Eggenfellner Aircraft Inc.

2007/2008 E6-Series Powerplant Installation Guide

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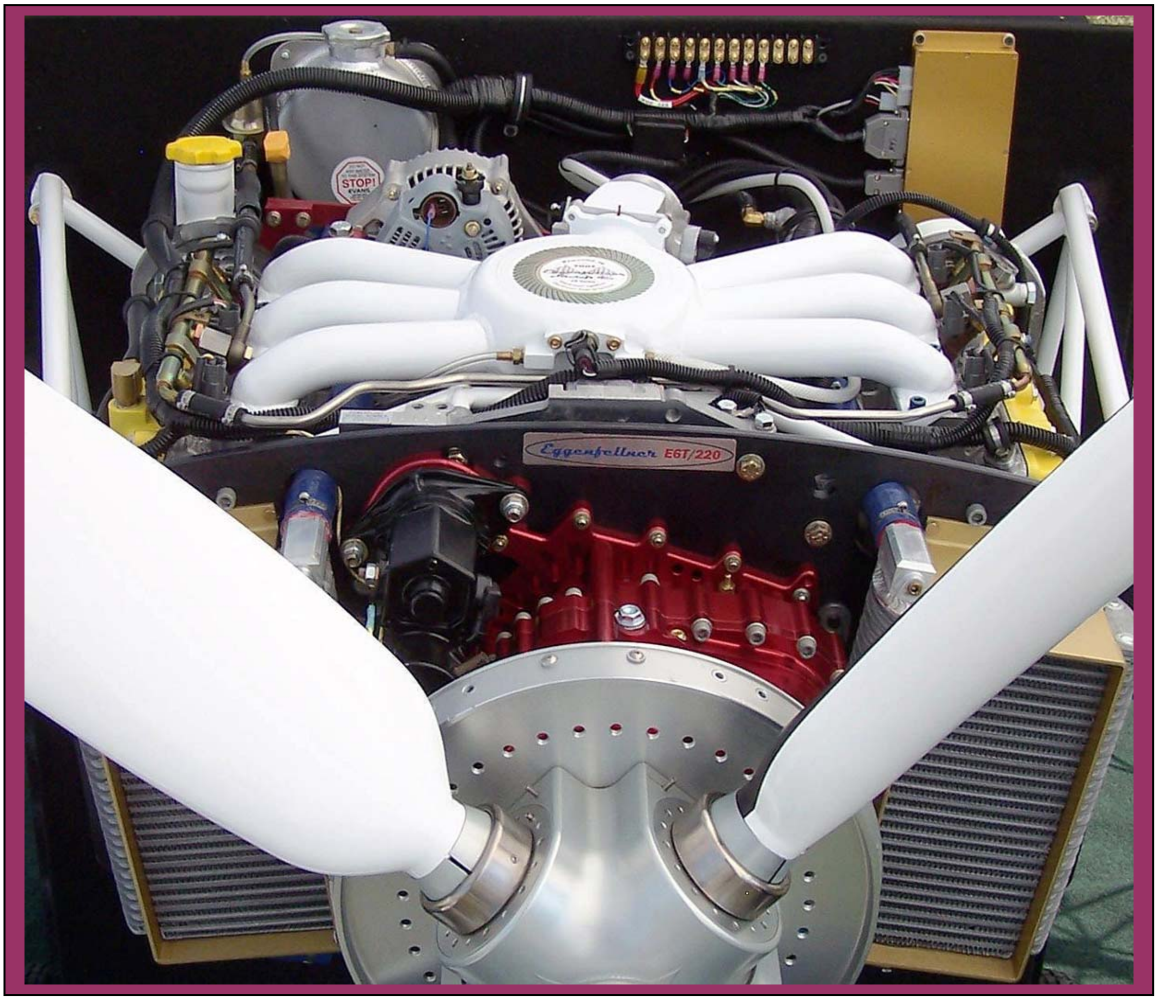


INTRODUCTION

The Eggenfellner "E-Series" powerplants introduced in 2007 have evolved to a point where they are significantly simpler to install than prior model years. This document describes the mechanical, fuel system, and electrical system installation of both the E6/200 (normally aspirated) and E6T/220 (turbo-normalized) model powerplants. The document closes with chapters on maintenance and operation.

Prior Art

The online ***pre-2007*** Installation Guide contains more "general information" that is not repeated in this guide. You are encouraged to review that document, but always consider this document the final authority for technical details relating to the E6-series powerplants.

What will and will not be covered in this guide

In prior years, our Installation Guide has gone into great detail regarding proper practices for wiring, plumbing, etc. Rather than to replicate all of that information, we will instead focus solely on the installation procedures. You are welcome to review the prior guide for practical information.

It is impossible for one guide to cover every conceivable combination of airframe and powerplant. Therefore, we have chosen to utilize one of the more popular kit planes, a VANS RV-10, as the model for installation. Some of the photographs will not directly relate to other aircraft models, but the information will be presented in a manner which is easily adapted.

The installation procedures are broken into several logical chapters:

1. **Mechanical Installation.** How to prepare the airframe and how to mount the powerplant to the airframe.
2. **Plumbing Installation.** How to run fuel, coolant, air, and exhaust “plumbing” between the airframe and powerplant.
3. **Electrical Installation.** How to wire the powerplant to your airframe.
4. **E6T/220 Turbo-Normalized Model.** Specifics of this model.
5. **Engine Operation.** Things you need to know to operate your engine.
6. **Cooling Considerations.** How to keep your cool.
7. **Maintenance.** Keeping your powerplant and its owner happy for years.

Terminology

In prior years, some terminology has confused builders, so let’s get these terms out of the way up-front.

ENGINE = The core internal combustion device, including block, heads, oil pan, valve covers, crankshaft, camshafts, valve train, intake manifold, etc. An engine is also known as a “motor” in many parts of the world.

POWERPLANT = A complete firewall-forward package including engine, engine-mount, cooling system, electrical system, gearbox, etc.

GEARBOX = The Propeller Speed Reduction Unit (aka PSRU). A geared transmission located between the engine and propeller.

ECU = Engine Control Unit. A computer system that controls fuel, ignition and other related functions. Sometimes referred to as the ECM (Engine Control Module) or simply “the computer”.

A Word about Safety

Safety. You should have an ample supply of this on hand! Be sure that your hoist and sling are up to the job, that you have plenty of room on a solid, level floor, and when working with fuel and wires, have good ventilation, and a fire extinguisher standing by. Avoid letting any part of your body be underneath a suspended powerplant or airframe. Always consider what would happen if the powerplant shifted or fell. Be safe!

STORAGE CONSIDERATIONS

Your powerplant will arrive on a standard wooden shipping palette wrapped with a protective plastic film enclosed in a multi-layer cardboard (local) or plywood (long distance) container.

If you intend to install your powerplant within 6 months time, we recommend that you store the powerplant as it was shipped, in a dry location away from temperature and humidity extremes. Keep the plastic film in place to avoid dust buildup.

A small amount of oil may accumulate in the cylinders during shipping and while the powerplant is vertical, but this will burn off in just a few seconds once the engine is running. A short burst of blue exhaust smoke can be expected when first run.

If you intend to store your powerplant for more than 6 months prior to installation, we recommend that you leave the powerplant attached to its wooden shipping palette, but tip the powerplant and palette horizontally as it will be installed in the airframe and support it if necessary by placing a stack of wooden blocks under the front engine mounting plate just inside each radiator. Be sure not to damage the radiators or hoses.

Optionally, you may install engine oil and turn the engine over periodically with the electric starter or even run the engine for short periods of time while on its shipping palette (this is how we run them at the factory). Turning the engine over with the starter helps to distribute oil and keep moisture out of the cylinders. Starting the engine for short periods of time accomplishes the same thing, but can also cause problems with fuel stagnation if the engine sits for long periods of time once fuel has been introduced. If you do choose to run the engine, we recommend adding approximately one cup of Marvel Mystery Oil to each 5 gallons of premium automotive fuel that you use. Run the engine at idle or no higher than a fast idle for no more than two minutes at a time to avoid overheating due to lack of airflow. Small fans alone cannot match the airflow from your propeller!

CHAPTER 1: MECHANICAL INSTALLATION

This chapter covers the preparation of the airframe to receive the powerplant and the mechanical process of installing the powerplant.

Required Tools, Equipment, and Supplies

- Engine Hoist or Fork Lift
- Strong Nylon Tow Strap or four HEAVY DUTY Ratcheting Tie-Down Straps.
- Portable Electric Drill with assorted drill bits including an extra-long 3/8" bit.
- Engine Mount Bolts, Washers, Castle Nuts and Cotter Pins (not supplied).
- "Sharpie" Felt-Tip Marker
- Appropriate tools for cutting a large (approx 2" diameter) hole in your firewall, such as a hole-saw, nibbler and rat tail file.
- General hand-tools to tighten engine mount bolts, etc.

Estimated Time (Mechanical Installation Only)

One person can typically perform the mechanical installation of a powerplant in 2 to 4 hours. Two people can usually reduce this time by about half an hour, while three or more people can easily quadruple the installation time!

General Sequence of Events

The powerplant may be installed prior to, or after, installing the airframe-resident fuel system plumbing and electrical equipment.

Installing the powerplant first, has the added benefits of knowing precisely where the fuel and electrical connections need to be located in the firewall and the weight of the powerplant can help to stabilize the airframe fuselage when climbing aboard to make connections. On the other hand, once the powerplant has been hung on the firewall, you will be required to work around some fairly tight quarters. This often requires 90-degree drills and similar tools.

A good approach to consider is hanging the powerplant in place long enough to take measurements and make markings, then remove it, cut and drill all the holes, then reinstall it. It sounds like more work, but it is actually not that difficult, and it requires fewer specialized tools.

Because of the wide variations of airframes and configurations, it is impossible for the factory to provide all of the location details for fuel lines and electrical wiring in advance.

PLEASE do not make the classic mistake of cutting and drilling holes in your firewall until you have the powerplant sitting in front of you! This is even truer for the E6T/220 powerplants which have a lot more 'stuff' to mount behind the engine.

The gear leg (on most models) will be installed in your engine mount before the powerplant is bolted to the firewall. The powerplant will be positioned against the firewall to take measurements and make marks. The powerplant will be removed and holes will be drilled in the firewall. The powerplant will be reinstalled and attached to the firewall.

If you intend to complete the airframe plumbing (fuel lines, heater hoses, etc.) then skip ahead to the section of this guide titled "Airframe Plumbing" and return here when those tasks have been completed.

Positioning the Airframe

The airframe should be supported on a smooth concrete or paved floor. The firewall should be positioned perpendicular to the floor. For tail-dragger airframes, this requires that the tail be raised and supported by an appropriate means such as a saw-horse, barrel, etc.

If your gear legs are part of the engine mount, the entire fuselage must be supported at a height that allows the powerplant to be installed and the gear legs to be clear of the floor.

BEWARE: The airframe will have a strong tendency to tip nose-down once the weight of the powerplant is on the firewall. For nose-wheel types, this weight can be supported by the nose gear, but for tail-wheel aircraft, the tail must be adequately tied down to something with enough weight to counterbalance the powerplant. The effects of suddenly adding several hundred pounds to your airframe can be unexpected, dangerous, and costly.

Leave yourself plenty of room to the front and sides to maneuver an engine hoist and try to locate a spot where the floor is solid and level underneath the powerplant.

Good lighting is essential. Lighting that rivals the Sun will do fine.

Gear Leg Considerations

For installations where landing gear legs are part of the engine mount, the gear leg assemblies should be present at the time of installation. If you are installing gear leg assemblies that insert into an engine mount tube structure, such as most VANS RV type airframes, the gear leg/s can often be pre-fitted and drilled to the engine mount tube prior to installing the powerplant on the firewall. This is best accomplished with the powerplant resting vertically on its shipping palette. The palette may need to be raised off the floor to fit main-gear legs. Use good judgment here. If your airframe kit manufacturer has a specific procedure for aligning the gear legs *after* the powerplant installation, then USE THE MANUFACTURERS RECOMMENDED PROCEDURE!

NOTE FOR VANS AIRCRAFT BUILDERS

Many of VANS Aircraft models use a single bolt to secure a gear leg through the engine mount. The following description may help you through the process.

Many engine mounts with tube type gear leg sockets have a small pilot hole drilled through one side of the socket tube. The tube itself has already been reamed to remove any welding scale, but it may be necessary to further clean out this tube with a small drum sander in an electric drill. Wipe a small amount of grease on the gear leg and test its fit in the engine mount tube. If it slides into place with 'mild force', you are ready to drill the retaining bolt hole. If not, clean the tube further with your drum sanding bit or a large reamer.

Once the gear leg fits, carefully measure the distance between the lower engine mounting plate bolts and the wheel end of the gear to make sure it is properly aligned before drilling the attachment bolt hole. Mark the position with a sharp felt-tip pen where the gear leg enters the engine mount tube. Clamp the gear leg in this position if you desire.

Using a 0.25" Cobalt drill bit, drill the initial hole through the engine mount tube, starting from the pre-drilled hole, through the gear leg and out the other side of the engine mount tube. Slowly enlarge this hole using subsequent sizes of bits until you are just under the final size for the bolt. Now complete the bolt hole using a precision reamer.

The final fit should be tight enough that the bolt must be pressed into the hole with a small hammer. If it is too loose, you will need to go to the next larger size bolt and try again, more carefully this time.

Some people have found it useful to wrap a blade removed from a set of feeler-gauges around the gear leg at the lower end of the engine mount tube to take up any slop in the fit at this location. This will typically be a very thin blade and it can be held in place with tape or some silicone sealer. Others have drilled and tapped for a small bolt through the engine mount tube on one side to pinch the gear leg at this point. Both of these "tricks" are optional.

Prefetching the Parts

Before large, heavy metal objects are swinging in mid-air, it is wise to locate all of the bolts you anticipate needing as well as those you don't! Read through your airframe instructions if they exist, and line up the tools and hardware you will need.

If engine mount bolts came with your airframe kit, it is almost certain that they will not fit this engine mount! Carefully measure the bolt lengths required for all engine mount bolts and pre-order these parts. Use only AN standard high-quality bolts with washers, castle-nuts, and cotter pins. Washers must be used under both the head and nut of each mounting bolt and it is acceptable to stack up to three washers under the castle nut if required by the available lengths of bolts.

A clean installation benefits from the use of Adel Clamps and assorted small nuts and bolts. As you are routing the various hoses and wires, it is good to have an assortment of these on hand rather than returning to it later on.

OK, at this point, we are ready to rumble, so let's begin a step-by-step procedure…

Lifting the Powerplant

1. Enlist two strong helpers or some old-fashioned ingenuity with your hoist. While still attached to the wooden shipping pallet, tip the powerplant horizontally as it would be installed in the airframe.

2. Support the powerplant in this position by placing a stack of wooden blocks under the engine mounting plate just inside each radiator. Be careful not to damage the radiators or hoses.

   We do not advise supporting the powerplant resting on its prop flange, however it is acceptable to raise the powerplant vertically by the prop flange if you are careful not to scratch or damage it in any way.

   While some prefer to use chains, we have always favored using several strong nylon straps to lift the powerplant, or a combination of the two. This usually results in fewer scratches to the various painted parts.

   If you use a section of chain, try to locate unused threaded holes in the upper engine block with suitable METRIC bolts. A two, three, or four point attachment is required. If you use only two points, you will want to add a ratcheting tie-down strap to the front or rear of the engine to allow it to be tilted and leveled.

   If you use entirely ratcheting tie-down straps or nylon tow straps, be sure to obtain HEAVY DUTY straps, not the cheap thin ones. To use straps, locate a position where each strap can wrap all the way around and under the engine block without damaging anything. It is acceptable to attach straps to the forward engine mount tubes, but avoid attaching them to the firewall-end of the engine mounting tubes as this will interfere with installing the bolts and can deform the engine mount itself. The benefit of using straps is that you can usually achieve a finer degree of leveling.

   WARNING: NEVER ATTACH ANY LIFTING MECHANISM TO THE INTAKE MANIFOLD. It may look strong, but it's just thin aluminum tubing!

Positioning and Marking the Engine Mount

3. Raise the hoist to the height required to install the powerplant and slowly roll it into position. The bottom engine mount bolts are immovable, so they will serve as the initial alignment guides. The upper engine mount tubes remain flexible, to a small degree, so they can be spread slightly as needed later on.

4. Adjust the level of the powerplant or airframe as needed to mate the engine mount to the firewall. When you are satisfied with the alignment of the engine mount, mark the centers of each bolt hole.

Note: If you are installing an E6T/220 powerplant with the optional Intercooler, pay attention to where the intercooler will mount so that it does not conflict with wires, hoses, and fuel lines. Refer to the chapter "E6T/220 Turbo-Normalized Model" for Intercooler details. Similarly, pay attention to where the Air Filter Box assembly will be located. On E6/200 models, the Air Filter Box will be on the PILOTS side, whereas on E6T/220 models, the Air Filter Box will be on the PASSENGER side.

5. Determine and mark where the fuel regulator, fuel supply and fuel return lines need to be located on the firewall. Pay attention to internal structure inside the cabin. Avoid sharp bends in the fuel lines and route them far away from sources of heat or chaffing.

6. Locate and mark the desired position for the bundle of wires to penetrate the firewall. The wire bundle will fall into a 'natural' position somewhere near the upper center of the firewall, however, pay attention to where the throttle cable and coolant reservoir will need to be. The wire bundle location is more flexible than some of these other items.

7. Locate and mark where the coolant reservoir will be located. The pressure cap must be above the top of the engine, as high as possible on the firewall, while still leaving room to remove the cap. The higher the reservoir is mounted, the easier it will be for the engine to purge air from its cooling system.

8. If you are installing a cabin heater, locate and mark where the heater hoses will mate up with the heater fittings. If a cabin heater option was ordered at the time the powerplant was ordered, then a length of blue silicone heater hose will be attached to your engine. This hose will have a split and pair of spring clamps roughly in the center of its length. Do not remove these clamps until you are actually ready to hook up the heater because the engine is full of expensive coolant. These hoses can be clamped during heater installation to prevent losing coolant.

9. Locate and mark where the throttle cable will penetrate the firewall. This will be obvious based on the angle of the red throttle cable bracket. Most builders prefer to use a small stainless-steel "eyeball" fitting to protect the throttle cable as it

passes through the firewall. These are available through most aircraft parts suppliers. A good swivel-eye type bulkhead fitting is Aircraft Spruce's p/n SE961-188B (0.188" dia.).

10. Finally, consider any other firewall mounted equipment such as brake fluid reservoirs, fire extinguisher fittings, etc. before finalizing your marks.

11. Once everything has been marked, remove the powerplant and return it to a safe position on the floor.

Drilling the Holes

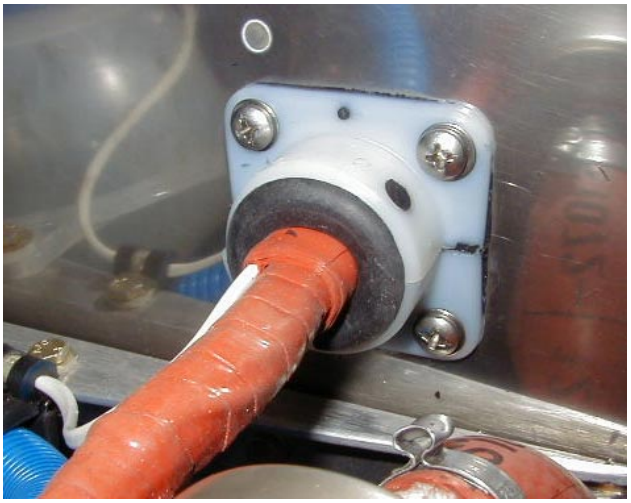
12. Drill the engine mount bolt holes. If you are not confident in the precision of your marks, you may want to drill the holes slightly undersized, and then finalize them by drilling THROUGH the engine mount bushings once the mount is again raised into position. This requires a LONG 3/8” drill bit and possibly a 90-degree electric drill.

13. Drill the fuel line bulkhead fitting holes. Note, if you are using one of our through-firewall-fuel-filters, drill the appropriate sized hole to install this filter, and the surrounding rivet/screw holes, leaving enough space for servicing the filter element. The filter element is to be serviced from the engine side of the firewall.

14. Drill mounting holes for the coolant reservoir. If your firewall is slanted away from perpendicular, you may need to fabricate some small brackets to hold the canister in a perpendicular manner. As stated previously, the coolant reservoir needs to be as high as possible above the top of the engine to allow for efficient dispersal of air from the cooling system.

15. Cut the opening for the bundle of wiring to pass through into the cabin. This can be done with a large hole-saw or a nibbler or just a ring of smaller holes cleaned up with a rat tail file. The size of this opening must accommodate the various connectors that attach to your engine control unit (ECU). Consider how you wish to seal up this opening once the bundle has been installed. Some builders make a two-piece stainless steel plate to screw or rivet over the opening, reducing the size of the cutout to just what is required by the wires themselves. If you do this, be sure there are no sharp edges that can chafe through the wires. Aircraft part vendors also offer a variety of firewall fittings to serve this purpose. Die hard builders might desire to use a Cannon Plug on their firewalls. This is fine as long as high quality parts and procedures are used.

    Below are some photos showing how to install a nylon bulkhead seal.

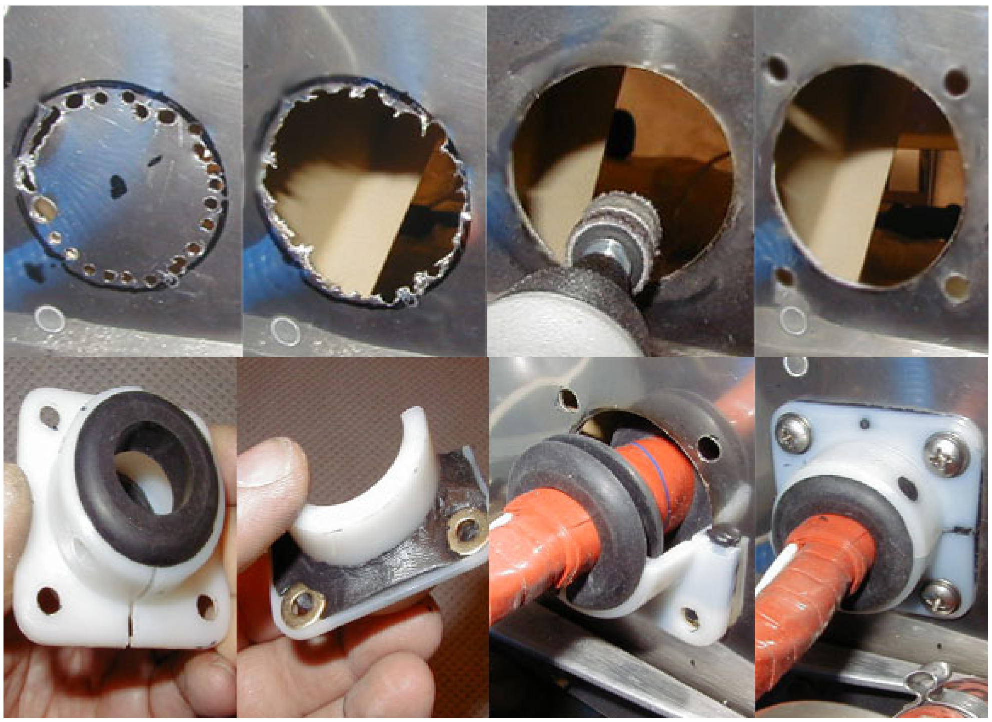


A nice firewall pass-through example.

Aircraft Spruce p/n NMCS45A-11,

Grommet p/n AN931-11-16 (you need 2 grommets)

A picture is worth a thousand words, so here's the whole sequence in pictures.



TIP: If your airframe vendor provided you with a nice piece of stainless-steel for a firewall, POLISH IT NOW. Nothing looks better or is easier to keep clean than a piece of highly polished stainless steel. A few minutes of elbow grease now will make for years of pride when showing off your powerplant. "Never Dull" polishing wool or a tube of "Semichrome" polish works well.

Attaching the Powerplant

16. Place a washer under the head of the two bottom-outer engine mount bolts and insert the pair of bolts from the inside of the airframe cabin protruding out through the firewall. Some duct tape helps to hold the bolts in place if they are easily moved.

17. Raise the powerplant into position again. Position the engine mount so that these lower two bolts slide into place through the mount. Loosely fasten these bolts with a washer and castle nut.

18. Continue positioning the engine mount as needed to align and insert the remaining lower engine mount bolts. Beware that there may be substantial downward force on the lower engine mount “V-Brace” (typically a “V’ shaped tube assembly). It may be necessary to apply some lifting force to the rear of the engine to get this brace and its bolts into alignment. If this gives you trouble, just ignore these bolts for now and return to them once the remaining engine mount bolts are secured. Once the powerplant is resting under its own weight, it is easier to raise the rear of the engine with your hoist or a floor jack to align these last bolts. In worst-case situations, you may need to loosen or remove the lower V-Brace bolt and cushions to get the V-Brace bolted up.

19. Align the upper engine mount tubes and insert the remaining bolts. These upper mount tubes can be spread or narrowed slightly as needed to align the bolts.

20. Once all the bolts are in position, tighten the nuts to their proper torque (refer to your manufacturers specifications or the Standard Aircraft Handbook) and insert the cotter pins.

21. Slowly lower the engine hoist. Pay attention to what the tail and gear legs are doing! Adjust or prop things up to prevent damage. You may want to take the time to install your wheels and tires before lowering the now-heavier airframe. If the fuselage tips easily, you may want to leave the hoist attached a while longer as you finish the installation. Often the empennage must be installed before tail weight is sufficient to prevent tipping. If things are solid, go ahead and remove the hoist and straps.

22. Take a break and admire your project!

Setting the Tail-Pipe Angle (E6/200 Only)

Non-turbocharged powerplants that were ordered with the in-cowl exhaust system and muffler will need to have the tail pipe installed once the powerplant is mounted.

REQUIRED TOOLS:

- 1/8” and 1/4” drill bits and electric drill
- Hacksaw or cutting wheel & die grinder
- 7/16” wrenches.
- Felt-tip pen.
- Flat File

Lock Pin & Clamp

1. The in-cowl muffler is suspended by the pair of inlet header pipes and a single strap between the rear of the muffler and the lower engine mount. You can adjust the angle of the tail pipe by altering the length of this mounting strap. If necessary, the muffler can be removed and flipped over to place the exit on the opposite side of the cowl exit area and slightly higher.

2. Remove the clamp and stainless steel lock pin from the tail pipe and set them aside.

3. Slip the tail pipe over the muffler exit tube.

4. Verify the desired angle of the tail pipe. If you need to adjust the angle, remove the muffler mounting strap and use the tail pipe to twist the muffler to the desired position. Once you have verified that there is no interference between the tail pipe, cowl, engine mount, nose gear (if so equipped) or any other object, hold the mounting strap into place, mark and drill a new hole in the strap, then reattach the strap.

5. Determine the desired length of the tail pipe. The tail pipe should always tilt slightly towards the rear of the aircraft but not so much that engine noise reverberates off the

fuselage bottom. Pointing the exhaust stream downward, away from the aircraft, makes for a quieter cabin environment.

6. Using a felt-tip pen, mark the desired length and angle to cut the tail pipe. Be sure to extend the pipe at least an inch below the OPEN cowl flap position.

7. Using a hacksaw, cut the tail pipe to length. Touch up the cut with a file if needed.

8. Reinstall the tail pipe and rotate it so that you have easy access to the ¼" lock pin hole in the tail pipe.

9. Using a ¼" drill bit and slow speed, drill through the hole in the tail pipe and through the muffler exit tube (one side only, not all the way through).

10. Insert the ¼" lock pin through both the tail pipe and muffler exit tube.

11. Install the stainless steel T-clamp around the tail pipe being certain to position the 1/8" tip of the lock pin into the hole in the clamp. The clamp can be tricky to install. It is best to completely loosen or remove the lock nut and rotate the clamp over the lock pin until the tip of the pin falls into the hole in the clamp. Do not attempt to completely separate the clamp as the T-bar will be difficult to reinstall.

12. Tighten the T-clamp just enough to secure the lock pin and prevent rattling. You will note that none of the tubing joints in the exhaust system have crush-type clamps such as you might use in a car. These stainless pipes have tight fitting joints that typically do no require crush type clamps. If you use crush type clamps, they will be difficult to service later on.

CHAPTER 2: PLUMBING INSTALLATION

This chapter covers the installation of engine related plumbing, focusing on firewall-forward, but also describing the related "Airframe Plumbing" in a later section with the same title. "Plumbing" includes all fuel, coolant, vents, and air duct installation.

Attaching the Fuel Lines

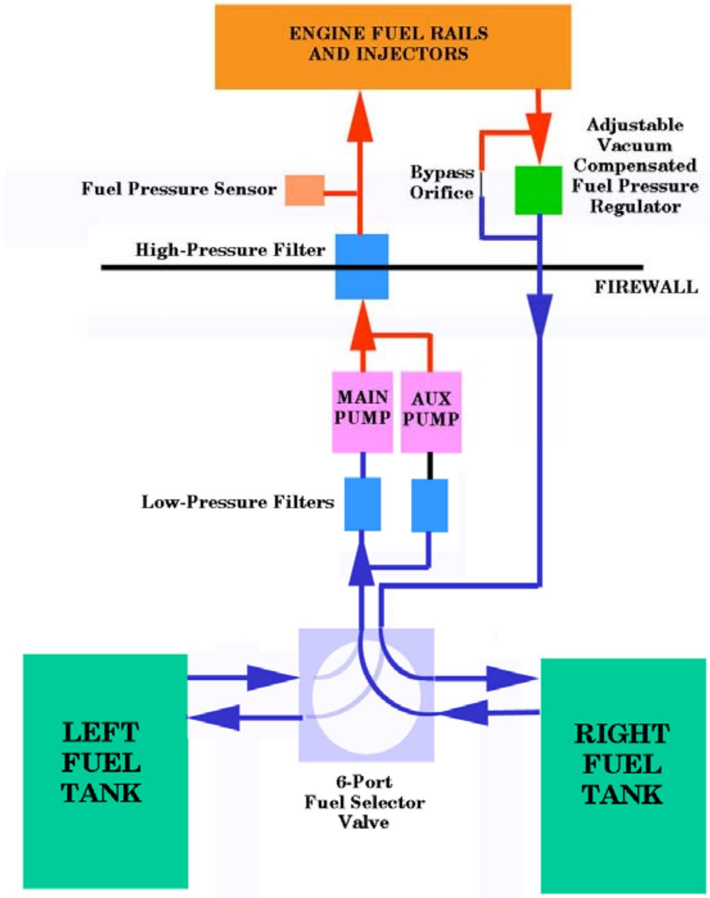
CAUTION: Use extreme care when installing barbed fittings into flexible hose so as to avoid cutting small shards of material inside the hose. More than a few new aircraft have failed due to fuel hose debris in the fuel lines.

TIP: We highly recommend the use of Oetiker clamps (as found everywhere else on our powerplants) or "fuel injection" type screw clamps. NEVER use automotive worm-drive screw clamps as these will ultimately damage your hoses and come loose.

TIP: We recommend the use of "Fire-sleeve" over the sections of fuel hose that connect the engine to the firewall fittings. This is available from any good aircraft parts supplier. Fire-sleeve protects the fuel lines from heat, vibration and abrasion.

Your engine requires what is known as a "FULL-LOOP" fuel system. Fuel injected engines require a continuous supply of high-pressure fuel to the injectors. In order to provide this fuel supply and to eliminate concern for "vapor lock", your powerplant uses a fuel system where cold fuel is continuously pumped through a loop that passes each injector and any excess fuel that is not consumed by the engine is returned to the same fuel tank it was sourced from. The fuel in this loop is naturally heated by the close proximity to the engine, so by continuously pumping more fuel than is required, we assure a steady stream of cold fuel. Any vapor bubbles are rapidly swept away.

The following is a useful diagram of the full loop fuel system. Become familiar with this diagram for installation, maintenance and operational reasons. Consider making this diagram a part of your Pilots and Owners Handbook.



Fuel pressure is regulated by a Fuel Pressure Regulator located on the return-side (Passenger side) of the engine fuel line. This regulator is adjustable, but is factory pre-set to the proper 40psi. A small vacuum line between the manifold and regulator will automatically adjust fuel pressure slightly based on engine load. We will cover the fuel pressure adjustment in the maintenance chapter of this guide.

Your fuel system is equipped with an additional device which is designed to prevent vapor lock. If you examine the fuel hose plumbing around the regulator, you will notice that a small section of fuel tube appears to 'bypass' the regulator. Along this bypass tube, there exists a small fitting containing internally, a tiny orifice. This is known as the "Pressure Bleed Bypass". Aircraft fuel systems can encounter sudden pockets of air in the fuel system. For example, if you un-port a fuel tank pickup in a steep maneuver on low fuel. If this happens, it would be possible for enough air to make it into the fuel rail that the fuel pump cavitates and temporarily looses its prime. The Pressure Bleed Bypass assures that there is always a low-pressure escape route for fuel and any trapped air, thus assuring quick recovery by the pump. If vapor can never be "locked" then you should never suffer from vapor-lock.

We will cover the airframe side of the fuel system installation a little later. For now, we are only interested in connecting the engine side of the fuel system to the firewall bulkhead fittings.

Fuel Supply Line & Filter

The fuel line on the pilot's side of the engine is the fuel supply line. There must be a high-pressure, high-volume, fuel filter in this line! This can be one of our through-firewall fuel filters, or other suitable EFI (Electronic Fuel Injection) type of filter. Refer to the "Maintenance" section for recommended part numbers. Avoid the use of "pretty" automotive filters as most of these cannot handle the high-pressure and high-volume required. Be sure your filter can handle at least 60psi and 40gph.

The fuel supply line provided is "Fuel Injection" hose. This is high-pressure hose. Never replace this hose with any type not rated for high-pressure fuel injection use.

The Subaru engine uses 5/16" inside diameter hose. This equates to AN-5 fittings. These fittings are somewhat uncommon, but available through good aircraft part suppliers. Some builders have chosen to adapt to AN-6 (3/8") fittings and hoses. This is fine as long as proper fittings and hoses are selected. Never reduce the size of lines to AN-4 (1/4") as this will excessively restrict fuel flow.

1. Having measured, marked, and drilled holes for your supply fuel line. Install either the through-firewall-filter option or obtain and install appropriate AN bulkhead fittings through the firewall. It is common practice to use steel fittings at the firewall for improved vibration and corrosion resistance. However, this is not strictly required on experimental aircraft.

2. Protect the exposed fuel supply line with fire-sleeve or a section of high temperature flexible conduit.

3. Trim the fuel supply line as needed to mate with the firewall bulkhead fitting and install the correct barbed-to-AN fitting into the hose. Use an Oetiker clamp or fuel-injection type screw clamp.

4. Attach the fuel supply line to the firewall bulkhead fitting.

Fuel Return Line

The fuel line on the passenger's side of the engine, attached to the bottom of the Fuel Pressure Regulator, is the fuel return line.

5. Protect the exposed fuel return line with fire-sleeve or a section of high temperature flexible conduit.

6. Mate the fuel return line with an appropriate bulkhead fitting. Trim and clamp as needed. A small brass barb-to-AN5 (5/16") fitting was provided for your use. A variety of other fitting types are available.

Fuel Pressure Regulator Adjustment

The Fuel Pressure Regulator was preset at the factory to provide 40psi "static" pressure with the engine turned OFF and one fuel pump turned ON. If after installation, your instrumentation does not read precisely 40psi under these conditions, you can adjust the regulator by loosening the lock nut under the adjustment bolt (where the vacuum tube is attached), slowly turn the adjustment bolt until you read 40psi, then tighten the lock nut.

When the engine is running, fuel pressure is adjusted slightly based on the current manifold pressure. Only adjust the regulator under static conditions, engine OFF and one fuel pump ON.

Attaching the Coolant Hoses

If you are installing a cabin heater option, you can go ahead and install the heater unit now, or skip this section and return to it later on. When the heater has been installed in the cabin, a pair of copper barbs will protrude through the firewall to make the heater hose connections. In aircraft with particularly cramped installations or having a heater mounted further back in the cabin, additional ½" solid aluminum tubing will need to be routed through the airframe to connect the heater to firewall bulkhead fittings. Never use long lengths of silicone tubing inside the airframe. It is heavy and easily punctured.

If you purchased a cabin heater kit, your powerplant will already be plumbed with a section of hose required to mate up with your cabin heater. Look for the long loop of blue silicone hose containing a pair of spring clamps in the middle of the loop. The splice between these two spring clamps is where you will open up this hose and attach the ends to your cabin heater. The splice fitting itself can be discarded.

CAUTION: Your engine contains very expensive lifetime coolant. Before you open up this heater hose connection, locate a clean container of at least 2 gallon capacity and be prepared to catch the coolant as it drains out of this hose.

TIP: As a less messy alternative, consider gently clamping the hose on both sides of the splice with small pieces of wood and pairs of clamps or vise-grips to prevent coolant from pouring out. It should only take a moment to hook up and clamp these hose connections, and the little loss of coolant sure beats completely draining it. Be sure to consider how much hose will need to be trimmed before deciding where to clamp the hoses.

1. Drain your coolant into a reusable container or clamp your heater hose on each side of the splice to prevent coolant loss.

2. Route the two sections of heater hose to mate up with the heater barbs at the firewall. Trim the hoses as needed. Be sure to route all coolant hoses away from exhaust pipes, mufflers, and any sharp objects that may chafe or puncture the hoses. Use Adel clamps as needed to secure all coolant hoses. Consider that there may be 200+ mph winds inside your cowl!

3. Clamp the hose connections with Oetiker clamps or reuse the provided spring clamps.

4. Release the hose clamps holding back Niagra Falls, or refill your coolant reservoir. Some amount of coolant loss is to be expected when installing a heater. The heater core itself will consume about a pint of coolant. Some extra NPG+ coolant should have been provided with your powerplant. If not, it can be ordered through the factory or directly from www.evanscooling.com

Coolant Overflow Tube

5. Your coolant reservoir has a small overflow hose that should also be routed down to the cowl exit area. Normally, the coolant reservoir remains between one third and one half full of coolant. Any higher and the coolant will be pushed out the pressure cap and down this tube. Before your system has settled down to the proper level, you can expect some overflow when the engine is hot. A common practice is to provide a "catch can" for this overflow. This can be as simple as a small can that is periodically emptied, or a fully functional "recovery canister" that draws any excess fluid back into the coolant reservoir as the engine cools down. Once your reservoir has found its proper level, very seldom does any more overflow occur.

Coolant Pressure Cap

Your engine comes with a relatively low 7-psi pressure cap on the coolant reservoir. Conventional automobile systems pressurize the cooling system to 20psi or greater to raise the boiling point of the coolant. Because our powerplants do not use water or conventional antifreeze, we have no need to pressurize the system any more than necessary. Our NPG+ coolant has a boiling point of 375F. Far above what your engine will ever reach. Since it is not necessary to run high pressure, it is desirable to minimize pressure to reduce fatigue on hoses, clamps, gaskets, etc. A tiny amount of pressure is desirable for pump efficiency. If you ever change your cap, stick with 7-psi.

Engine Breather Tube

6. Route and secure the engine breather tube. This black tube runs between a brass fitting on the passenger side engine valve cover to the cowl exit area. Simply

verify that the tube is pointing out the cowl exit and facing rearward to disperse crankcase vapors overboard. It is normal for a small amount of water and oil vapor to exit this tube. In a pollution-controlled automobile, a PVC (Positive Crankcase Vent) valve would be installed in this hose and the vapor would be routed back into the intake manifold to be re-burned. As the engine ages, the amount of vapor will increase slightly. If you ever have the unfortunate experience of "blowing a piston" the vapor will be substantial.

AIRFRAME PLUMBING

In this section we will examine the plumbing of the airframe itself.

Most conventional aircraft have two fuel tanks, one in each wing. Some have additional header tanks (typically a smaller tank to collect fuel at a level closer to the engine) and auxiliary tanks. We will not get into plumbing of auxiliary tanks, but we will mention the proper way to implement a header tank as some of our customers will be required to use these.

If you have been reading the prior sections, you'll understand that our fuel system requires a continuous flowing "loop" of fuel between the aircrafts fuel tank, the engine, and back to the tank again. The fuel in this loop is held at a controlled pressure of 40psi by a fuel regulator and the engine injects only a small portion of the total volume of fuel that passes through this loop. Approximately 35 gallons per hour move through the loop.

This system assures a steady and ample supply of relatively cold fuel and helps to sweep away any heat and vapor bubbles that may develop in the system. If you place your hand on the engines fuel-rail then turn on the fuel pump, you will instantly notice the temperature of the fuel rail drop!

To accomplish this full loop system, the airframe requires some additional plumbing that is not typically found on gravity feed systems.

First, **the tank supplying the fuel must also be the tank we return unused fuel to**, otherwise we would eventually transfer all our fuel and overflow the return side tank or run the supply side tank empty! *I know what you're thinking, but please don't get "creative" with this. It is far too easy to make a mistake and find your fuel has gone somewhere you didn't intend.*

To guarantee that the supply tank is also the return tank, we use a 6-port fuel selector valve. This valve has two distinct valve segments (spools), one for supply lines and one for return lines. When you select a tank, you select it for both supply and return. Thus two ports connect to each tank (a supply and a return) and the remaining two ports go to the engine (also a supply and return).

Secondly, **each fuel tank must be fitted with a return line.** Because the engine will consume some of the fuel, the return line can be slightly smaller than the supply line, or it can be the same size if you prefer. For the airframe supply lines, we require the use of 3/8" ID aluminum fuel tubing and AN-6 fittings. For the airframe return lines we recommend the use of 5/16" ID aluminum tubing and AN-5 fittings, however you can also use the larger lines for return if you want to keep all of your plumbing consistent. AN-5 fittings are somewhat harder to find, but are stocked by Aircraft Spruce and others.

The return lines run from the 6-port selector valve to each fuel tank. At the fuel tanks, this return line is typically connected to a bulkhead fitting in the side of the tank access panel or end panel. Inside each tank, it is important to install a short section of tubing that returns the fuel far enough away from the fuel pickup line as to avoid simply recycling the hot, vaporous, return fuel right back into the pickup tube! It is not necessary to go more than a foot or two away from the pickup tube. This gives the fuel a chance to mingle with cool fuel and to disperse any vapor bubbles.

Fuel Valve Installation

The 6-port fuel valve is to be located as close to the floor of the fuselage as possible to avoid having to pump fuel up-hill. Many of the popular kit planes provide a perfect spot for the valve, but for some there will be limited room to make all of the connections. To help out, we now offer these valves in two line styles, including one that has 90-degree fittings for tight spaces. These are favored for RV-10 aircraft in particular. Additionally, valve shaft extensions are available to fit most center console installations.

Below is an example of a good valve installation. Notice the smooth bends with large bend radius. These bends were made with a $20 tubing bender purchased at a local home building store (and a little practice). Never settle for dented or twisted tubes! Tubing is inexpensive compared to tubing failures. Expect to scrap several pieces before you get the feel for this process. The flare fittings are 37-degree flares made with a quality aircraft flaring tool. These tools cost approx $100 but are a good investment.

Words of wisdom; wherever possible, install the flare nut and make the flared end before bending the tube and always remember to put the sleeve and nut onto the tube before flaring the tube! You'll see….

This is an Andair 6-port valve installed in the center console of a VANS RV-9A.

Tighter consoles will benefit from one of our new valves that have built-in 90-degree fittings.

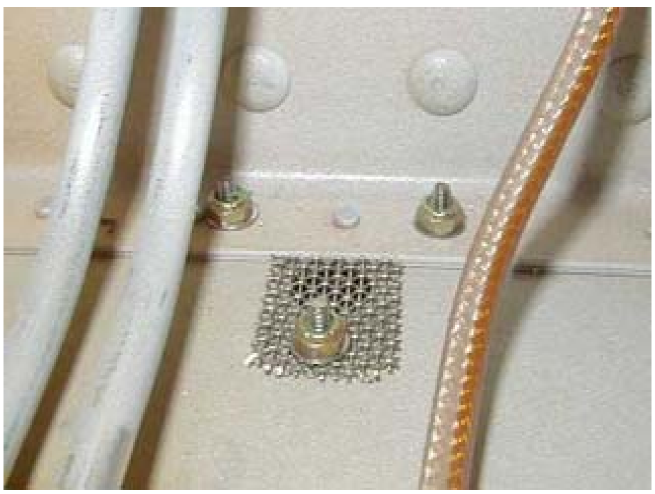
Shaft extensions are now available to mount the valve even lower than shown here.

In the above photo, you can see the pairs of tubes coming in from the left and right tanks and the center pair of tubes heading forward to the engine. The upper tubes are all 3/8" supply lines, while the lower tubes are 5/16" return lines.

Be sure that all of your flared ends seat squarely on their fittings. Never allow a flare nut to pull the tube into place! This creates strain on the flared fitting that can result in a future crack and leak. If a tube doesn't sit squarely on its fitting, bend it some more or make another tube that does fit. Never use Teflon thread tape or other sealants on flared fittings.

Installing a Cabin Floor Drain

Always consider what will happen if a fuel line, valve, filter, or other component should spring a leak inside your cabin! It is a very simple task to make a barrier around areas that house fuel components and provide a drain and vent system. Below is a simple example of how this can be done.



This floor drain is nothing more than a hole drilled through the bottom skin with a small section of stainless-steel mesh to keep insects out.

In the event of a fuel leak, this will prevent fuel from spreading through the cabin.

A similar vent hole allows fresh air to circulate in the fuel area.

Fuel Pump Installation

The dual fuel pumps and low-pressure filters are typically plumbed together with flexible fuel injection hose when they arrive from the factory to give you an idea of how they are to be arranged. You can transfer this setup directly to your airframe or you can create your own design.

Below is a photo of the pumps as they are shipped from the factory.

Fuel flows from the fuel tanks into the selector valve then through the hose on the left, through the low-pressure filters and into the pumps. The pump outputs tee together and a single line runs forward to the firewall, through a high-pressure filter, then to the fuel rail.

The electric pumps each require a power wire and a ground wire. The polarity of the wires is marked on the pump terminals. For obvious reasons, you want to make very solid, reliable, electrical connections to fuel pumps and route the wiring away from the pumps as directly as possible. Silicone boots are a good addition to pump connections. Pumps normally draw between 4 (unloaded) and 7 (restricted) amps of electrical current, so be sure to use a suitable gauge wire for both power and ground connections. This is also dependent on the length of the wire, but typically these will be between 18 and 14 gauge wire.

The pumps themselves should be rubber-mounted to the floor of the aircraft cabin or a suitable sub-floor bracket. It is important to mount the pumps as low as practical to improve their ability to prime themselves and to restrict potential fuel leaks to the floor area. The pumps come from the factory with simple brackets and rubber cushion clamps that will allow you to make a suitable installation.

Finally, the fuel pumps make a noticeable whining sound when running. When closed into a console or floor panel, the sound will not be noticeable over the engine and propeller sound. It is reassuring to be able to hear the pumps during engine startup.

Below is one example of how prior builders have added their own creativity to fuel pump installation.

This builder replaced most of the hose with metal tubing and mounted the pumps on a nice set of brackets.

Small sections of tubing at the pump connections are for maintenance and vibration isolation purposes.

The two check-valves were not required because the pumps have their own internal check valves.

Filters, Strainers, Screens, and Gascolators

Several filters are required in your fuel system.   Let's review each one.

1. Typically, each fuel tank pickup tube will have some form of screen over it to avoid becoming blocked by large debris that may fall into the tanks while fueling.

2. Prior to the pump inlets a low-pressure/high-volume fuel filter is required to capture particles that may block internal passages within the pump or cause premature failure of the pump.   These are typically 100 micron filter elements. Because the fuel at this point is not yet pressurized, these filters need only be able to handle the volume of fuel that passes through them, approximately 35 gallons per hour.   Typically one such filter should be provided for each pump, however some builders have chosen to use a single high-quality filter canister and some have even chosen to filter the fuel from each tank prior to the fuel select valve. We recommend placing individual filters directly in front of each pump to minimize pump priming issues.   **We do not support the idea that the backup pump should have no filter!**

   These low-pressure filters should be replaced shortly after your first flight since that is when a lot of construction debris is present and then during each annual inspection.   Because they will be serviced often, give some thought to their accessibility and capture or draining of the fuel that will inevitably leak during filter changes.   Replace any short rubber hose sections each time you replace filters. Use smooth fuel-injection type screw clamps or Oetiker clamps only.

3. Internal to each fuel pump is a small check-valve and another screen.   These are fairly coarse screens only intended to protect the check valves.   They are not serviceable.   The check-valves prevent one pump from pushing fuel back through the other non-running pump and prevent bleed pressure losses in the fuel system.

4. After leaving the fuel pumps, pressurized fuel is routed to the firewall and a high-pressure/high-volume filter.   This filter is typically a 70 micron filter element. This filter must be able to handle at least 60 psi pressure and 35 gallons per hour

flow. This is typical of a "fuel-injection" type filter. You can purchase these at automotive parts stores, through an aircraft or auto racing parts supplier, or better yet, through our factory. We sell a combination firewall-bulkhead-fitting and fuel filter that has a quick disconnect body to allow filter inspection.

5. Leaving the high-pressure filter, fuel is routed around the fuel injector rails. Each fuel injector has an extremely fine mesh screen inside it. This is the last point of filtration. Occasionally we find fuel injectors that are clogged or stuck, usually due to stale fuel that has gummed up the works. You can remove the injector rails, being careful not to lose or damage the o-ring seals, and clean the injector screens with spray carburetor cleaner. If the injector is stuck, you can take them to an automotive repair shop equipped to clean injectors or you may trigger them with a 9-volt transistor battery while spraying carburetor cleaner through them. ***If you do this, obviously attach wires to the injector and make the electrical connections far away from flammable solvents!***

6. The fuel pressure regulator has its own internal screen to protect its valve. This is not serviceable. If the pressure regulator fails, it must be replaced.

Gascolators & Water Drains

Over the years we have experimented with a number of different gascolators and water drains. It is our conclusion that small gascolators are not very effective in full loop fuel systems due to the sheer volume of fuel flowing through them. Any water that may be trapped in a gascolator is quickly swept up into the flow again unless the gascolator is very large. Gascolators do provide a coarse screen filter, but that's about their only real benefit in our system.

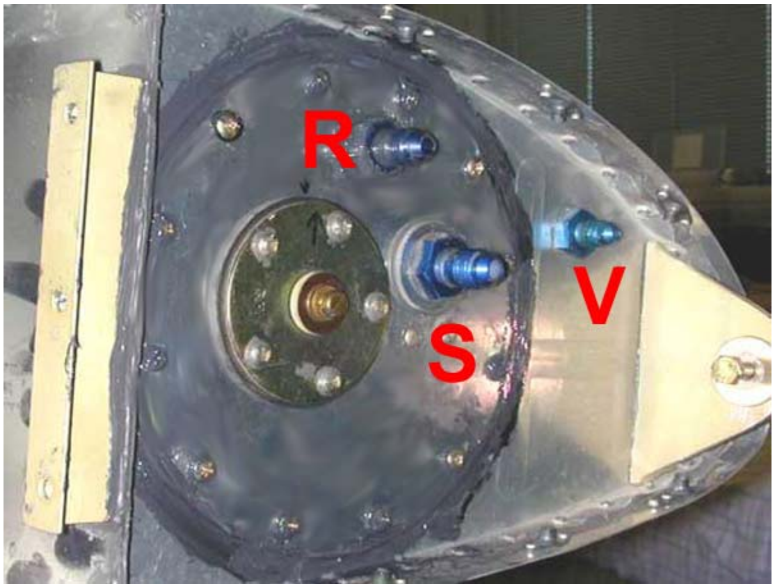
Water drainage should be accomplished with sump drains in the gas tanks.

These engines are very robust when it comes to water ingestion. Water will usually pass right through the full loop back to the tanks or it will be sprayed through the injectors along with the fuel. If care is taken to assure fuel quality and the tank sumps are drained, there is no need for further drainage.

A warning to die-hard gascolator fans. If you use a spring "poppet" type drain valve in a gascolator, it is entirely possible that the pumps will draw air INTO the system through these drain valves! A tiny tear in an o-ring or a piece of dirt under the o-ring seat results in a path of least resistance for air. Always use a positive seating drain valve such as a needle valve.

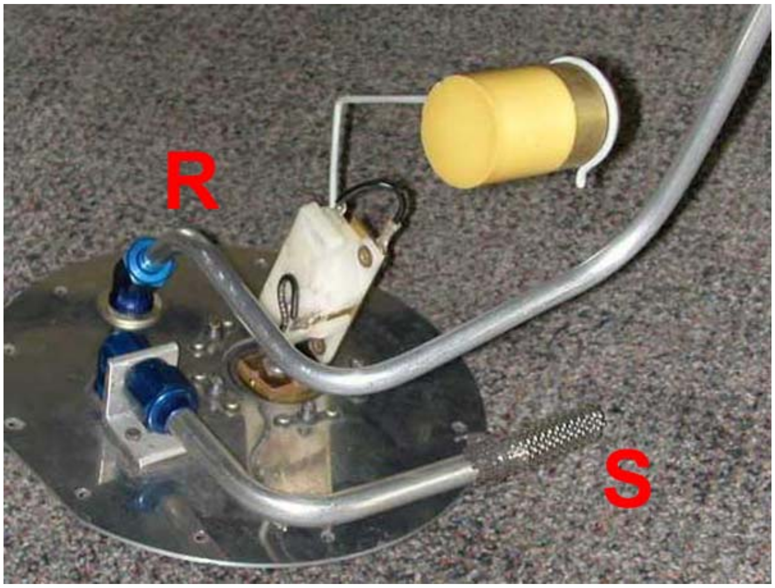
Fuel Return Line

Our full-loop fuel system must ultimately return unused fuel to the fuel tanks. This requires the installation of a second fuel line between the fuel selector valve and a bulkhead fitting for each fuel tank (high-wing aircraft builders, read the next topic too).



This photo shows a typical VANS aircraft fuel tank with an additional bulkhead fitting installed in the access plate for the fuel return line ("R"). The other two are the supply line ("S") and vent ("V").

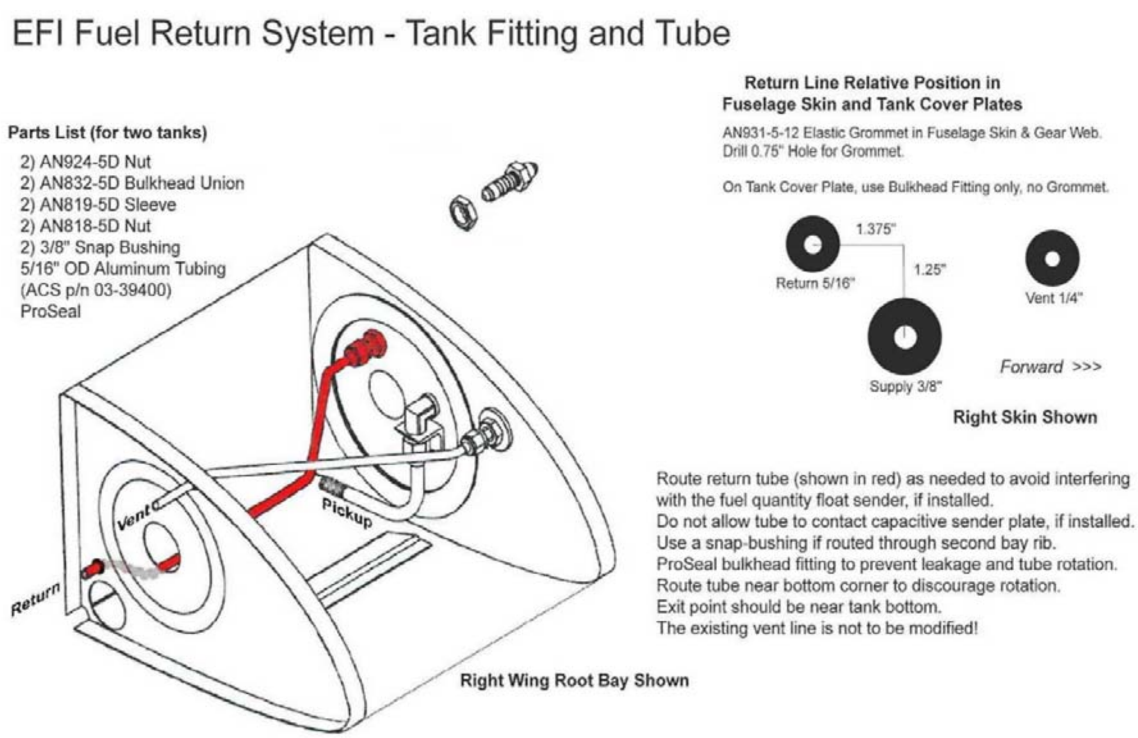
The return line can also go on the rib instead of the access plate if that is simpler to construct.



Inside view of a typical fuel tank access panel.

Be sure the return line does not interfere with the fuel quantity float.

The return line is about 18" long to return the fuel far away from the supply line pickup tube.



Fuel Quantity Senders

While on the subject of fuel systems, we have learned from experience that “capacitive” type fuel senders are undesirable for aircraft that can use both 100LL and automotive fuels due to the difference in dielectric properties of these fuels. The variation in quantity indication can be as high as 10% and is unpredictable when the two fuels are mixed. A good old-fashioned float type sender will treat you better and doesn’t care what fuel is in the tank.

High Wingers and Header Tanks

High wing aircraft have an advantage over low wing aircraft in that they can use gravity to assist with fuel flow. However, they are also subject to a different set of problems than most low wing aircraft. Some of the more common high wing kit planes have folding wings, fiberglass tanks, very tight space around the fuel tank root panels, and problems with un-porting fuel pickup tubes in certain flight attitudes. For this reason, the manufacturers have implemented small “header tanks” in the door columns or behind the seats. These headers were intended to act as accumulators for enough fuel to ride through a temporarily un-ported tank.

If possible and practical, it is always best to provide the full return fuel line plumbing to each MAIN tank, even in high-wing aircraft.

If this is not possible or practical, then the next best solution is to provide a "common header tank" located behind the front seats or under the floor. Each wing will supply fuel to this common header tank and the engine will draw fuel from this tank alone and return fuel to this tank alone. If the aircraft is equipped with small door column header tanks, these can be left as-is, upstream of the common header tank, or they can be removed as they really serve no purpose that the common header tank can't fulfill.

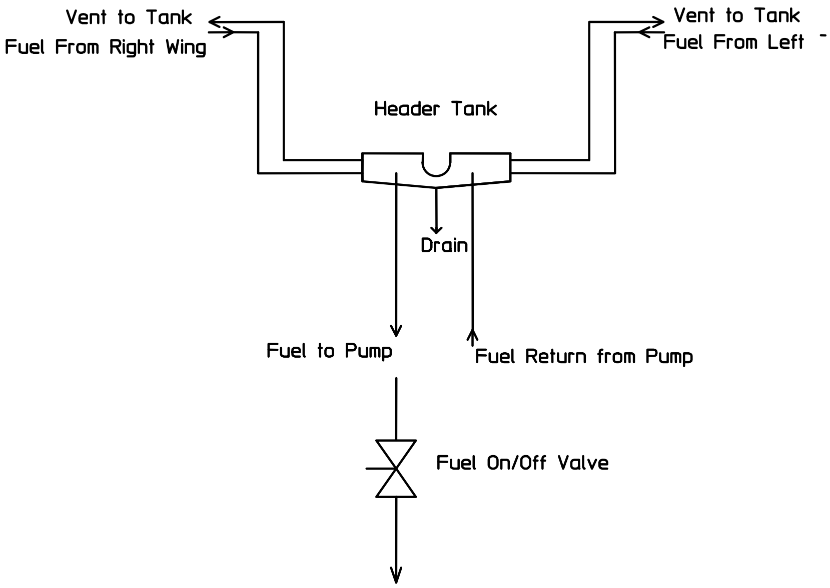
The common header tank must be a minimum of 5 gallon capacity. This is essential to allow the warm, vaporous, return fuel to cool down and disperse vapor bubbles before being drawn back into the supply line.

Since this common header tank is the sole source of fuel, a simple ON/OFF fuel valve is all that is required. Usually an ON/OFF valve is also provided for each tank feeding into the common header tank too. These are usually left in the ON position except when servicing the header tank.

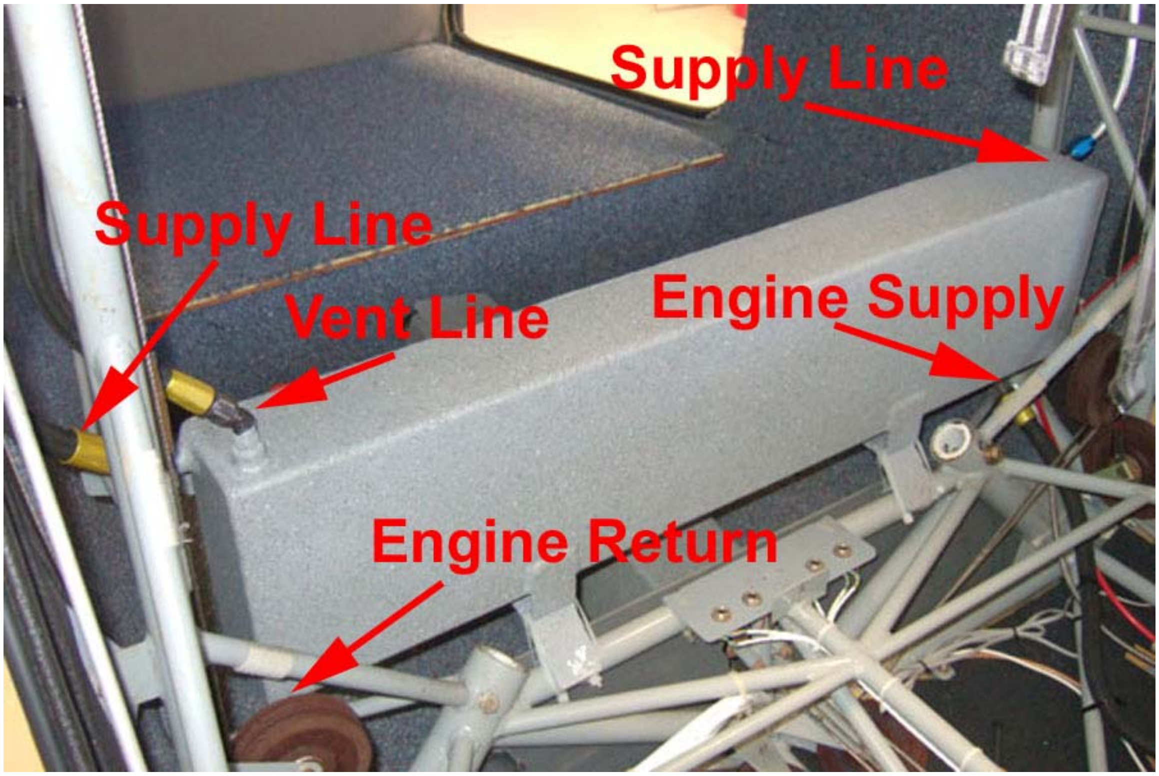
Now what about those vapor bubbles being returned to the header tank? Where will they go? **You must provide a vent line for the common header tank.** Never expect that air in the header tank will push its way backwards through a tank supply line! The volume of flow from the tanks would make this very unlikely and at best, the system would surge and gurgle, neither one a desirable trait for an aircraft fuel system! A dedicated vent line can either run to a high point above the aircraft or be teed into one of the main wing tank vent lines. This will assure a low-pressure escape route for air in the header tank.

Finally, since the common header tank is the lowest fuel source in the aircraft, it is the obvious good place to locate a fuel gauge or low fuel indication device, as well as a sump drain valve.

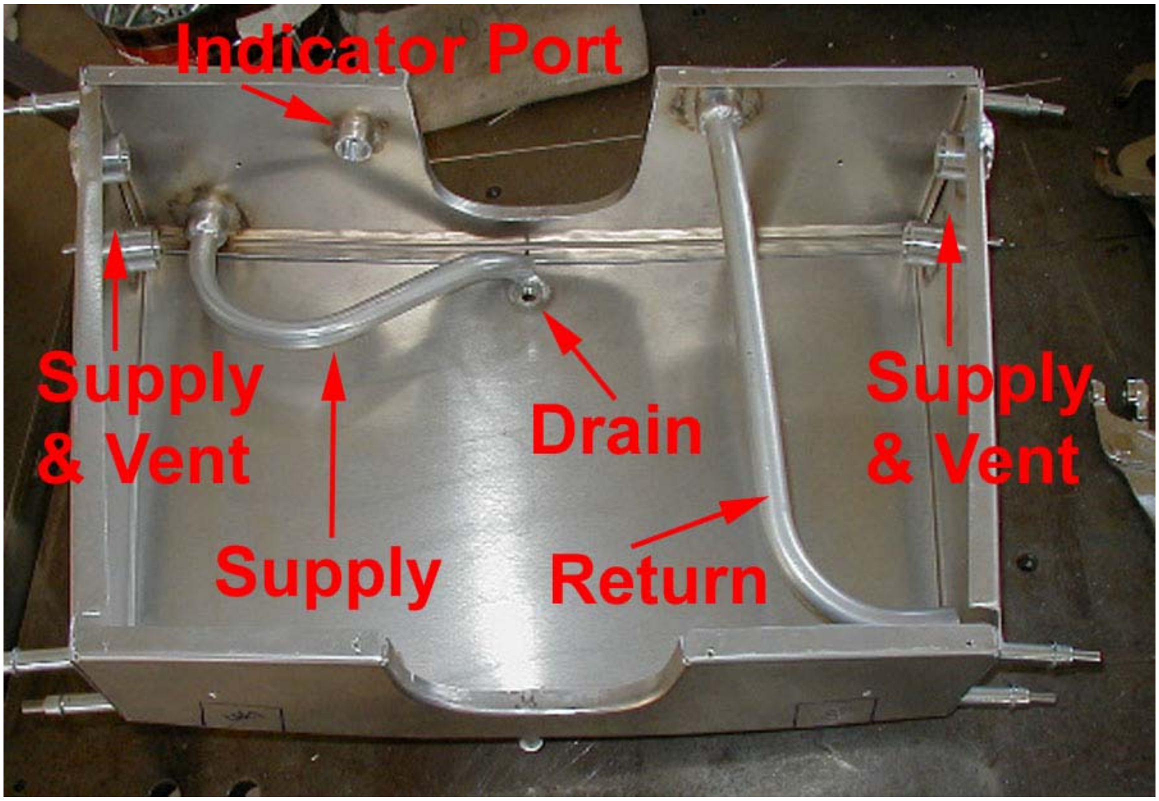
Example of a Glastar/Sportsman Fuel Line Layout with Header Tank



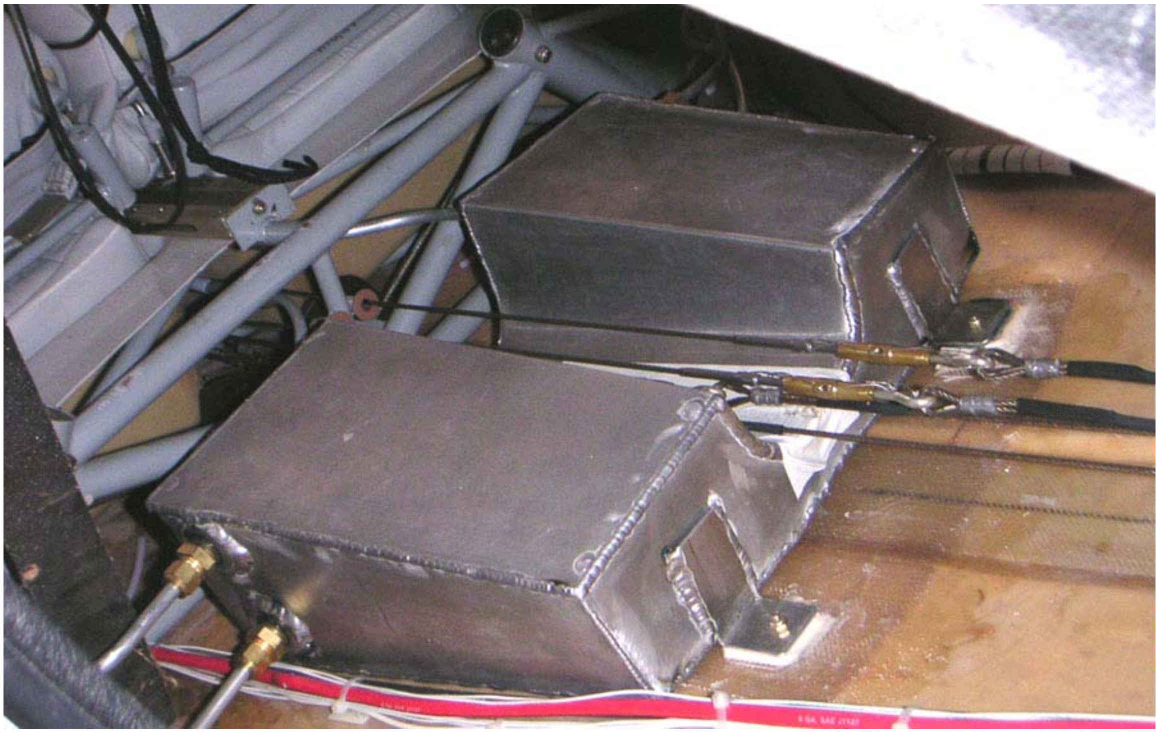
For systems requiring individual selection of fuel tanks, then the fuel tank lines would first go to the fuel selector valve and then a single line would go to the header tank. This system is in place in flying Glastars and has been shown to be reliable and safe.

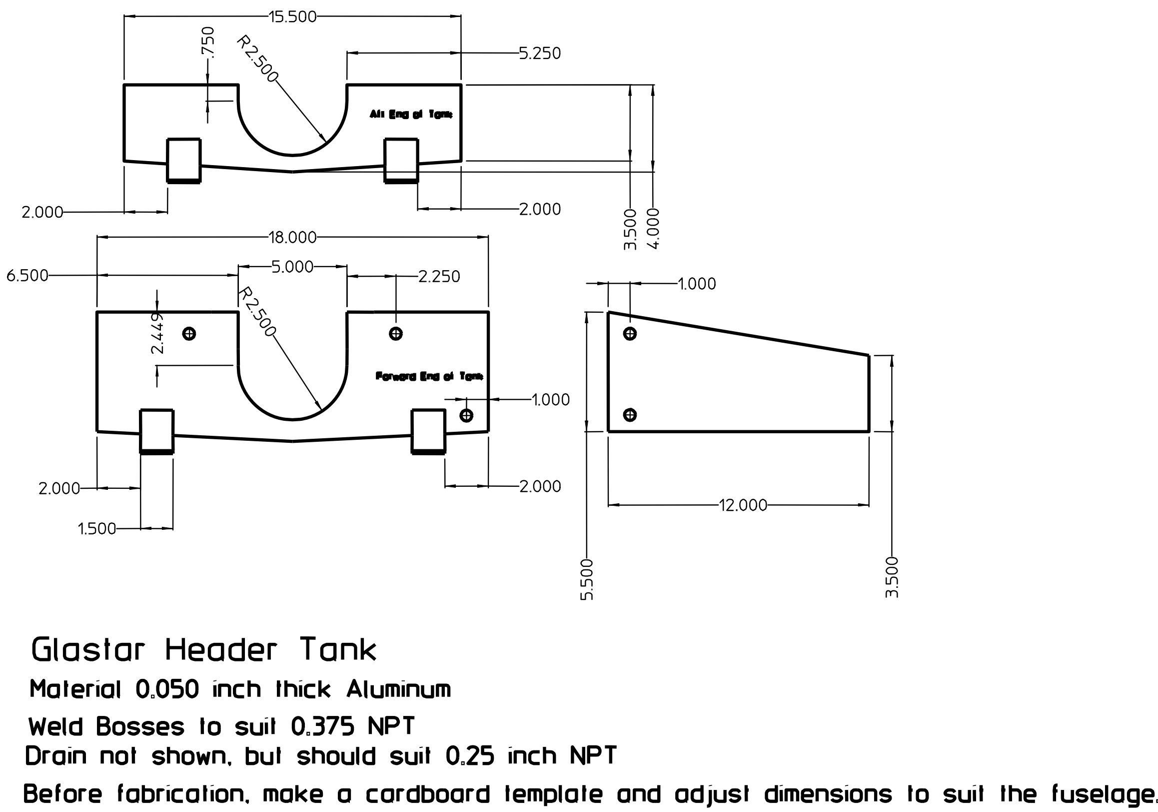


Excellent example of a Common Header Tank for High-Wing Aircraft (Sportsman)



Another fine example of a smaller, under-floor common header tank (Glastar).


Under-floor common header tank installed.   Note cable pass-thru channel.



Layout details for small under-floor tank. Note: the builder recommends using 0.062 material rather than 0.050 as shown.

Installing the Air Filter Box Assembly

In this section we will cover the mechanical installation of the Air Filter Box assembly as well as adding NACA inlet ducts to a fiberglass cowl. If you are just now installing your engine, then you certainly have not completed your cowl installation, so just perform the mechanical installation part and plan on referring back to this section when you are ready for fiberglass work.

NOTE: All E6T/220 model engines were shipped with their air filter assemblies and ducts factory installed. Many of these steps may already be done. If you are installing the “Intercooler” option, you will need to rearrange and possibly replace some of the ducts as needed. Refer to the chapter “E6T/220 Turbo-Normalize Model” for more Intercooler details.

1) E6/200 (NON-Turbocharged) engines will have their air filter box located on the pilots side of the cowl. This provides the most direct path to the throttle body. E6T/220 (Turbocharged) engines will have their air filter box located on the passenger side of the cowl because that is where the turbocharger intake is located.

2) Examine the air filter box assembly and note its pieces. Refer to the photographs that follow the description.

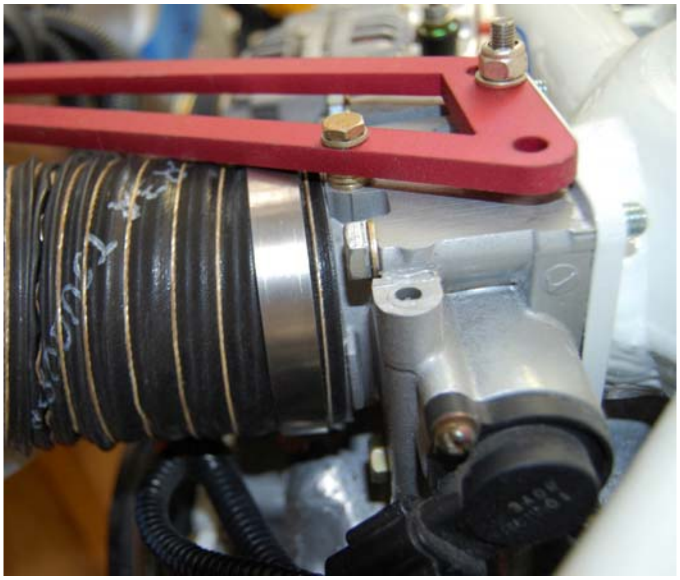
FRAME: The large "frame" will be fastened to the firewall and/or engine mount tubes so that it sits against the inside of the cowl. The two rectangular cutouts in this frame will mate up with a pair of NACA ducts that allow air through the side of the cowl. When properly fitted, there is no need for any type of weather-strip between the NACA ducts and frame. The NACA ducts will be glued to the cowl and simply sit in front of these openings with only enough of a gap to allow the cowl to be removed.

BOX: The slightly smaller box slips into the frame from the engine side. This box provides the plenum chamber in which the air filter element resides. During installation, the box is inserted into the frame only as far as necessary to secure it with rivets or screws. It remains permanently attached to the frame. The filter element slides into the frame and seats against the rim of the box.

FLANGE: The E6/200 engines use a 3.25" diameter flange fastened through the back of the box to attach a section of flexible duct. The E6T/220 engines use a small cube-shaped box housing a 2.0" flange, providing several options for what direction the duct will point to mate with the turbocharger inlet as directly as possible. The factory has pre-installed this part, but it can be removed and rotated if necessary.

3) Fasten the flexible duct to the throttle body (E6/200) or turbocharger inlet (E6T/220) and secure with a clamp. It is useful to apply a small amount of high temp silicone sealant to the inside of the duct to prevent the inner spring from unraveling. If you do this, set the duct aside for an hour before installing it to let the silicone dry.

NOTE: Some early E6/200 engines shipped with a silicone reducer boot attached to the throttle body. This boot is no longer used. Remove it and return it to the factory when you get a chance (we use them on the E6T/220 engines).


E6/200 Duct to Throttle Body

4) Route the duct as required reaching the side of the cowl where the air filter box will be located. Don't yet bother trying to secure the duct as we are only trying to get a rough measurement.

5) Hold the air filter assembly frame in place and get an idea of where it might best be mounted to clear the engine and make the duct as direct as possible. Typically the frame will be mounted with one side touching the vertical engine mount tube against the firewall. It can be fastened using long screws and stand-off bushings or just using a few Adel clamps around nearby tubes. If you have yet to install your cowl, be sure to leave room for any cowl fasteners.

6) Once you have located the general position of the frame, determine how it must be located to contact the side of the cowl. Once you have determined these positions, mark them with a felt-tip pen and secure the air filter assembly frame using whatever hardware works best for your installation. Keep in mind that this frame is permanently attached to the aircraft and does not need to be removed. The filter element slips into the frame from the outside once the cowl is removed. Consider using a strap, stand-offs, or Adel clamps to secure the frame as shown below.


Using a strap to secure the frame.


Using Adel clamps to secure the frame.

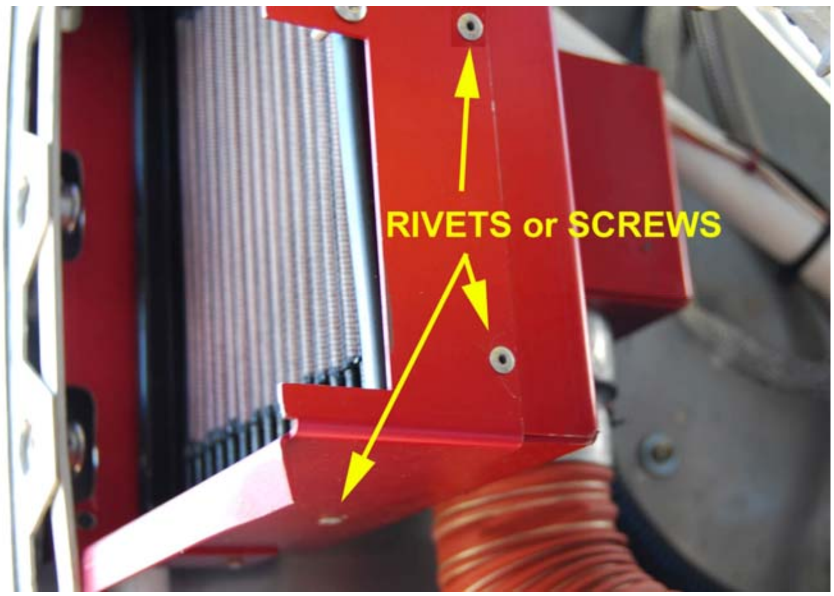
7) Attach the flange to the air filter box using blind rivets or strong adhesive. We use "The Right Stuff" (yes, that's what it's called) which is an adhesive available at most auto parts stores. If you use adhesive, allow time for it to cure.

8) Complete the task of routing the duct to the flange. Trim the duct to length with a sharp knife, cutting the spiral wire with side cutter pliers. It is useful to bend any exposed wire ends downward and place a bit of high-temp silicone adhesive on them to prevent unraveling.

9) Attach the duct to the flange and secure with a clamp.

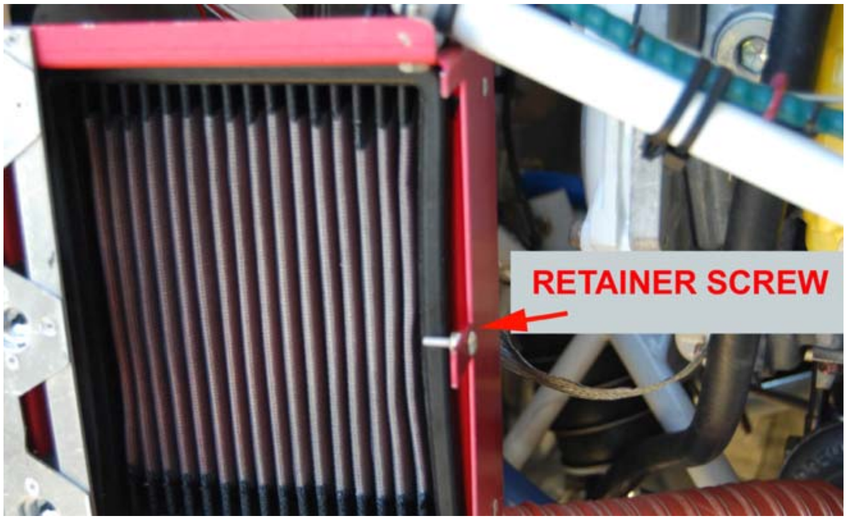
10) Finish the routing of the duct. Fasten only where necessary to keep the duct away from sharp or moving objects, using long tie-wraps, blobs of adhesive or similar techniques.

11) Slide the air filter box into the frame only as far as required to secure these parts together. Drill holes and secure with blind rivets or sheet metal screws in at least three places. The front face of the air filter element, when inserted into the box, must not block the rectangular openings in the front side of the frame.



12) Insert the air filter element and press around its perimeter to fully seat the rubber rim.

13) Drill a small hole in the tab between the rectangular frame openings and insert a short screw and nut. This prevents the possibility of the air filter element coming loose and blocking these openings.



This completes the mechanical installation of the Air Filter Box assembly. When you are ready to do cowl work, continue with the remaining steps.

14) Replace the side of the cowl. Using a felt-tip pen, mark where the face of the frame and its rectangular openings are on the inside of the cowl. Draw a line all the way around the frame if possible and accurately mark the location of the openings. This is where your NACA scoops will be located.

15) Remove the cowl. Set the NACA scoops against the inside of the cowl lined up with the frame marks. Draw lines around the scoops.

Inside View

Outside View

16) Rough up the inside of the cowl and the flanges around the NACA scoops with 80 grit sandpaper to assure a good bond.
NOTE: Some people prefer to cut the opening for the NACA scoops before installing them, while others prefer to route out the openings after installing them. This is a matter of personal preference, either way can product fine results. If you choose to cut the openings now, do so.

17) Bond the NACA scoops to the inside of the cowl using Epoxy Filler or Epoxy Resin. It is usually not necessary to use rivets or screws, but you may use these if you prefer.

18) If you have not already cut the NACA scoop openings, do so now.

19) Smooth out any seams around the NACA scoops by applying filler.

20) Reinstall the cowl and verify that the edges of the NACA scoops line up with the rectangular openings in the air filter assembly. Adjust or trim as needed.

21) If you have used care in positioning the air filter frame, no weather-strip is required between the cowl and frame, however it never hurts to apply a thin piece of self-adhesive foam weather-strip to the rim of the frame to prevent rattling and provide a better seal.

Your K&N Filter Element is a lifetime element. You should clean it periodically according to the manufacturers' instructions.

CHAPTER 3: ELECTRICAL INSTALLATION

This chapter covers the installation of all cables and wiring required to operate the powerplant. There are many options and alternatives available for airframe and powerplant wiring and it is impossible for us to cover them all, so we will intentionally focus on the fundamental requirements of the powerplant itself and provide enough detail that these requirements can be satisfied by providers of alternative electrical systems.

If you are not comfortable performing wiring related tasks, we strongly urge you to seek assistance from someone who is. These powerplants require a rock-solid electrical system, so this is not the place to take risks.

Engine Sensors

Various sensors are located on the engine for monitoring temperature and pressures. If you ordered your powerplant along with an engine monitor, then your sensors will be pre-installed. You are required to connect the engine monitor wiring harness to these sensors following the instructions provided by the vendor.

If you did not order an engine monitor, you will need to obtain and install your own set of sensors for at least, the following items.

- Oil Temperature
- Oil Pressure
- Coolant Temperature
- Gearbox Temperature
- Fuel Pressure
- Battery Voltage (2)

A pictorial guide to the engine sensor locations is provided in the Maintenance chapter of this document.

General Electrical Strategy & Requirements

Your powerplant is a technically advanced design which depends on a computer and a variety of electronic sensors to control operation of its ignition and fuel injection system. This is fundamentally different from traditional aircraft engines which generate spark from mechanical magnetos. One can argue the merits of mechanical versus electronic controls endlessly; however, the type of electronic system your powerplant uses has evolved over decades of use in millions of vehicles (far more than aircraft) in wide-ranging environmental conditions and was designed by corporations with very deep pockets and no desire to see their vehicles stranded by failures.

The use of modern electronics provides a very precise control over fuel mixture and ignition timing, responding instantly to changing conditions as well as long-term engine wear. The computer even senses engine "knock" (detonation) resulting from changing fuel type or quality and adjusts the ignition timing accordingly to avoid engine damage.

The Achilles heel of any electronic engine control system is its fundamental requirement for a rock-solid electrical supply. A battery alone meets this requirement perfectly. However, batteries live only so long before they need to be recharged.

Introducing an Alternator and voltage regulator into the picture creates a far more complex and somewhat electrically noisy environment and also the need to monitor for, and respond to, additional failure modes. Monitoring failure modes requires instrumentation and responding to failure modes requires switches and relays. Our once-simple battery has grown into quite an assortment of devices, each contributing to the overall failure rate.

When flying an airplane, a pilot gets accustomed to the sound of the engine. When this sound falls silent, most pilots would agree that their ability to quickly and clearly perform failure analysis and formulate a response is somewhat limited by their interest in the soil passing below their seat.

So why not just plug in a fresh battery and leave everything else turned off? Brilliant!

1. **Requirement –** The electrical system must have dual batteries, each capable of operating the powerplant for at least 30 minutes of flight at cruise power, with only the essential equipment required to operate the engine.

2. **Requirement –** A means of selecting one, the other, or both batteries.

3. **Requirement –** A means of turning off all but the essential equipment required to keep the engine running.

4. **Requirement –** A means of monitoring the charge state of each battery.

There are two fundamental strategies for providing dual batteries. Each has their own merits and drawbacks. Either will work and both have been proven reliable in many aircraft.

Strategy 1 – Hot Standby Battery; Switched on demand.

This strategy simply keeps a spare battery standing by until it is needed. It is then switched into service to supplement or replace the primary battery. Boats and Campers often use this strategy and any marine or camper supply store will carry large battery switches that select, one, the other, or both batteries. Some issues with this method are that the standby battery needs an occasional charge to keep it fresh and if there is a wiring failure downstream that is killing the primary battery, switching in a fresh one is like tossing fuel on a raging fire. However, requirement #3 addresses this problem, making this a reasonably effective and simple strategy.

Strategy 2 – Redundant Batteries; Isolated on demand.

This strategy is slightly different. Both batteries are used in parallel under normal operating conditions. Both are providing energy and both are receiving a charge from the alternator. If something goes wrong, the batteries can be isolated so one can act as a spare for essential loads when required. Again, requirement #3 is critical.

It is our opinion that Strategy 2 is superior because it assures that both batteries are receiving a charge and the load is being shared at all times during normal use. Batteries are generally *happiest* when in service. How many times have you reached for a flashlight during a power failure and found the batteries were dead from just sitting there? Two batteries in parallel provide greater capacity and greater ability to cope with changing loads.

Regarding Requirement 3; "A means of turning off all but the essential equipment keeping the engine running", this can also be accomplished in a variety of ways. In its simplest form, a visible circuit breaker panel allows the pilot or copilot to turn off non-essential loads to reduce the burden on the battery. In doing so, they may even inadvertently isolate the cause of the electrical failure. But inadvertent troubleshooting is not really an exact science, and in actual flight conditions, rapidly pulling rows of circuit breakers is likely to be very unsettling to passengers and pilots at a time when calm could prevail.

A better way to isolate essential loads is *not to combine them to begin with*! Instead, a dedicated electrical bus should be created for the essential loads. These include the engine computer, the fuel pumps, and possibly the propeller controller if your particular plane would be difficult to land without prop control. An engine failure in IFR conditions might lead one to declare a gyro as critical equipment too. If more sophisticated equipment is needed to make a successful landing, then it too could be sourced from this bus with a dedicated circuit breaker to disable it if not needed or a clearly tagged emergency procedure for turning it off when not needed and on only when needed or when the field is in sight. Every load reduces your duration. Every switch movement complicates your emergency procedure.

Selecting the power feed to our essential equipment should be fast and not require a lot of thought. The big marine battery switch could do this, or a suitable high-quality aviation switch, or a double-pole contactor relay, or two single pole contactor relays, or a pair of high-power diodes, or other solid state device. Having lots of options usually indicates a workable strategy.

As you have learned, there are a number of ways to satisfy our requirements. We can't describe them all, so we will focus on a strategy that provides: *Redundant batteries; isolated on demand, and a high quality switch to select the power source for our essential equipment.*

Speaking of Busses

A "Bus" is a term applied to a collection of related electrical circuits. The actual physical implementation of a bus, if any, can take the form of a metal bar tying several circuit breakers to the same power source, or a set of wires organized in a 'daisy-chained' manner providing power to multiple circuit breakers, or it can simply be a "logical" collection of related circuits often organized and labeled in rows of circuit-breakers.

An electrical system having two batteries, such as ours, is likely to be organized with several busses. A "Main" or "Primary" Bus is likely to be tied directly to the Main Battery. An "Aux" or "Secondary" or "Backup" Bus is likely to be tied directly to the Aux Battery, but it might also simply power the Main Bus from the Aux Battery. Most aircraft will also organize an Avionics Buss as a subset of one of the others.

It's a simple organizational concept really, but alas, all things simple tend to grow in complexity in the actual implementation.

In our system, we have a need to provide power to some critical items that will keep the engine running at all times. We will create a bus and call it the "Essential Equipment Buss" or "Emergency Bus" or "Engine Bus". Whatever makes the most logical sense for the pilot. In this guide, we will refer to it as the "Essential Equipment Bus" for consistency with prior documents. For short-hand, we will refer to it as the "E-Bus".

The unique thing about the "E-Bus" is that the collection of circuit breakers and circuits that it supplies power to, must be able to receive that power from one, the other, or both batteries, so that this equipment always has power, even if one or the other (but never both) battery is taken off-line (isolated) for some reason. This is accomplished by a mighty switch that selects which of the other two busses is supplying power to the Essential Equipment.

The most likely reason for isolating a battery is to preserve its charge for later use. For example, if our alternator fails, we find ourselves running off batteries alone. Isolating one battery while closely monitoring the active one, gives us a slight advantage over just draining them both equally because we will have a 'second-chance' with a fresh battery if we do not find a suitable landing location within the life of the first battery. It's a mental game for sure. Very much like running low on fuel, but not knowing precisely when the tank will run dry. It's comforting to know you have a few gallons to spare standing by.

Another scenario is the "up in smoke" pilots nightmare. Something major goes up in smoke behind that expensive panel (a screw falls into the works for example) and it fills the cockpit with awful smelling smoke and the engine is stumbling from low voltage. This is not something you can take your time to analyze. Isolate the batteries and turn off all power except to the "Essential Equipment Bus" and get yourself to the nearest airport. This can be done quickly and discretely with just a couple switches.

Batteries

If you haven't done so already, now is the time to acquire a pair of batteries. We use motorcycle size batteries. Several types are suitable, but the factory prefers the **Hawker Industries, "Odyssey PC625 or PC680"** type of dry-cell batteries (Reference URL: www.Batteries4Everything.com). Prices vary quite a bit for these batteries, so shop around. $60 to $90 dollars is the going price per battery.

Whichever type of batteries you prefer, make sure they have suitable bolt-type connector studs. During cable installation, tighten the nuts gently, using lock washers and flat washers, to avoid damaging the battery terminals. Avoid spillable batteries or ones with special venting requirements.

The actual location and mounting of the batteries will be determined once the motor has been positioned on the firewall. Moving your batteries is your best option for fine-tuning your aircrafts balance (CG) so remain flexible as long as possible with regards to battery location and cabling.

Required Electrical Tools

Electrical Tools

1. High-quality wire strippers (20AWG through 10AWG) AWG = Average Wire Gauge or just Gauge for short.
2. Terminal Crimping Pliers
3. A large gauge terminal crimping tool for 8AWG through 4AWG cable ends.
4. A sharp razor knife such as an Exacto knife.
5. A good soldering iron or soldering station and high-quality electrical solder.
6. A bottle of alcohol or solvent for removing soldering flux.
7. A propane torch (propane or MAPP gas). Get a self-lighting model; you'll never regret it.
8. A good assortment of shrink-tubing (various sizes and colors, including clear) and an electric heat gun to shrink it (not shown).
9. A good assortment of tie-wraps.
10. 2 or 3 rolls of high-temperature (orange-red) **silicone** tape.
11. A can of white "Liquid Electrical Tape".
12. An assortment of Teflon aviation wire and cable. Sizes are denoted as we go, or refer to the master parts list.
13. An assortment of protective rubber terminal boots (approx. 8 large ones and 12 small ones).

ENGINE WIRING SCHEMATIC DIAGRAM

The diagram on the following page illustrates one method of wiring the aircraft which satisfies our requirements. We have intentionally simplified it to show only the engine-related circuits with references to where the remaining circuits can be wired in.

This method requires a pair of continuous-duty contactor relays (Master Relays) available from Aircraft Spruce and a specific high-quality aircraft switch made by “Microswitch” a division of “Honeywell”, part number 4NT1-1. This switch is available through several sources and can be ordered over the internet. High-amperage ANL-type fuses protect the primary power distribution cabling and alternator output cable. These are optional, but a good addition as they will prevent very large sparks in the unfortunate event of a serious crash landing. Be sure to size the alternator fuse appropriately for the alternator option you have purchased.

All switches must be high-quality components capable of reliably sourcing 20 Amps per contact. Please avoid the use of local hardware store parts in your critical electrical system!

Study the diagram before continuing. Inevitably some variations will need to occur. Consult a qualified avionics technician if you are unsure of what needs to be done. The switch layout diagram is simply a suggestion.

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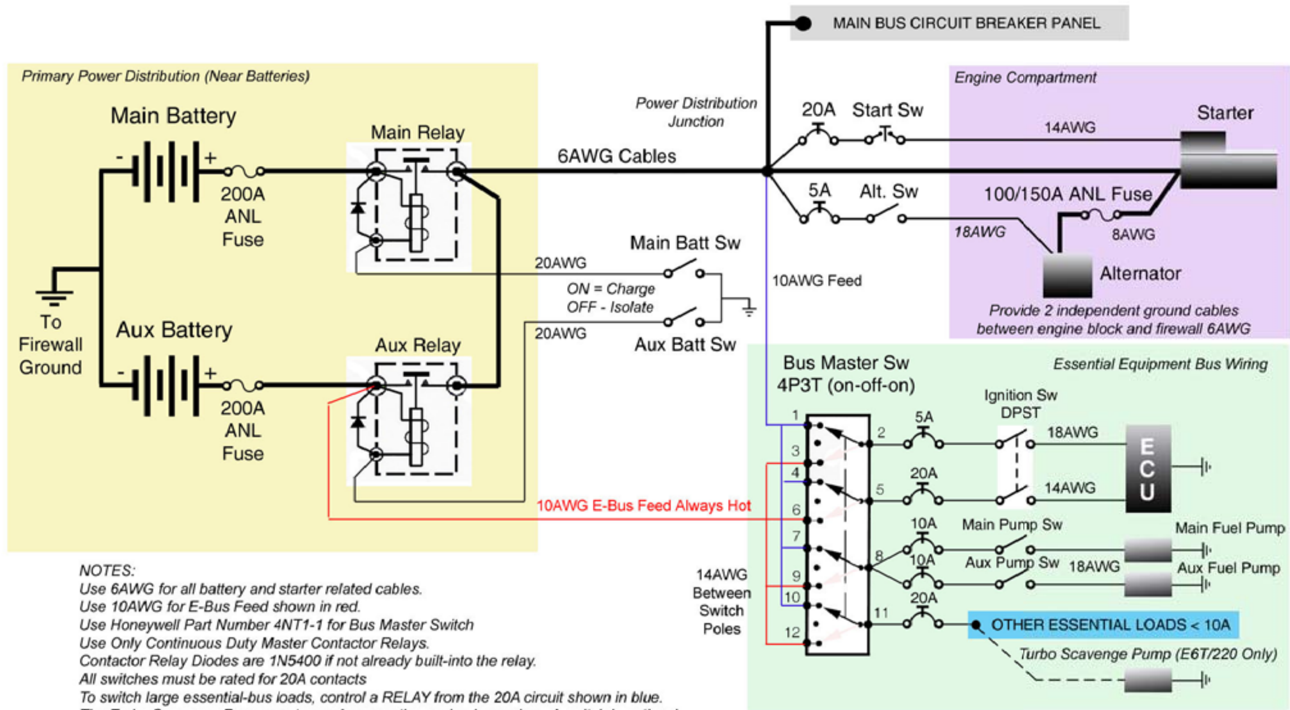
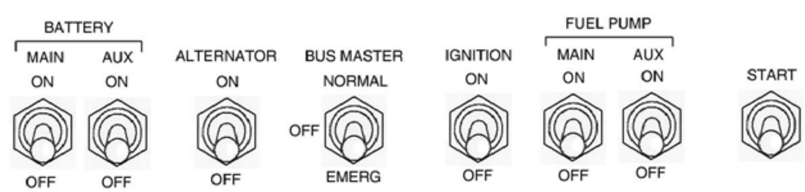


NOTES:
Use 6AWG for all battery and starter related cables.
Use 10AWG for E-Bus Feed shown in red.
Use Honeywell Part Number 4NT1-1 for Bus Master Switch
Use Only Continuous Duty Master Contactor Relays.
Contactor Relay Diodes are 1N5400 if not already built-into the relay.
All switches must be rated for 20A contacts
To switch large essential-bus loads, control a RELAY from the 20A circuit shown in blue.
The Turbo Scavenge Pump must run whenever the engine is running. A switch is optional.



Electrical Cable Installation

There are several large gauge cables required by your powerplant. Each of these cables will need to attach to the firewall or pass through the firewall into the cabin. You need to protect these cables from chafing using firewall pass-through fittings or similar fixtures. It is acceptable to pass these cables through the same opening as the engine wire bundle as long as some distance between the cables and the rest of the engine wiring can be maintained.

Ground Cables

First, TWO separate ground cables must be constructed and run between the engine block and firewall. Most installations will provide a firewall grounding plate for various electrical connections. Refer to the electrical chapter of our earlier model installation guide if you are unsure of what one of these looks like. The ideal ground cable installation will utilize TWO sections of 6 AWG cable run from different locations on the engine block to different bolts on the firewall or grounding plate. The following photographs show an example of proper grounding.

Avoid using braided straps for grounding the engine. Straps have a tendency to fray and to flutter in the wind inside the cowl, slicing open hoses and other wires. It is also common to underestimate the size of strap required simply because they look big when they are flattened out. Real 6AWG cables with Teflon insulation and well crimped and optionally soldered terminal lugs are the way to go.

1. Construct and install your two 6AWG ground cables now.

Starter Cable

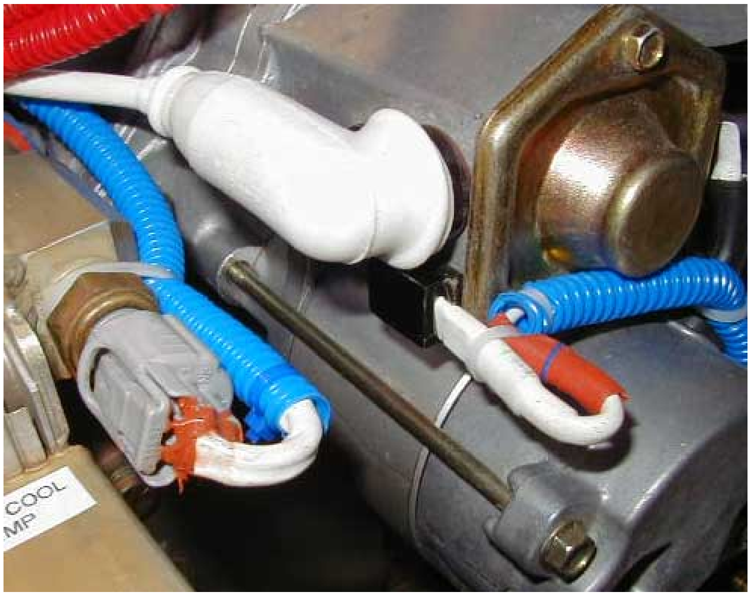
Next, your powerplant will need a 6 AWG cable to the starter motor. Your starter motor is a geared motor containing its own starter solenoid relay. Therefore, no additional starter contactor relay (such as found in many aircraft) is required. This starter cable runs directly to the main positive post of the primary battery and remains “hot” at all times. If you are using a battery switch, you can run this cable to the common post of the battery switch so that either or both can start the engine.

Some aviation electricians don’t like the idea of an always-hot cable to the starter (even though this is how nearly all cars are) and will insist on adding a conventional starter contactor relay in the cable. It is our opinion that placing two relays in series is unnecessary complexity.

We highly recommend the use of a 200 Amp “ANL” (blade) type fuse and fuse holder located in the main positive cable near each battery. The 200 Amp fuse is strong enough to allow the starter motor to operate, but in the event of a catastrophic failure, such as a crash or shorted battery cable, the fuse would blow and prevent substantial arcing and possible fire. These ANL type fuses are available from many vendors.

The starter cable may run all the way from the battery to the starter or from a large terminal block inside your cabin. Protect the starter end of this cable with a silicone boot. A warning label regarding this connection being "Always Hot" is a good idea.

2. Install your starter cable now. Leave the batteries disconnected until all engine wiring is finished and we are ready to do a systems check.


Starter Cable & Boot

Alternator Cable

Your Alternator output terminal must have a 6 AWG cable (often referred to as a "B-Lead") connecting the large screw terminal on the alternator with the battery charging system.

In its simplest form, this cable can just run over to the starter motor cable terminal, thus connecting it back to the main battery.

Most installations will provide a suitable circuit breaker or fuse for this cable and even more sophisticated power distribution systems that take direct control of the alternator output will require that this cable connect to another location. Consult your vendors' wiring diagrams or consult with a qualified aviation electrician to determine this detail.

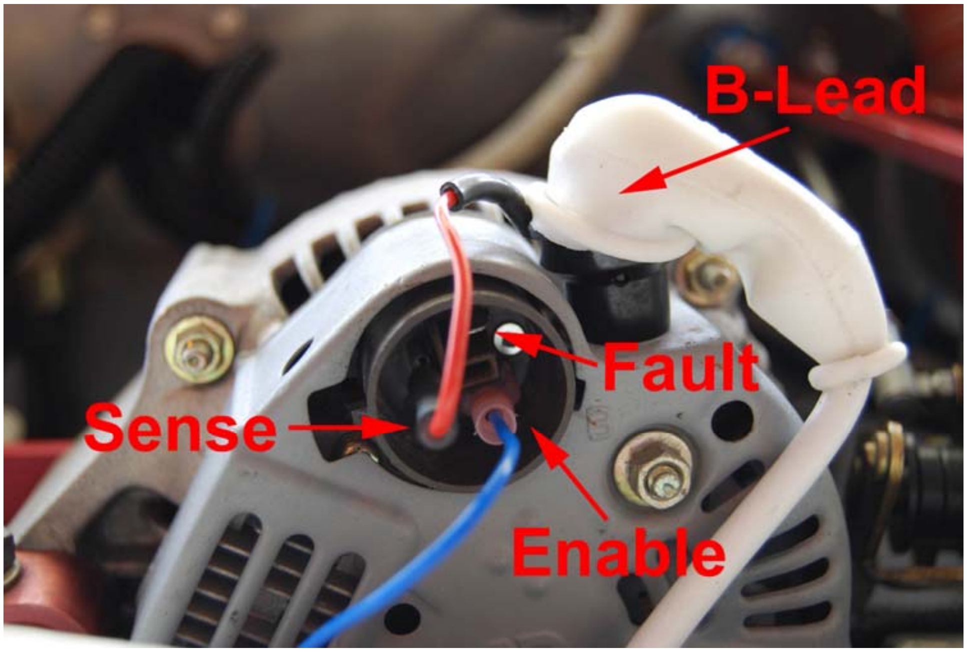
The standard alternator (40 Amp Continuous/55 Amp Peak) supplied with our powerplants can use a 60 Amp circuit breaker or 60-100 Amp ANL type fuse. The optional high output alternator (70 Amp Continuous, 110 Amp Peak) should have a 120-150 Amp circuit breaker or ANL type fuse.

3. Run a 6AWG cable from the alternator screw terminal to one side of this circuit breaker or fuse.

4. Secure the alternator terminal with a lock-washer and nut. Protect all exposed terminals with silicone boots.

5. Run a 6AWG cable from the other side of this circuit breaker or fuse to your power distribution system or starter motor. If using a custom power distribution system, consult your vendors' circuit diagrams for specific details, as there are a variety of ways to wire this connection.

The following photograph shows the connections on one of our high output alternators. Note the white silicone boot over the main cable. The short red jumper wire is provided by the factory and is required by the internal regulator. The remaining terminal connection is for an alternator fault light (aka idiot light). To use this feature, provide 12 volts to one side of a small lamp and hook the ground side of the lamp to this terminal. The alternator will ground the terminal if it detects a failure, thus illuminating the lamp.



Engine Wiring Harness Bundle

The main bundle of wires pre-attached to your engine must all pass through an opening in your firewall and be reattached to the Engine Control Unit (ECU) and various other connections inside the cabin as described in this section.

The ECU (gold colored case) and the Coil Driver (small black plastic case with wires on both ends) must be mounted inside the cabin. The Manifold Pressure Sensor (black sensor with silicone hose and connector) can be mounted on the engine side of the firewall or inside the cabin.

6. Identify the desired location for the wire bundle and drill or cut the firewall hole.

7. Carefully push/pull the wire bundle through the firewall hole. Try not to deform the bundle more than necessary or to put strain on the wires entering and exiting the Coil Driver box. It may be necessary to unscrew the terminal strip connections temporarily to fit the bundle through the hole.

8. Install whatever method you choose to use to protect, secure, and seal the wiring bundle at the hole in the firewall.

Manifold Pressure Sensor

The 2-Bar Manifold Pressure Sensor is the small black rectangular device having a silicone hose connecting it to the engine intake manifold and an electrical connector. Other instruments that need to display Manifold Pressure can tee into this hose or use a separate hose connection to the manifold. This sensor can be mounted inside the cabin or on the firewall, whichever is more convenient. A small orifice device is located in the MAP line just in front of the sensor to buffer rapid changes, smoothing out ECU operation.

9. Drill holes as needed to secure the Manifold Pressure Sensor to the firewall or inside of the cabin behind the instrument panel. Make sure the connector and vacuum hose are both secure.

Mounting the ECU

Mount the ECU (Engine Control Computer) in a location that permits relatively easy access to it as periodic software updates require the unit to be swapped out.

Although no explicit cooling is required by the ECU, avoid mounting it near sources of heat and keep it away from all possible sources of water.

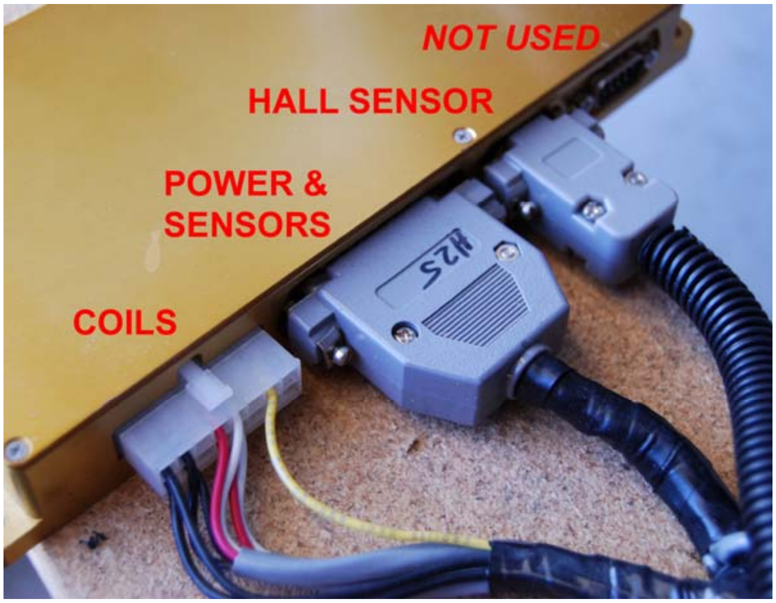
It is best to mount the ECU so that its various connectors are facing down or are otherwise easily accessible.

Avoid mounting the ECU directly behind or in close proximity to radio stacks and antennas.

10. Secure the ECU using four machine screws. Fabricate a bracket if needed.

ECU Connectors

Once the wiring harness has been passed through the firewall, locate a suitable mounting location for the ECU within range of the harness connectors. There are three connectors that mate up with the ECU as shown in the next photograph.



Be sure to mount the ECU where it will be accessible for future software updates.

Mount it in a cool dry location away from radio stacks.

Secure the connectors with the retaining screws and relieve any strain on the cables with clamps.

11. Install the ECU connectors and secure with the provided screws.

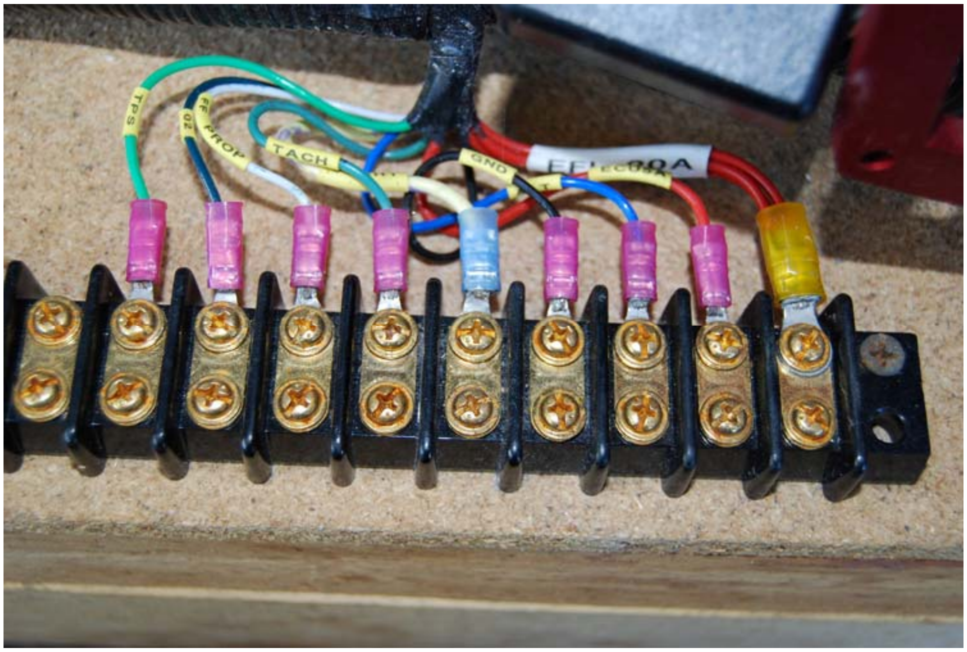
Wiring the Engine Terminals

The terminal strip supplied with your powerplant may be used or discarded. It was primarily intended for factory convenience. Each wire on this terminal strip is color-coded and clearly marked with labeled shrink tubing.

Note: If you intend to use the supplied terminal strip, be sure to obtain 24 #6 flat washers to place under the screw heads to properly secure the terminals in an airworthy manner. Without flat washers, the serrated screw heads can weaken the soft terminal rings.

12. If you decide to use the terminal strip, locate a good position for it inside the cabin and near the ECU and fasten it with four screws. You will need good access to the terminals.

There are nine wires attached to the terminal strip at the factory. Only the first five wires are required to run the engine. The remaining wires are for various options and accessories. We will describe the purpose and connection of each wire.



Review the following descriptions of the wires.

1) **RED – 20A EFI Power.** This wire provides power for your Electronic Fuel Injection system. This includes the ignition coils and fuel injector coils.

This circuit is **critical** and must obtain power from the "Essential Equipment Bus". In other words, no matter which battery is supplying power, this circuit must remain powered.

Use a **20 Amp** resetable, aircraft-quality circuit breaker.

Having said all this, it is not strictly necessary for this circuit to be switched on and off along with the ignition switch at all. If the ECU is powered down, then it will never trigger the coils and this circuit will sit idle, consuming no power. However, most builders will prefer to have this circuit "switched" in order to minimize the number of "always hot" circuits in the aircraft. This requires that whatever switch or relay is controlling this circuit, be capable of reliably handling the 20 Amp load.

Just try to understand the functions for now. We will get into exact wiring in a moment.

2) **RED – 5A ECU Power.** This wire provides power for the ECU, the computer that controls your engine.

This circuit is **critical** and must obtain power from the "Essential Equipment Bus". In other words, no matter which battery is supplying power, this circuit must remain powered.

Use a **5 Amp** resetable, aircraft-quality circuit breaker.

This circuit should be switched by your Ignition Switch. Turning off this circuit effectively shuts down the engine.

3) **BLUE – 5A Alternator Enable**. To enable your alternator to produce charging current, this wire must be connected to a power source. This power source can be switched by the Master Switch or a subservient "Alternator" switch. People have come to know this function as an "alternator field", however that is a term that has lingered on from years ago. It is actually just an enable signal going to a solid-state voltage regulator inside the alternator. It knows only ON or OFF, not specific voltages in between.

If you wish to have the ability to manually turn on and off the alternator, a switch should be provided. However, beware that turning an alternator on and off under heavy load can dramatically shorten the life of the alternator and cause substantial spikes and surges. If used, this switch should be left in the ON position, except when the alternator actually needs to be taken offline for some reason. For simplicity, this wire can simply be switched by the Master Switch or the Ignition Switch.

This wire is only 'critical' in the sense that if it is not receiving power, the alternator will not produce current to charge the batteries. However, the most likely failure scenario that would cause you to resort to a backup battery in the first place, is an alternator failure! If I were to use an alternator switch, I would go ahead and take power from the Essential Equipment Bus because I could always turn the alternator off if it was the cause of power loss. If this wire is hard-wired with no switch, I would wire it to a MAIN battery bus instead, causing the alternator to go off-line automatically if I select the AUX bus.

4) **BLACK – Ground.** This wire is the ground wire for the Engine Control Unit. No circuit protection is required on ground wires.

This is a **critical** wire and must be securely routed and fastened to an appropriate ground plate connection. Lose this ground connection and the engine stops! Treat it with respect and make a good connection.

5) **Yellow** with **Blue Stripe – 20A Starter**. This wire provides power to engage your starter solenoid relay, thus cranking your engine.

Because starter solenoids are known to draw large power surges, this circuit should get power through a 20 Amp circuit breaker inline with a switch, button, or relay capable of sourcing 20 Amps. If you prefer to use a more delicate switch or key switch, this circuit should be connected to a power relay which is then operated by the switch.

6) **LIGHT BLUE – Tach.** This is a tachometer signal from the ECU. It is a 5-volt square wave compatible with most instruments capable of displaying RPM. It provides one pulse per revolution of the engine. It can also be used as the tachometer input to the Constant-Speed Propeller Controller.

7) **WHITE – FF/Prop.** This wire is connected to one of the fuel injector coil triggers. It is used by engine instrumentation or Fuel Flow Transducers for calculating fuel consumption. It can also be used as the tachometer input to the Constant-Speed Propeller Controller. This wire must never be grounded. Individual instruments must provide circuit protection for this wire, with a fuse of typically 1 Amp or less.

8) **DARK GREEN – O2 Sensor.** No additional connections need to be made here. Note that a decision was made in mid year 2007, to discontinue use of oxygen sensors and “closed loop” operation. The problems associated with oxygen sensors far outweighed any benefit. All ECUs have this feature turned off permanently. Thus, no connections are required on this terminal, although the sensor can remain wired up without causing problems.

9) **LIGHT GREEN – TPS.** Throttle Position Sensor. Turbocharged engines use this signal to sense throttle position. Non-turbocharged engines do not use this wire. This wire must never be grounded.

CHAPTER 4: E6T/220 Turbo-Normalized Model

The E6T/220 is a far more complex powerplant than its normally aspirated brother, the E6/200. The turbo-normalizing system uses an array of mechanical, electrical, and computer components. This chapter is intended to familiarize you with these components. Since all of these things were pre-installed and tested at the factory, only a small number of additional steps are required to install an E6T/220, such as mounting the control computer and routing some additional wires and cables.

What you need to know about: Turbo-Normalizing

A turbo-“charger” is really nothing more than a high-volume air pump designed to push much more air and fuel through the engine. Exhaust gases which would normally be pushed through a muffler and (wasted) out a tailpipe, are instead pushed through a tiny turbine wheel to spin a shaft at impressively high speeds (approx 200,000+ RPM!). The energy consumed by doing this, leaves the exhaust gasses with far less heat and energy and what’s left can be sent directly out a tail pipe with no real need for a muffler. It’s essentially “free” energy that would have otherwise been wasted.

On the other side of the turbine shaft, is another form of turbine wheel called a “compressor”. As you might guess the compressor draws in fresh air from the air filter and compresses it before sending it on its way to the engine intake manifold.

All of this high speed action and compression generates a lot of heat. Because it would be difficult to provide seals that operate at these speeds and temperatures, the shaft between the turbine and compressor floats in a pressurized oil bath and “slingers” throw the excess oil to the side where a scavenge pump can pick it up and return it to the engine. If the turbocharger were located higher than the oil pan, a gravity feed return could be used, but in our application, we want the heat of the turbocharger to be as close to the cowl exit as possible, thus we place the turbocharger below the oil pan and use a scavenge pump to return the oil. Because of the low mounted location, a check-valve is used in the oil supply line to prevent oil from dripping out when the engine is turned off. A small orifice in the same line meters the amount of oil flow the turbocharger requires.

In addition to a steady stream of oil, the turbocharger taps into the liquid cooling system of the engine and circulates coolant through its casting.

The turbocharger is so efficient, that it is capable of produce tremendous amounts of pressure, far greater than our engine could use, even when idling. To control this pressure, two methods are employed. First, a “waste-gate” is located in the exhaust stream just ahead of the turbine wheel. When OPEN, exhaust is allows to bypass the turbine wheel and directly exit the tail pipe. This effectively slows down the turbine, but does not entirely stop it. When CLOSED, all exhaust is routed through the turbine wheel and it rapidly spins up to its maximum speed, where the compressor creates its maximum boost pressure.

Because our E6-series engine is already a relatively high-compression engine (10.5:1), it cannot accept large amounts of boost pressure without suffering severe damage. To assure that any excess boost pressure generated by the compressor does not damage the engine, a second control valve known as the "dump-valve" is located in the boost duct between the compressor and engine intake manifold. This valve when OPEN, dumps excess pressure overboard. When CLOSED, the boost pressure is sent into the intake manifold. Together, the dump-valve and wastegate-valve provide very precise control over the amount of boost pressure the engine receives.

A small microprocessor-based controller is used to monitor the manifold air pressure (MAP) and open or close the valves as needed to maintain a set pressure.

A turbo-"normalized" engine is one that is set up to maintain a "normal" amount of air pressure at all times, rather than a boosted amount of air pressure. For aircraft use, we set the normal pressure to roughly sea-level, or 30" (inches of mercury). This provides the engine with a manifold air pressure which is safe and efficient for the engine. As the aircraft climbs to higher altitudes and less-dense air, the controller will slowly close the pair of control valves to send progressively more pressure into the manifold, maintaining the preset 30" of MAP to the highest altitude it can. Eventually, the air become so thin that the compressor can no longer keep up and the MAP will taper off to something less than 30". This altitude will be the "service ceiling" of the turbo-normalizer, and is estimated to be nearly 20,000 feet!

At no time in our flight, did the engine 'see' anything other than normal pressure. Thus as far as it is concerned, it is functioning at sea level.

Over-boosting the engine is certain to result in catastrophic failure within very few seconds. For this reason, great care has been taken in the design of the controller and valves to provide a fail-safe mode of operation. A red warning lamp as well as a MAP warning (if the optional EIS-4000 is installed) will tell the pilot of an over-boost condition due to some sort of failure. To resolve the condition, the throttle may be reduced, or a switch is provided to force the control valves wide-open. Note that if this is done at high altitudes, the braking effect will be significant as the engine is suddenly unable to generate much power in the thin air until it returns to a lower altitude.

Two more protective devices exist. The engine control computer (ECU) utilizes a "knock-sensor" that will detect trouble in the engine and attempt to retard the timing to reduce power output. Finally, the ECU also monitors MAP and will cut-off fuel flow if MAP ever reaches 34.7". This causes a distinct "shudder" that is certain to wake up the pilot and let him know to close the throttle slightly and investigate the problem.

The turbocharger is not the only thing that gets hot when all this air is compressed. The air itself, going into the intake manifold can be heated to well over 200F. Air is much less dense when hot. Just as an airports' density-altitude is significantly higher during hot days, the engine will not perform as well as it would if the intake air were colder, thus denser. For this reason, we offer an option that is known as an "Intercooler". The intercooler is simply a radiator designed to cool air. By passing the air coming out of the compressor through an intercooler and passing cold outside air over the intercooler core, we can drop the manifold intake air temperature by nearly 100F. The real-world effect of doing this is that your aircraft will have a higher useful service ceiling; the engine will operate more efficiently, be less prone to detonation, and will last some amount of time longer. If you routinely fly in high mountain ranges, you should seriously consider the intercooler option.

The following photographs will familiarize you with the various turbo-normalizer components.

Intake Air Temperature Probe

The Intake Air Temperature Probe measures the compressor duct air as it enters the engine intake manifold.

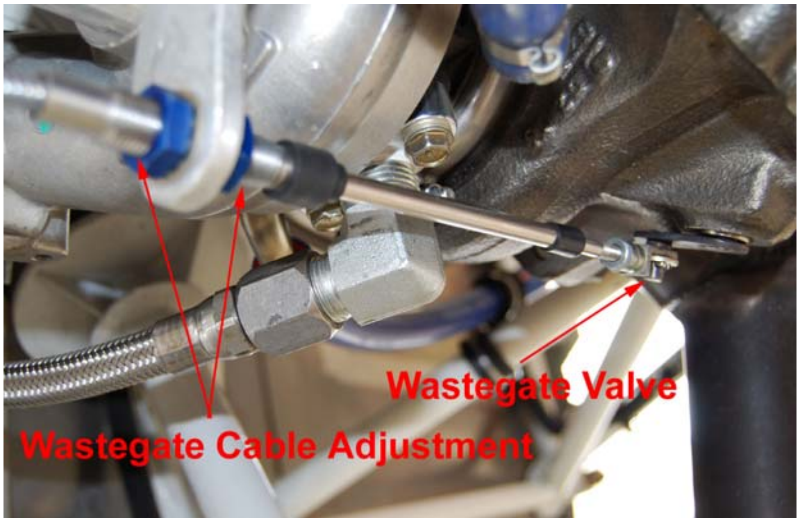
This sensor plays an important role in fuel metering.

Wastegate Control Valve & Valve Linkage Adjustment

The Wastegate Control Valve is operated in conjunction with the Dump-Valve using a pair of electric servo motors and cables. The servos are controlled by a microprocessor that monitors manifold pressure and operates the servos as needed to maintain 30" of manifold pressure. The servo motors are self-synchronizing and operate in parallel with each other.

During installation of the servos, the cable lengths must be adjusted so that both the Wastegate and Dump valves are in a fully CLOSED position along with their individual servo motors. The controller will automatically run the servos to the OPEN position whenever the controller switch is turned OFF. To move the servos to the CLOSED position for cable adjustment, turn the controller ON and OPEN the throttle all the way.

You can now adjust the cable stop nuts until both valves are just CLOSED. Do not over-tighten the cable adjustment or it can damage the servo motors. Before flight, verify that both valves open when the controller is turned OFF.



The Wastegate Valve is controlled by a cable and electric servo motor.

Adjustment should not be necessary, but if it is, the valve and servo motor must both be in the CLOSED (pulled) position when setting cable length. Adjustment nuts are found and both ends of the cable.

The linkage at the Wastegate has a slotted end. Don't attempt to fix this, *cause it ain't broken!*

It is intended to allow some cable play.

Always use a stainless steel cotter pin here.

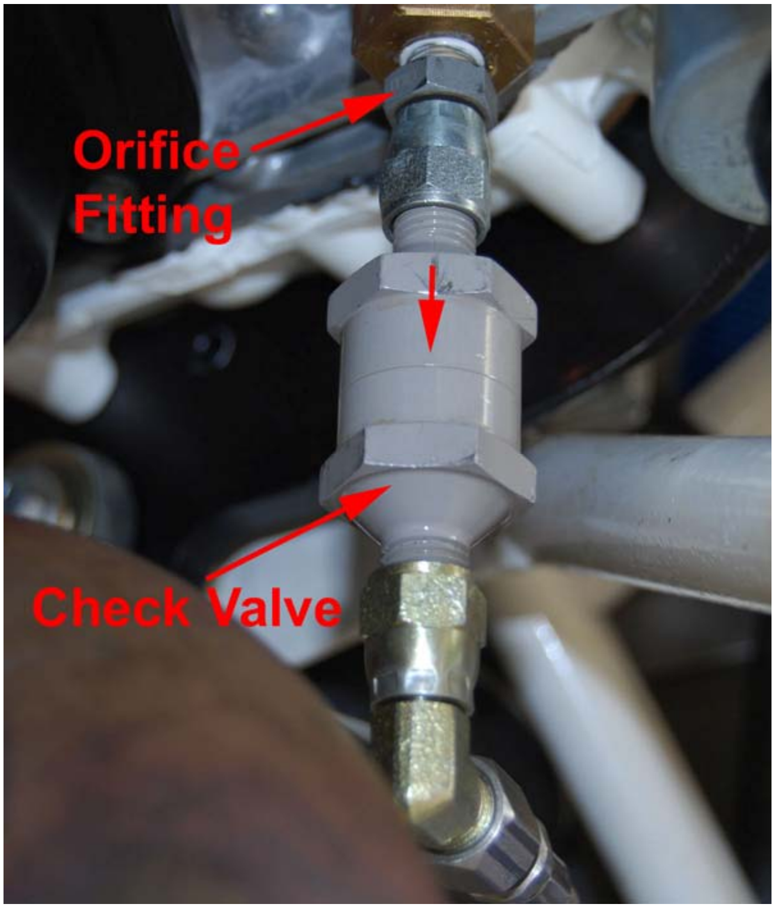
Oil Supply Line Check-Valve and Orifice

The turbocharger oil supply line is located on bottom of the engine, just to the pilots' side of the oil pan.

A small check-valve is used to prevent oil from slowly draining out of the engine oil galleys whenever the engine is stopped. This valve uses a 5-pound release pressure to open, allowing oil to flow downward only when the engine is running.

The uppermost check-valve fitting is special. It has a tiny (0.033") orifice inside which limits the volume of oil to the turbocharger. Without this orifice, the oil would overflow the turbine bearings resulting in excessive oil leakage and smoke from the exhaust. If these symptoms occur, first check to see that the scavenge pump is operating correctly, then check that the orifice is clean and that the check-valve is functioning properly.

OPERATIONAL NOTE: You must allow the scavenge pump to run for about twenty seconds after engine shutdown to purge the oil remaining in the turbocharger and lines, otherwise a small amount of oil may slowly seep back down to the turbocharger and drip from the turbo exhaust pipe. Always keep an eye on your oil level!



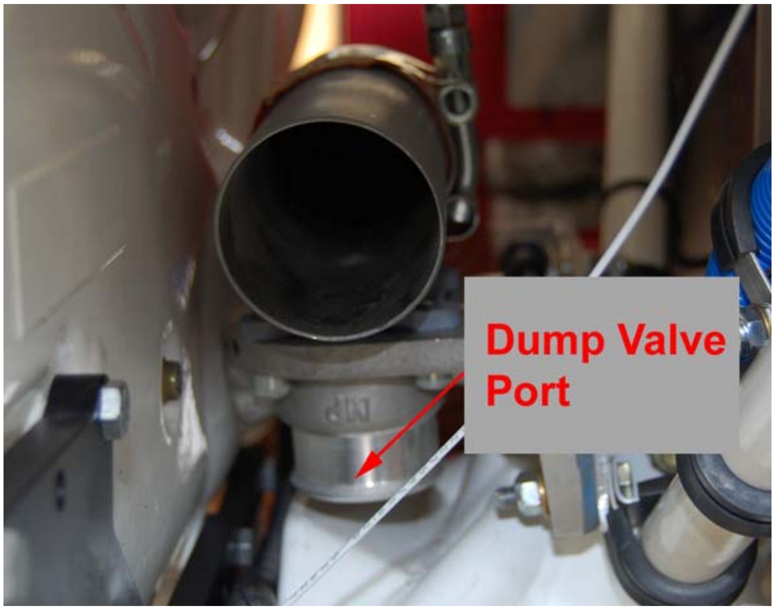
The Check-Valve is located near the oil pan. Because of the low location of the turbocharger, this valve prevents oil from dripping out of the oil galley when the engine and scavenge pump are not running.

If oil drips from the exit pipe or the engine smokes when started, the check valve may be serviced.

A tiny (0.033”) orifice inside the upper fitting limits oil flow to the turbocharger. This should be checked during maintenance intervals.

Dump Valve

The Dump Valve is a simple butterfly type valve located in the flexible compressor duct behind the engine. The dump valve “dumps” excess boost pressure overboard when it is not needed. The open port below the dump valve must remain free and clear. Refer to the description of the “Wastegate Control Valve & Valve Linkage Adjustment” for details on how to adjust the dump valve control cable during installation.

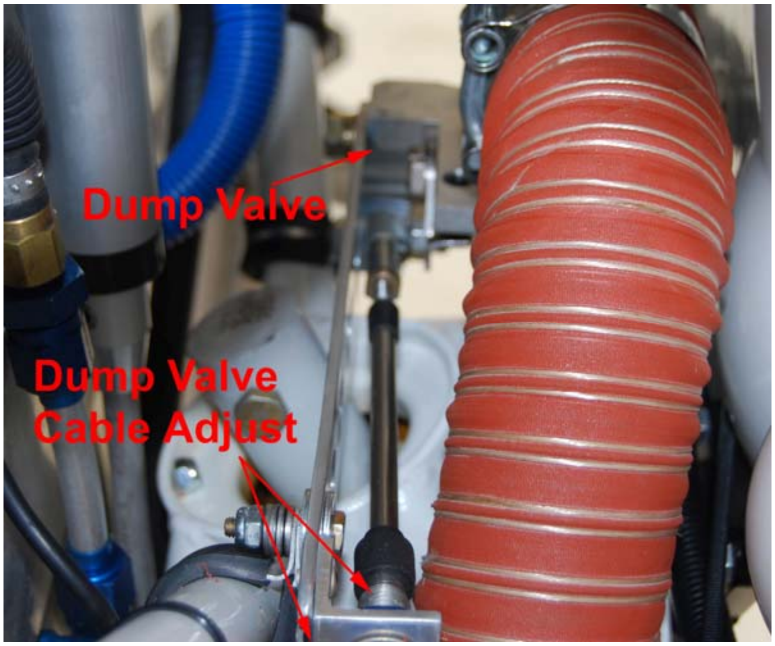


The Dump-Valve is located behind the engine.

Be sure not to block the exit port.

This port also helps the engine breath in the event of a turbocharger failure.

Periodically check the clamps on all ducts.



Similar to the Wastegate Valve, the Dump Valve adjustment is made using the cable nuts while the valve and servo motor are in the CLOSED (pushed) position.

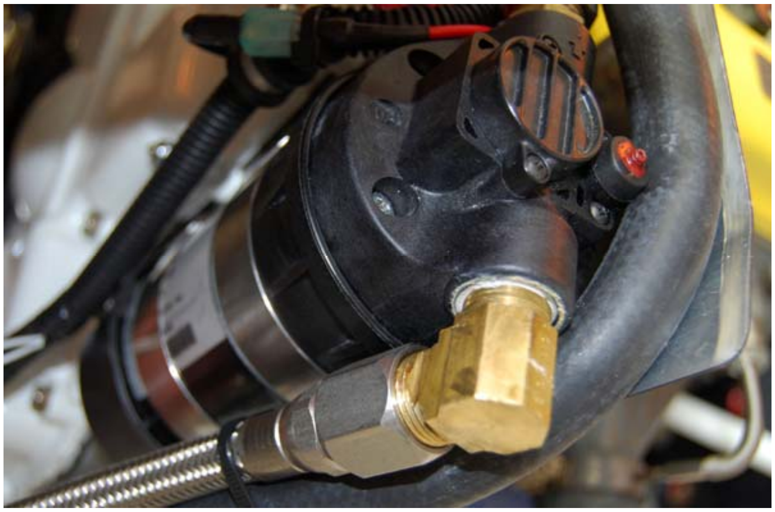
The CLOSED position for the dump valve is when the cable is fully extended. This is opposite of the Wastegate valve. When in doubt, you can always look inside the dump valve port.

Scavenge Pump

Because our turbocharger is located below the oil pan, we must pump the oil that flows through the turbocharger back up to the valve cover. A small electric scavenge pump provides this service.

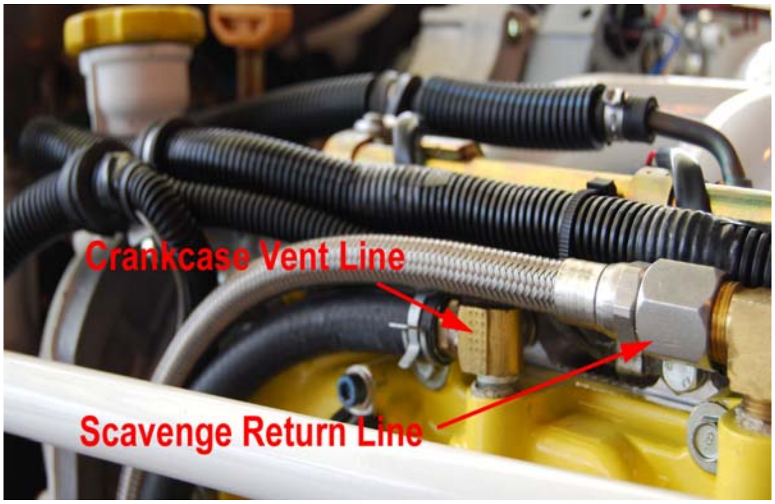
The pump must be switched via Master Switch or Ignition Switch so that it is assured to be running whenever the engine is running. By using the Master Switch, the pump will start slightly ahead of engine startup and remain running slightly after engine shutdown.

This is important as it assures that oil will not drain out of the turbocharger after shutdown.



The Scavenge Pump is mounted below the engine on the passenger side. It must be running at all times that the engine is running and should be left on for a few seconds after shutting the engine off.

Notice the heat shield in front of the pump to block the heat of the exhaust header pipe.



The Scavenge Pump returns oil to a fitting at the top of the valve cover.

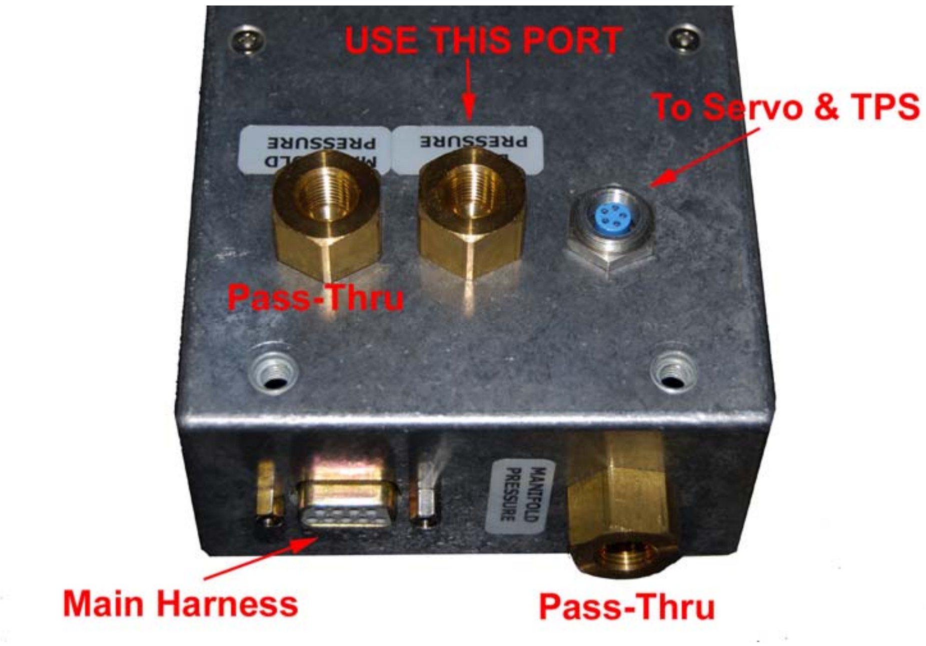
Whenever service has been performed on the turbo oil system, this line should be unhooked and placed into a can during the first 30 seconds of engine operation to make sure oil is still flowing.

Boost Controller

The turbo-normalizer wastegate and dump valves are managed by a microprocessor based controller. The boost controller monitors the manifold pressure (MAP) and opens or closes the servo-operated valves as needed to maintain 30” of manifold pressure.

Refer to the instructions that come with the boost controller for installation and operation details.

WARNING: Never alter the factory switch settings inside the controller. Your engine is NOT designed to handle boost pressures in excess of 30”. Increasing boost pressure WILL destroy your engine very quickly!



The controller is designed to mount against your firewall or other convenient location. It has one fitting labeled “Boost Pressure” and two fittings labeled “Manifold Pressure”.

The Manifold Pressure fittings simply provide a firewall pass-through for bringing your MAP hose into the cockpit. These two connections pass directly through the controller with no internal connection to the controller itself. Use them as you would use a bulkhead fitting if you like.

The fitting labeled “Boost Pressure” is the only fitting actually connected to the controller. This is where we must connect our MAP hose! That’s right. In our application, there is no separate hose for boost, so if you want to use both boost and manifold fittings, just tee a short section of hose to both of them. Operationally, we only care about the one labeled “Boost Pressure”.

The 9-pin DSUB type connector is where your wiring harness will connect. The harness requires connection to power and ground and is pre-wired to an ON/OFF switch and two indicator lamps.

Boost Control Switch

The boost control switch allows you to disable the controller if you choose. Turning the controller OFF will cause both control valves to move fully OPEN, effectively eliminating boost. Normally this switch is left in the ON position.

Boost Indicator Lamps

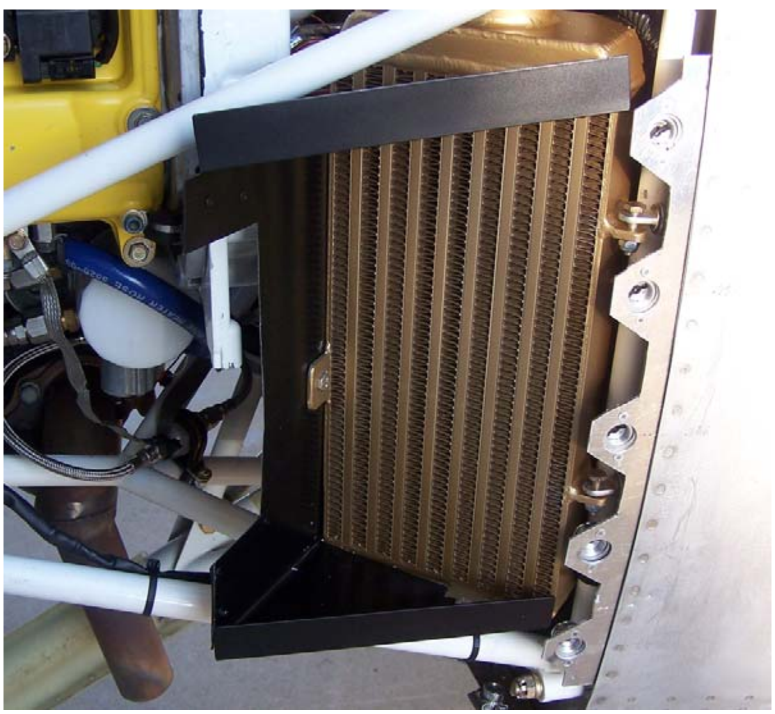
The green lamp indicates when the servos are in motion and the red lamp indicates an over-boost condition. It is normal to see the green lamp flash briefly as the servos maintain control of the valves. It is **abnormal** to see the red lamp! If you encounter an over-boost condition, the red lamp will illuminate and you should **take immediate steps to reduce power through throttle or by turning off the boost controller**. Your engine monitor should also be set up to alarm you whenever MAP exceeds and maintains > 32”.

Intercooler Option

The Intercooler option is an air-to-air heat exchanger that bolts to the pilots’ side firewall using a pair of eye-bolts and Adel clamps. If it was ordered along with the engine, it will be pre-positioned by the factory and only the firewall mounting bolts need to be installed. If the Intercooler is purchased separately, it will require some rework to the existing flexible ducting to place it between the dump-valve and throttle body. Use only “SCEET” type, two-layer, silicone duct or 2” diameter aluminum tube for boost ducts. Use of lower quality SCAT type tubing will eventually result in duct failure and must be avoided.

A single large NACA inlet scoop must be bonded to the pilots’ side of the cowl to provide ample fresh air into the Intercooler. The method of installing this scoop is identical to that described in the procedure for the Air Filter Box.

Aside from physically mounting the Intercooler and hooking up the ducts, no further installation or operational details are required.



The Intercooler option mounts to the pilots’ side of the rear vertical engine mount tube. This provides the shortest possible duct length and takes advantage of the cowl side for its large NACA inlet scoop.

To eye-bolts and an Adel clamp sure the Intercooler.

A shroud helps to direct incoming cool air through the Intercooler

A single large NACA inlet scoop provides ample airflow to the Intercooler option.

The scoop is bonded to the inside of the cowl and mates with the opening in the Intercooler shroud, requiring no further seal.

CHAPTER 5: ENGINE OPERATION

Your engine has already been run at the factory just as it was shipped to you. But it's always a good idea to make sure it runs before you go flying! (That's a joke).

You can test run your engine without a propeller installed if you keep the RPM below approximate 2000 and hold the duration to less than about two minutes. Without the prop, cooling airflow is non-existent, so don't let it run longer than it takes for the thermostat to open. You can tell when the thermostat opens because the radiators suddenly become very warm. If you have your propeller installed, obviously remain clear of it! Add a little pitch to the blades to improve airflow through the radiators and monitor the coolant temperature. Even with a prop, you are still lacking forward motion (assuming your wheels are chocked).

It is normal to hear some gearbox 'chatter' when running the engine at very slow speeds, particularly without a prop. The gearbox has very large toothed gears and needs resistance to keep the gears loaded.

Fluids

Add and check them now…

- **ENGINE OIL:** Add **5w30 Synthetic-Blend or Mineral Oil**. Do not use full synthetic as it will have trouble with the lead in 100LL fuel. The engine takes approximately 6 quarts, but this varies depending on whether you have just changed your oil filter and whether the oil cooler and lines are full. If this is the first time you have run your engine, check the oil level again after about a minute of run time. The level should be at the upper mark of the dip stick. Tail-draggers should raise the tail of the aircraft to check the initial oil level, then lower the tail and check it again, remembering where the full indication is when the tail is on the ground.

  These engines consume very little oil, however it is always best to know that the level is good before each flight. The E6T/220 models will use slightly more oil because of the capacity of the turbocharger. It is not uncommon for the turbocharger to consume a little oil too, so keep an eye on it. If you find oil dripping out of your turbocharger exit pipe, either you failed to let the scavenge pump run for a few seconds after shutdown, or the check valve may be leaking and should be inspected.

  Engine oil and filter should be changed at least every 100 hours.

- **GEARBOX OIL:** Add **16 ounces of 75w90 Synthetic Gear Oil.** We prefer the Mobil-1 brand. This will bring the gear oil level to just above the center mark in your gearbox oil level inspection window. If you overfill or underfill the gearbox, the temperature will run slightly higher than normal. Gearboxes should not run hotter than the engine. Yes we know the drain plug is difficult to reach on some engine models. The oil cooler can be lowered by removing two bolts.

Gearbox oil should be changed at least every 100 hours.

- **COOLANT:** These engines use **EVANS NPG+** waterless coolant. NEVER ADD WATER OR CONVENTIONAL ANTIFREEZE or you will contaminate the coolant! Additional coolant is available from the factory, or directly from Evans Cooling Inc. at www.evanscooling.com. The boiling point of this coolant is 375F which is why we use it and why it needs no water. You will never boil over with this coolant. Because there is no water, we can run very low pressure in the cooling system (controlled by the 7psi pressure cap) which is easier on hoses, clamps, gaskets, etc. It is normal for your engine to run slightly hotter than it would with ordinary water/anti-freeze mix. 220F is fine. 230F in a steep climb is also fine. Anything higher and you should lower your angle of climb to increase air speed and lower your cowl flap.

  Your engine should be full of coolant when it arrives, but if you have opened up heater lines etc. you will need to add some coolant to the reservoir. The reservoir is typically about one third to one half full. It needs some room for expansion as the coolant heats up. For this reason, some coolant may flow from the overflow hose until the engine is warm and the proper level is achieved. Unless you have a leak or air pockets in your cooling system, the level should remain good and the coolant is good for the life of the engine. Running the engine for a few minutes with the pressure cap off helps to purge any air from the system.

- **BATTERIES:** OK, they're dry-cells, but make sure they both have a good charge. The Odyssey type batteries require a special type of charger. Never use a regular automotive charger and especially never use a trickle charger as these do not provide proper charge voltage or currents. When running with the alternator turned on, you should see between 14.0 and 14.2 volts with no loads. Under load, you will see slightly lower voltages, approx 13.5 volts. After sitting for a few days or weeks, the voltage may drop lower. Not to worry, these batteries have a shelf life of about eight years. Still, it's a good idea to buy new batteries every few years or rotate one out every couple of years.

- **FUEL:** All E6-Series Powerplants require high-octane fuel. These are high-compression, high-performance engines!

  E6/200 CAN USE PREMIUM AUTOMOTIVE FUEL OF 92 OCTANE OR GREATER OR 100LL AVGAS.

  E6T/220 ENGINES MUST RUN 100LL FUEL AND SHOULD <u>NOT</u> RUN AUTOMOTIVE FUEL.

Never run lower grade fuels! It can and will destroy your engine.

Starting the Engine

If this is the first time you have started your engine, it is wise to crank the engine over for several revolutions before turning on the ignition switch. This allows oil pressure to build up and purge the system of any air. It also assures that the cylinders are free of any oil that may have accumulated during engine shipment and helps to lubricate the cylinder walls and other bearings.

The engine will start best with the throttle closed. The ECU senses the throttle position and will engage a fuel mixture that is appropriately rich for approximately 10 revolutions of the engine (5 prop revolutions). The ECU does not engage the spark until 2 revolutions have gone by. If the engine does not start within 5 revolutions of the prop, turn the ignition switch off and on again to reset the ECU's start sequence.

When the engine starts for the first time, it is not unusual to see a puff of smoke from the exhaust. This is oil burning off that collected in the cylinders during shipment. The exhaust pipes may also smoke for a little while as oil and anti-seize compounds burn off. Subsequent starts will be smoother than the initial start.

Note: It is very difficult to program the cold start sequence down here in Florida where it is never cold. We enlisted the help of some Canadian friends, but if starting is extremely difficult in very cold climates, please contact the factory. We do have solutions!

Idle Adjustment

The idle was set at the factory, but without a prop installed. This means it will probably idle too slow and you may hear some gearbox 'chatter'. The correct idle speed is 1300 engine RPM which equates to 650 prop RPM. Below this speed you will almost certainly hear some amount of gearbox chatter. *Those are big teeth in that there gearbox and the prop disk tends to get ahead of itself at such low RPM.*

To set the idle, first determine the tools you will need. Depending on what type of throttle body is on your engine (we used two types in 2007) you will either need a 2.5mm allen wrench or a 3mm allen wrench and a 9mm or 10mm open end wrench to work the lock-nut.

Loosen the lock nut and turn the center screw with an allen wrench a turn or two in the direction you see that it needs to go. Extend the screw to speed it up, retract the screw to slow it down. Because the throttle linkage gets in the way, this is best done with the engine stopped. You can leave the lock nut loose until you get the speed set right.

Let the engine become fully warm. The ECU switches fuel map tables when the engine reaches normal operating temps and the engine naturally changes speed a little. Repeat the previous step as needed until you achieve the right idle speed, then tighten the lock nut again.

Run-Up

It typically takes about five minutes for the engine to reach the temperature where the thermostat is fully open. Depending on the climate, some engines never fully warm up if the cowl is removed. It is not unusual for one radiator to heat up before the other. Give them time to stabilize.

As a rule of thumb, never initiate a full power takeoff until the engine reaches at least 140F coolant temperature. Otherwise the thermostat will open very quickly in your climb and very hot coolant will meet very cold coolant very quickly. We've never seen a failure because of this, but it just makes sense to take it easy on your engine.

Be sure to dial in a prop pitch suitable for takeoff when doing your run-up.

E6T/220 Specifics

The E6T/220 requires that the turbo-normalizer be operative for flight.

The engine can develop and maintain substantial power with the turbo-normalizer turned OFF because it is still drawing air through the turbine. Even with the control valves fully open, the turbine continues to spin, at a much lower speed, but enough to supply minimal airflow to the engine. **This is sufficient for cruise and landing, but this reduced power level is not recommended for takeoff or climb.**

In the event of a turbocharger failure which results in turbine stoppage (seizure), the turbo-normalizer controller should be turned OFF. This results in opening both control valves. The open Wastegate allows exhaust to bypass the seized turbine and the open dump valve allows another source of unrestricted air *into* the engine. **In the event of a turbo-normalizer failure, you will be operated at a greatly reduced power level and should therefore take appropriate actions to land at an airport for repairs.**

In a serious bind, where no repairs are possible (i.e. middle of nowhere), you may disconnect the silicone boot from the throttle body and remove or tie back the ducting to eliminate any intake restriction and fly as a normally aspirated engine to the nearest repair facility. Make sure that the wastegate valve is left in a fully OPEN position and that the scavenge pump is operational.

Never fly with an inoperative scavenge pump as you will eventually deplete your oil supply!

CHAPTER 6: COOLING CONSIDERATIONS

We have always maintained that a properly cooled powerplant is a properly *cowled* powerplant.

We now offer a custom "E-cowl" for several popular models of kit planes that has been proven to provide good cooling and performance characteristics. For aircraft which we do not yet have cowls, we offer a "template" cowl consisting of a single layer fiberglass layup of our E-cowl mold. This allows you to benefit from our experience when building your own custom cowl.

Our customers have experimented over the years with countless variations of radiator, oil cooler, and scoop configurations, but with very few exceptions, the formula for optimal cooling goes as follows:

1. Provide AMPLE inlet air to both of the radiators and oil cooler. Do not try to "reduce drag" to squeeze every last half-knot of speed out of your plane at the expense of cooling your engine!

2. If you are "hell-bent-on-speed", make sure your engine cools FIRST, then work on improving speed through small incremental changes. You only get one chance to destroy your engine versus many years to have fun with speed mods.

3. Tightly seal the radiator and oil cooler inlets to the cowl to force the airflow through the radiators.

4. Provide AMPLE exit airflow to reduce pressure inside the cowl behind the radiators and oil cooler. Ample airflow is a variable term. What is ample during high-power, low-airspeed climbs is more than ample during relaxed cruise flight. The only way to serve both modes of flight without penalizing one, is to provide a large area movable cowl exit flap. Period. Open it during climb and close it during cruise.

5. Avoid sharp bends, as much as practical, in the airflow from inlet to exit. The optimal maximum divergence is 5-degrees. When you exceed this, you will be limiting the potential effectiveness of the cooling system. Note: You may be able to make up for less than optimal flow in one area by improving other areas and still cool just fine.

6. Oil cooling is approximately 40% of the overall cooling. Give the oil cooler a good supply of airflow and a clear shot at the exit area with as few bends as possible. Good oil temperatures will fall within 5 to 10 degrees Fahrenheit of coolant temperature.

7. Proper coolant temperatures are 190F to 205F in cruise, and 205F to 230F in hard climbs. In excess of 230F you should step-climb or reduce your angle of climb

to improve airflow and cooling. At greater than 235F you should immediately reduce power and level out until temperatures drop and consider a review of your cowl to determine why your temperature is so high. Keep in mind that NPG+ coolant does not boil until 375F, so you should never "boil-over" but you can start to damage bearings and seals above approx 250F. It is normal for NPG+ to cause an engine to run slightly hotter than the "automotive" specification using a water/glycol anti-freeze, but the advantages far outweigh the disadvantages.

8. Provide ample airflow to the gearbox. Use small diameter (1" or 2") ducts to direct airflow to each side and the bottom of the gearbox from the radiator and oil cooler ducts respectively. A reasonable spinner-gap, on the order of 0.375" will also help cool the gearbox and make the cowl easier to install and remove. The gearbox temperature should always be equal to or lower than the coolant temperature. If your gearbox is generating heat in excess of the engine coolant temperature, investigate and resolve the problem. We see wide variation in gearbox temperatures ranging from 160F to 220F. Above 240F your gearbox can be damaged in short order.

Please consider your engines cooling requirements first, and gaining every knot of speed second. We have clearly proven the formula above using our new E-cowl design. We have excellent cooling and performance that is competitive with equal or even larger "conventional" engines. Decades of fine-tuning has gone into "conventional" air-cooled engines. Your liquid-cooled engine is still evolving. Please take our advice as an excellent starting point and let us know the results of any further experimentation that would benefit everyone.

CHAPTER 7: POWERPLANT MAINTENANCE

One of the many great things about Subaru engines is that they are very trouble-free engines requiring only minimal care.   Aside from idle speed, there is nothing to adjust or tune.   All that is required is a routine maintenance schedule for service parts that are available at any automotive parts store.

FLUID-RELATED MAINTENANCE SCHEDULE

SERVICE ITEM	**INITIAL FLIGHT**	**EVERY 100 HOURS**	**EVERY ANNUAL**
Engine Oil Filter	Replace	Replace	Replace {1}
Engine Oil	Change {2}	Change {2}	Change {2}
Air Filter	Inspect	Clean {3}	Clean {3}
Low-Pressure Fuel Filters	Inspect or Replace	Inspect or Replace	Replace {4}
High-Pressure Fuel Filter	Inspect or Replace	Inspect or Replace	Replace {5}
Gearbox Oil	Check Level	Replace {6}	Replace {6}
Coolant (NPG+)	Check Level {7}	Check Level {7}	Check Level {7}

{1} – Use any high-performance oil filter listed for a Subaru 6-cylinder engine after 2006.   K&N Filters Inc. manufactures a filter with a safety-wire retainer if desired. Tighten per manufacturers' instructions or approx ¾ turn after gasket contacts base.

Part Numbers: Proline Filter: PPL-14459 or K&N Filter: HP-1004

{2} – Use **5w30 Synthetic-Blend** or Mineral Oil.   Do not use full Synthetic oils. Quantity will vary based on oil cooler configuration. 6 quarts is a good approximation, less if the oil cooler is full.

Examples: Valvolene "DuraBlend" or Castrol "Syntec" blend.

{3} – The supplied K&N Air Filter is a 'lifetime' filter.   I can be cleaned with a blast from an air hose or washed per manufacturers' instructions.   K&N sells light oil that is applied after cleaning their filters.

Part Number: K&N Filter: 33-2022

{4} – The two low-pressure fuel filters are available at any automotive parts store.   Take the old ones in and match them up.   Some people will prefer to use their own ideal filter. This is fine as long as they can handle a minimum of 35 gallons per hour flow rate.

Part Number: Purolator F20011 (Clear Plastic Type)

{5} – The high-pressure fuel filter is available at any automotive parts store. Take the old one in and match it up. Be sure to get one rated for EFI Fuel Injected engines that can handle a minimum of 35 gallons per hour flow rate and 60 psi pressure. Users of the Andair Through-Firewall-Filter can simply flush the 'lifetime' filter element in gasoline and replace it.

Part Number: Purolator F54618

{6} – Use **16 ounces (half of the typical squeeze bottle) of 75w90 Synthetic Gear Oil.** 16 oz will fill the gearbox to slightly above the center of the inspection window when the aircraft fuselage is level. Do not overfill or underfill the gearbox. There are no filters to change. On some particularly tight installations, the engine oil cooler must be lowered to gain access to the gearbox drain plug.

Example: 75w90 Mobil-1 Light Truck and SUV Synthetic Gear Oil.

{7} – Use only **Evans NPG+ coolant.** You may purchase this through the factory or directly from Evans Cooling Inc. at www.evanscooling.com. Use only NPG+. Never add water!!! In a bind, you can use a small amount of pure "Environmentally-Friendly Propylene-Glycol" (i.e. "Sierra" brand) with NO WATER.

MECHANICAL MAINTENANCE SCHEDULE

SERVICE ITEM	INITIAL FLIGHT	EVERY 100 HOURS	EVERY ANNUAL
Prop Brushes & Rings	Inspect	Inspect & Clean {1}	Inspect & Clean {1}
Prop Bolts & Blades	Inspect	Inspect	Check Torque {2}
Engine Mount Bolts	Inspect	Inspect	Check Torque {3}
Exhaust Bolts	Inspect	Inspect	Check Torque {4}
Alternator Belt	Inspect {5}	Inspect/Replace {5}	Inspect/Replace {5}
Batteries	Inspect {6}	Inspect {6}	Inspect/Replace {6}
Spark Plugs	Inspect {7}	Inspect {7}	Inspect/Replace {7}
Cooling Hoses	Inspect {8}	Inspect {8}	Inspect {8}
Intake Ducts	Inspect {9}	Inspect {9}	Inspect {9}
Fuel Lines	Inspect {10}	Inspect {10}	Inspect {10}

{1} – Propeller Slip-Rings become tarnished after a while, particularly when exposed to rain and snow. A light cleaning with a fine Scotch-Brite pad will keep them in good shape.

{2} – Refer to your Propeller Service Manual for details on checking the blade and bolt torque as well as any other maintenance tasks.

{3} – Forward Engine Mount Bolts are tightened until the rubber cushions swell to approx 1/8" larger diameter than the cup washers backing them. If the rubber cushions are cracked or dried out, contact the factory to purchase new ones. Torque the firewall engine mount bolts per airframe manufacturers' recommendation or per the Standard Aircraft Maintenance Handbook. Always use new cotter pins.

{4} – Exhaust stud bolts are torqued to 650 inch-pounds (55 foot-pounds). New gaskets can be purchased from your local Subaru dealer if needed.

{5} – The alternator belt should be adjusted so that there is approx ½' of TOTAL deflection in the center of the belt (1/4" each way) with moderate hand pressure. To adjust the belt, loosen the long pivot bolt as well as the slotted adjustment bolt. Pry gently beneath the alternator to the desired tension, then tighten the slotted bolt and pivot bolts.

Standard Alternator Belt – Dayco PolyCog 5040270 (4-groove)
High Output Alternator Belt – Dayco PolyCog 5050280 (5-groove)

{6} – We recommend Hawker Energy "Odyssey" dry-cell batteries. When a proper charge is maintained, these batteries will last for many years. We recommend a rotation strategy of periodically replacing one battery. How often is a matter of how well you maintain your aircraft and how heavily the batteries have been used.

Part Number: Odyssey PC-625 (625 cold cranking amps) or PC-680 (680 cold cranking amps) with terminal studs.

{7} – Use NGK brand Iridium Spark Plugs gapped to 0.044". A light tan colored insulator indicates optimal performance. A lighter color can indicate a lean condition while a darker color can indicate a rich condition. Always apply a small amount of anti-seize compound to the threads (avoiding the tip) when installing new spark plugs.

Part Number: NGK Brand Iridium ILFR6B.

{8} – Inspect all cooling hoses on the engine and heater. Replace any sections which appear to be dried out, cracked, discolored, split, hardened, etc. Use only two-ply silicone hose. We highly recommend using Oetiker brand clamps.

{9} – Inspect all flexible intake ducts for signs of cracks or damage. For non-turbocharger installations, use SCAT type silicone duct. For turbocharged installations use ONLY two-ply **SCEET** type silicone duct.

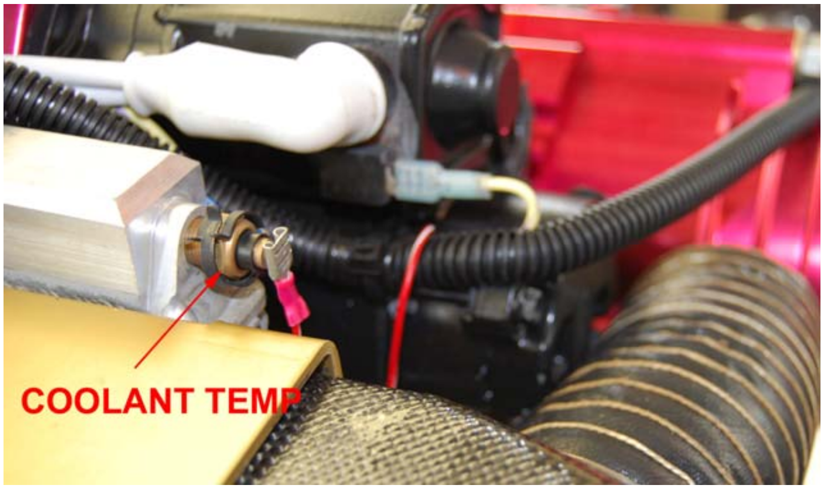
{10} – Inspect all sections of flexible fuel line. Replace any sections which appear to be dried out, cracked, discolored, pinched, hardened, chaffing, etc. Use only "fuel-injection" type fuel hose or similar hose approved for high-pressure aircraft fuel system use (i.e. Aeroquip). Always use fuel-injection type clamps or Oetiker clamps. Never use regular automotive worm-screw clamps!

Pressure and Temperature Ranges

The following table suggests appropriate temperature and pressure ranges for your powerplant. Some variations can be expected with different configurations. These are only guidelines.

SENSOR	MIN	CAUTION	MAX	NOMINAL
Oil Temperature	0	230F	240F	190F to 220F
Oil Pressure	10psi	12psi	110psi	> 15psi@idle, 30 to 100psi
Coolant Temperature	0	230F	235F	190F to 220F, >140F@takeoff
Fuel Pressure	25psi	35psi	45psi	36 to 42 psi
Gearbox Temperature	0	230F	240F	180F to 220F
Battery Voltage	12.5V	13.0V	14.5V	13.8 to 14.2 VDC running

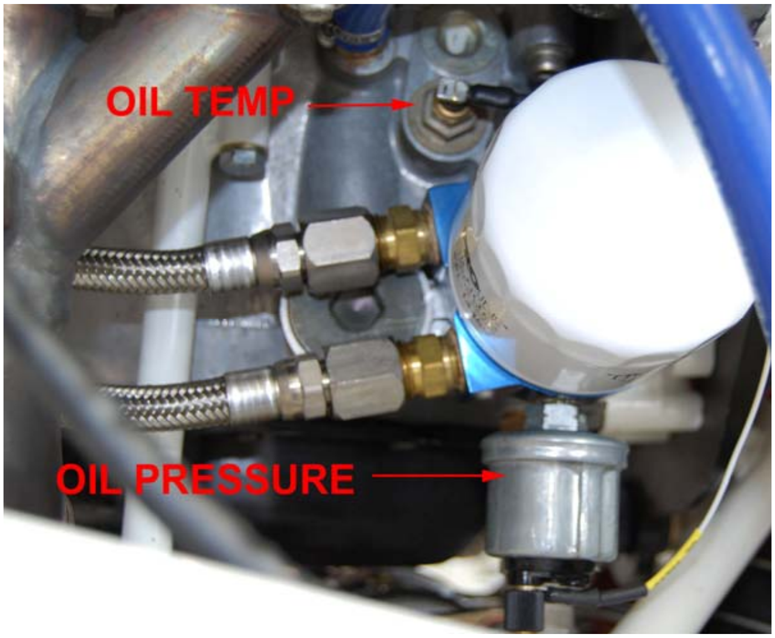
Pictorial Guide to Engine Sensors and Locations



Coolant Temp Sensor is located in upper right side radiator.

1/8" NPT thread Resistive Sensor

Verify proper ground and provide a ground wire if needed.

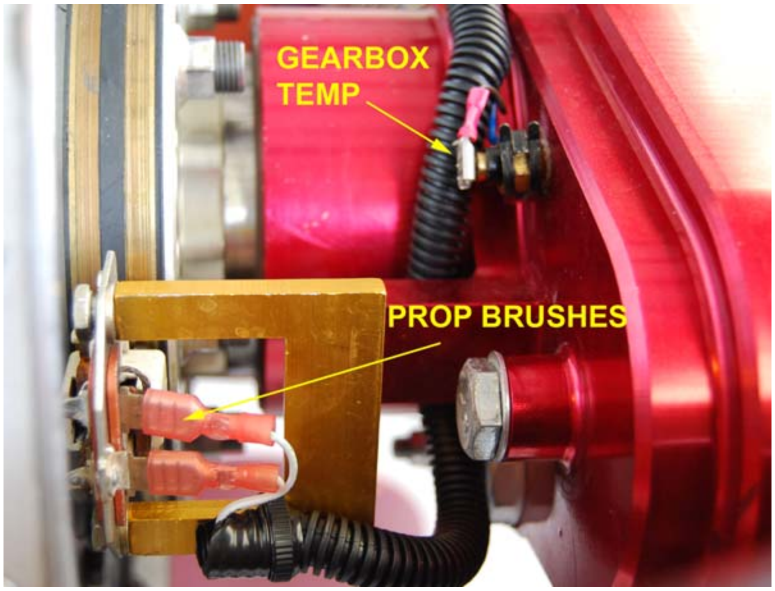


Oil Temp Sensor is located in the block just above the oil filter.

1/8” NPT thread, resistive sensor.

Oil Pressure Sensor is located below the oil filter in the adapter or block.

1/8” NPT thread, resistive sensor.



Gearbox Temp Sensor is located in the top or front (shown) of the gearbox.

1/8” NPT thread, resistive sensor. Verify proper ground and provide a ground wire if needed.

Prop Brush Block for a Sensenitch/Quinti type prop is shown.

Engine Logbook

You are required to maintain an Engine Log Book listing the installation date, and periodic maintenance performed on your engine. You can purchase these from Aircraft Spruce at www.aircraftspruce.com/menus/bv/books_log.html

Your powerplant serial number is found on a small stainless steel plate affixed to the upper aluminum bellhousing.

…MISSION ACCOMPLISHED!

We sincerely hope that this Installation Guide has provided you with ample information to install, operate, and enjoy your Eggenfellner Powerplant. As always, we look forward to hearing from you and meeting you at the major airshows. If you have comments or corrections regarding this document, please direct them to EAAINC@aol.com with the subject line: Installation Guide Comments. We will do our best to evolve this material to satisfy your needs.