily red line it. Avoid this.
- 13) Observe and listen for abnormal sights or sounds.
- 14) Record any indicated values for engine pressures, temperatures, and fuel flow.
- 15) Run the motor for no more than one minute.
- 16) SHUTDOWN. Turn the BUS MASTER OFF, or follow the SHUTDOWN CHECKLIST. Don't be so wrapped up in grinning that you forget to turn things off (like I did).
- 17) Mark the time and date in your engine logbook.

***Congratulations!***

## Post Test Run 1 Checks

- Check all fuel fittings and lines for signs of leaks, remedy any problems.
- Check around the header pipes for any signs of heat damage, remedy any problems.
- Check all coolant lines for signs of leaks, remedy any problems.
- Top off the coolant level if necessary.
- Check and top off the oil level if necessary.

## Calibrating the Auto-Failover Pressure Switch

The auto-failover pressure switch is no longer user-settable and does not need to be calibrated. It is factory preset to engage the AUX PUMP whenever fuel pressure drops below 28psi. If your engine has a user-adjustable switch, contact the factory for a replacement.

## Second Test Run

For your second run, we want to run the motor a little bit longer. We are confident now that there are no serious problems to resolve, so we can turn more attention to testing other fuel and ignition system functions. Because we are going to run longer, we need to have monitoring capability for the coolant temperature. Familiarize yourself with whatever monitoring system you are using. It normally takes the motor about five minutes to reach full operating temperature. If you would like to run longer than this, you will need to install some sort of supplementary cooling fans in front of each radiator. This is how we test our motors at the factory. As an alternative, you can now install your cowling and prop.

For this next run, we want to test the ignition modes and fuel pump modes. This includes the following:

- 1) Ability to run in OVERRIDE mode, bypassing the EXP.**
- 2) Ability to run from the AUX Fuel Pump.**
- 3) Ability to auto-failover between MAIN and AUX Fuel Pumps**
- 4) Verify alternator output**
- 5) Since we are running longer, we want to monitor coolant temperature and optionally test the heater.**

Prep the motor for your next run as before.

*WATCH THE DURATION.* The motor will reach full operating temperature in about five minutes, so keep the run shorter than this, or use supplementary cooling fans (or the prop and cowling) to keep things cool.

We will need to disable the Main Fuel Pump at one point in the following test, so make sure you have access to the Main Fuel Pump Fuse before starting.

- 1) Start the motor using your, now memorized, startup procedures.
- 2) Turn ON your heater control valve, but leave the blower fan OFF for now.

- 3) Turn on the EXP ALT switch and verify that the batteries are charging. This can be verified using the optional annunciator panel from ControlVision if installed, or by monitoring the bus voltage and looking for an increase to 13.8 volts or better when the alternator is ON.
- 4) With the motor idling, lower the BUS MASTER switch to the OVERRIDE position and verify that the motor continues to run. Note: Move the switch quickly so you don't linger in the center OFF position.
- 5) Raise the BUS MASTER switch quickly to the NORMAL position and verify that it continues to run.
- 6) Lower the PUMP SELECT switch to the AUX Pump position and verify that it continues to run.
- 7) Center the PUMP SELECT switch to the AUTO position and verify that it continues to run.
- 8) Quickly pull the Main Fuel Pump fuse and verify that the AUX PUMP and indicator lamp come on and the motor continues to run. **DO NOT REPLACE THE FUSE UNTIL THE SYSTEM HAS BEEN SHUT DOWN.**
- 9) Continue to run the motor while monitoring the steady rise in coolant temperature. At approx 190 degrees, the thermostat will open and the temperature will drop a few degrees before starting to rise again.
- 10) Turn on the heater fan briefly to verify that good heat is being produced.
- 11) Record any indicated pressures, temperatures, and flow rates.
- 12) Shutdown the engine and systems before reaching a high temperature (195 degrees max for this run). If you are running with the prop installed or supplementary cooling fans, you should be able to continue the run as long as you like, just keep an eye on the coolant temp.

## Post Second Test Run Checks

- Check coolant level and top off as needed.
- Remedy any other problems observed during the run.
- Make engine logbook entry.

## Third and Subsequent Test Runs

Further testing should be done with the prop and cowling installed. It is OK to perform other short duration test runs as above, but the next goal will be to verify proper operation under loads and higher RPMs. This is best done on a suitable airport ramp in a plane that is ready to fly.

**The goals of the next tests should include:**

- 1) Full static run-up
- 2) Prop pitch variations during run-up
- 4) Smoothness during throttle increases and decreases
- 5) Idle settings
- 6) Operation for greater than five minutes at full takeoff power.
- 7) OPTIONAL - Operation at takeoff attitude.

Test goals number 6 and 7 deserve a little more discussion.

## **"Operation for greater than five minutes at full takeoff power"**

This test will verify that the ECM is performing correctly at higher RPM's than typically used in an automobile installation. The factory ECM employs some programming that is capable of automatic power reduction in the event of a stuck throttle or rollover condition. This capability has been disabled in your powerplant, but this test will validate this point. It will also help to shake out any fuel flow issues or loose parts.

## **"Operation at takeoff attitude"**

This OPTIONAL test involves running the motor with a pilot onboard, the main wheels chocked, brakes fully applied, and the nose of the plane tilted at an angle which simulates takeoff attitude. This can be done by minimizing prop pitch (or better yet, without a prop installed) and either lowering the tail to the ground (a couple of heavy volunteers will do the job) or placing a stand under the nose wheel. Because of the precarious nature of this test, we consider it to be an optional test performed at the builders discretion. The idea is to identify any fuel delivery problems that may arise at high angles of flight (i.e. during your first takeoff). This test has been recommended by prior builders as a way to identify problems with fuel tanks, pickup tubes, trapped air pockets, etc. which would otherwise not be reproducible until actual first flight. Although it seems like an extreme test, finding this type of problem on the ground is far better than during takeoff and these things do indeed occur with some frequency (albiet small) among homebuilt aircraft. A reasonable alternative would be to limit your climb angle during your first flight until you have sufficient altitude and good position for a safe landing, then performing some steep climbs and turns. Discuss this with your EAA Flight Advisor.

## **Before First Flight**

During your first flight, you should not have to worry about your engine; you've got other things on your mind. If you have done a good job with your installation and testing, you will be free to focus on flight characteristics. Before your first flight, we ask that you do the following:

- 1) Drain and replace your engine oil and oil filter.**
- 2) Remove and clean any screens in your gascolator and fuel system components, flushing the tanks is good too.**
- 3) Replace your fuel filter (be careful, the fuel line retains pressure, open and bleed off the pressure slowly, protect your eyes).**

These three steps will assure that no debris has entered your fuel and oil systems which might ruin your day. The cost of oil and filters is trivial and worth the investment.

If at any point during your installation, test process, or subsequent use, you have problems or questions which we could help with, please feel free to check in with our factory and newsgroup.

*Thanks again for purchasing an Eggenfellner Powerplant and  
congratulations on your successful installation and test!*

*Happy flying!*

