Falco Construction Note 61004-1

Engine Installation

This Falco Construction Note replaces Advanced Builder Memo "Chapter 41 Engine Installation"

Nylon Tubing

Nylon tubing is used wherever possible. Nylon tubing is very light—in the 1/4" size, the tubing is one-fifteenth the weight of Aeroquip 601 hose. It is also compact, which means that the already-tight spaces in the Falco will be less crowded. Nylon tubing has been used on a number of homebuilt aircraft for brake lines, fuel lines, oil lines, and low pressure hydraulic lines. The use for brake lines is most common, and results in a lightweight easy-to-install system.

Nylon tubing is easy to install since it is pulled through like wire. Aluminum tubing requires that the tubing be bent with a tubing bender. Flareless Swagelok fittings may be used with both nylon and aluminum tubing, and these fittings do not require flaring the ends for the tubing as is required with AN fittings.

In some cases, it is preferable to have the tubing hold a specific bend. Nylon tubing can be bent by heating with a hair dryer. Hold the tubing to the bend required while the tubing cools or just put it under a cold-water tap.

We are talking about nylon tubing and not polyethylene tubing. Nylon tubing is sold under the Nylo-Seal name by Aircraft Spruce, Wicks and other suppliers. You will be able to purchase it locally at a refrigeration and air conditioning supply store.

At room temperature, nylon tubing has a burst pressure of 2,500 psi. The working pressure is 625 psi, and it is based on a safety factor of 4. Nylo-Seal tubing is satisfactory for continuous operation up to 180° F, but becomes embrittled above this point. Burst pressure declines to 1,400 psi at 230° F, and the tubing is listed as unusable at 280° F. Because of these limitations, nylon tubing is not used in front of the firewall. The only exception to this would be for the brake reservoir, where we would like to use the tubing. In this application, the tubing is operating under essentially zero pressure.

Nylo-Seal tubing has acceptable chemical resistance to hydrocarbons (fuel and oil), chlorinated hydrocarbons, acetone, MEK, toluene, xylene, weak acids, weak bases and strong bases. The resistance to strong acids varies with the acid.

Nylon is subject to attack from ultraviolet radiation, and this will cause the lines to lose strength with time. The service life of nylon is not known, but in the Falco the tubing would be out of direct sunlight; therefore, ultraviolet deterioration is thought to be at a minimum.

Swagelok Fittings

Swagelok fittings are manufactured by Crawford Manufacturing and come in a wide variety of styles. These fittings are flareless fittings; that is, they do not require that the tubing be flared.

To install a tube into a Swagelok fitting, there are three steps. (1). Insert the tubing into the Swagelok tube fitting. Make sure that the tubing rests firmly on the shoulder of the fitting and that the nut is finger-tight. (2). Before tightening the Swagelok nut, scribe the nut at the 6:00 o'clock position. (3). Now while holding the fitting body steady with a backup wrench, tighten the nut one-and-one-quarter turns. (For 1/16", 1/8", 3/16", 2, 3 and 4mm size tube fittings, only 3/4 turns from finger-tight is necessary.)

By scribing the nut yourself at the 6:00 o'clock position as it appears to you, there will be no doubt as to the starting position. When tightened 1-1/4 turns to the 9:00 o'clock position you can easily see that the fitting has been properly installed.

For high-pressure applications and high-safety-factor systems, a common starting point is desirable due to the variation of tubing diameters. Therefore, use a wrench to snug up the nut until the tubing will not turn (by hand) in the fitting. At this point, scribe the nut and body of the fitting. Now, tighten the nut one-and-one-quarter turns and the fitting is ready to hold pressures well above the working pressure of the tubing.

Connections can be disconnected and re-tightened many, many times and the same reliable, leak-proof seal obtained every time the reconnection is made.

Swagelok fittings are sold by a series of distributors. These distributors are not used to dealing with individuals wishing to purchase a few fittings. We will be happy to supply the name of the local distributor, but it will probably be necessary for us to purchase a supply of these fittings prior to finalization of the plumbing kits.

Aeroquip 666 Teflon Hose and Fittings

Aeroquip 666 medium pressure hose is used in the engine compartment. Aeroquip 666 is a lightweight hose with a seamless extruded inner tube of Teflon and a tightly braided reinforcement of stainless steel wire. Service and shelf life of Aeroquip Teflon hose is unlimited for all practical purposes, however the service life on impulsing applications may be limited by fatigue in the wire reinforcement. Aeroquip 666 hose is rated for continuous operation from –65°F to +450°F.

Aeroquip 666 hose assemblies can be made with Aeroquip Super Gem reusable fitting or Aeroquip Compression Crimp fittings. The drawings show the reusable fittings as well as the appropriate Aeroquip hose assembly number for compression-crimp fittings. The length of the hose is shown, and the additional length of the fittings is shown in reference. When ordering hose assemblies from Aeroquip, you must give the assembly length (the hose length plus the referenced fitting lengths), which is expressed in four digits and the last digit indicated the fractional length in 1/8's of an inch. (Lycoming part numbers apparently use the same scheme but with three digits)

Aeroquip Compression Crimp fittings are lighter and cheaper but can only be installed by Aeroquip. The Aeroquip hose assembnly number given on each drawing are for the Compression Crimp fittings.

Aeroquip 601 Hose and Fittings

Aeroquip 601 hose is a similar hose except that the inner tube is a seamless synthetic rubber compound, which is subject to attack by ozone. Accordingly, this hose has a life that is dated from the manufacturing date, and the hose must be replaced at regular intervals—a three-year replacement schedule is suggested by some people. Aeroquip 601 hose is rated for continuous operation from –40°F to +300°F. It may be used with a temperature range of –65°F to +375°F on approval of installation by Aeroquip. Since it is so vastly superior, we strongly recommend that only Aeroquip 666 hose be used.

The hose assemblies can be made with Aeroquip Little Gem reusable fittings, which are not compatible with Aeroquip 666 hose. To use Aeroquip 601 hose, you may substitute the part numbers shown below.

Hose	Aeroquip 666-4	Aeroquip 601-4
Straight fitting	Aeroquip F66000-4	Aeroquip 816-4
90° fitting	Aeroquip F6605-4	Aeroquip 8891-4
Hose	Aeroquip 666-6	Aeroquip 601-6
Straight fitting	Aeroquip F66000-6	Aeroquip 816-6D
90° fitting	Aeroquip F6633-6	Aeroquip 8846-6D

Anti-Sieze Lubricants for Aluminum Fittings

The threads of an aluminum fitting should be coated with an anti-sieze lubricant and sealer, or you will find the fitting nearly impossible to remove. For aluminum to aluminum fittings use either Titeseal or Sealube. Both are available from Aircraft Spruce and Specialty and other suppliers. For dissimilar metals, such as steel or brass fittings in aluminum, use 3M anti-sieze compound or the equivalent. This would apply especially to any steel or brass fitting installed in the engine crankcase and to spark plugs.

Fuel and Manifold Pressure Line Installation

When the instrument panel is removed, the manifold pressure/fuel pressure gauge must be removed from the panel. Originally, the idea was that the gauge would be removed from the panel before the panel was taken off its studs. We have had reports that there is not enough room to do this, that the operation takes two people, and requires that the instrument panel be brought aft slightly (off its studs and held by a helper) while the tachometer, manifold pressure/fuel pressure gauge and EGT are removed. Keep this in mind when you install the tubing to the gauge so that you will have enough length.

Oil Cooler Lines

Both oil cooler hose assemblies are the same length. The upper outboard 45° fitting is angled down and outboard and the line from it runs to the outboard port on the oil cooler. The inboard 45° fitting is angled down and slightly outboard and the line from it runs to the inboard port on the oil cooler. The use of 45° fittings is required with engines that have an oil filter. The direction of the flow through the oil cooler is not important.

Oil Pressure Transducer Line

The oil pressure connection port is on the aft end of the engine. This is a 1/8” NPT port above and in front of the right magneto, and below the upper right Lord mount. The 45° AN823-4D *must be installed on the engine before the engine is installed on the engine mount*. This fitting should be installed so that it points down and to the right side of the airplane, and maybe just a smiggen to the rear.

The oil pressure transducer is mounted on the engine mount, using either Adel clamps or nylon tywraps. The transducer should be installed between the two upper tubes of the engine mount. Remember to set the thing up so that the engine can move around without jerking on the hose.

Fuel Pump Vent Line

The engine-driven fuel pump has a .125”-27 dryseal straight pipe thread hole for a vent line. This will accommodate a standard 1/8" NPT fitting, although it is best to use some Teflon tape on the threads.

The Lycoming installation drawings specify that a .020-.030”Ø restrictor fitting or check valve must be installed in the fuel pump vent line. We have never seen this done on a Lycoming installation. Lycoming engineers say that all of the newer diaphragm fuel pumps have this restrictor installed internally. If the fuel pump does not have a restrictor, use a piece of aluminum, drilled with the required size hole, and insert it in the AN840-4D.

If you have never seen the inside of a diaphragm fuel pump, then it may help you to understand how they work. The pump is connected to the engine and the engine causes an arm in the pump to go up and down. This pushes the diaphragm up and down, and it works something like an accordian or a bellows. Check valves in the bottom of the pump allow fuel to be sucked in and pushed out when the diaphragm moves up and down. An internal pressure relief valve allows fuel to recirculate in the pump once it reaches a certain pressure.

There are actually two diaphragms, and the vent port is between them. If the lower diaphragm develops a leak, fuel will flow out of the vent. The purpose of the vent is to dump the fuel overboard in a safe place (away from the exhaust) and to keep the engine compartment from being sprayed with raw gasoline. The purpose of the restrictor is to keep the fuel pump from pumping all of the fuel overboard.

Engine Controls

The details for the engine controls are shown on Drawing No. 131. This drawing applies only to the controls for the IO-320-B1A and IO-360-B1E engines. The drawing is self-explanatory, but we need to cover a few problems.

Mixture Control Cable

One builder reported that his 180 hp IO-360-B1E engine was supplied with a crank mixture control arm (like the one installed on the throttle), and this arm hit the nose gear lower drag strut during retraction. The cranked mixture control arm was replaced with a straight one, and the problem was solved.

Hartzell Governors

Hartzell makes a line of governors which can also be used with their propellers. These governors are an old Hamilton-Standard design, which was sold to Woodward and then to Hartzell. There is nothing wrong with the Hartzell governor design, but they are large, heavy governors, and it is difficult to design and install a bracket to hold the control cable. This is the reason that we went to a Woodward governor. If you want to use a Hartzell governor, you may do so, but you will have to design and install a bracket to mount the control arm. P/N 810-1 will not work with the Hartzell governor. This interference problem is not a factor for those builders using engines with the carburetor or injector in the bottom of the engine.

The correct Hartzell governor is the F-2-7A. This is an oil-pressure-to-increase-pitch governor for 2700 maximum engine rpm and .866/1 drive ratio. Governor shops sometimes rework governors so the part number may not match the one just given, but the previous sentence contains all the information the governor shop needs. If you purchase a governor from a twin-engine aircraft, you can be sure that it will be an oil-pressure-to-*decrease*-pitch. This will not work with the Hartzell propellers we use.

Slick Magnetos

We've had a report from one builder that there is a problem with Slick magnetos. These magnetos are substantially larger than the Bendix magnetos normally installed, and as a result the governor control bracket comes very close to the left magneto P-lead terminal. If the bracket should touch the terminal when the engine is running, it will ground out the magneto and effectively turn the magneto off. If you have this situation, you should take measures to prevent this from happening. This can include notching the governor bracket and installing an insulating (phenolic, nylon, etc.) block on the bracket so that the bracket is prevented from hitting the magneto terminal.

Engine Controls For Other Model Engines

Some builders are installing engines with the carburetor or injector located on the bottom of the engine. For these engines, the governor installation is identical to that shown on Drawing No. 131.

The mixture and throttle control cables would normally be of a different length. Our engine control cables are made in quantity, and the cable manufacturer does not want to quote small quantities, but it is possible to have cable assemblies made. In particular, Cablecraft has a number of distributors who make up custom cable assemblies—there is one such company here in Richmond. The Cablecraft cables have a polyethylene lining, while the cables we use have a Teflon lining, which gives better temperature performance and lower friction.

Special throttle and mixture control cable support brackets must be made for these engines. When we have the time, we will do such designs, but at this time the builders will have to fend for themselves.

Smoke System Provisions

Note on Drawing No. 131 Detail B, that a hole is provided for a smoke system line. When we were designing P/N 824-1, we realized that it was only a matter of time before a builder decided to install a smoke system in the Falco. We decided it would be simpler to incorporate a provision for a smoke system in P/N 824-1 so that it would not have to be changed at a later date. The opening is for a 3/8" bulkhead fitting.

This provision can also be used for a number of other uses. You can use this hole for temporary installation of tubing to measure air pressures at various locations in the engine compartment. You can also use the hole for temporary installation of a ferry tanks, should any of you want to fly over oceans. In this case, a ferry tank installed on the right passenger seat tracks would be plumbed direct to the fuel system forward of the firewall. Our Falco was set up this way when it was ferried over from Ireland. When the ferry tank was used, the ferry tank valve was opened and the regular fuel selector valve was cut off.

Induction System—IO-320-B1A & IO-360-B1E

The induction system for these engines consists of a NACA submerged duct on the right side of the cowling. We have done a *very* preliminary drawing for this and hope to do a final installation drawing soon. The induction scoop is a part that is impossible to design on paper. The preliminary drawing shows the overall dimensions for the NACA submerged duct and the Brackett filter, but since the scoop is curved and twisted, it is difficult to draw. The dimensions for the inlet are shown as though the side of the cowling were a flat surface.

We have recently made these parts for the induction system and have added them to the kits. To install the parts, assemble the parts in the following order:

❑ Install the Brackett BA5810 filter assembly between the induction scoop and the funnel. The aluminum grill is installed on the scoop side of the filter. The rubber seal is against the funnel. The assembly is held together with four AN3-25A bolts which are installed from the funnel side of the assembly. Install four MS21047-4 nutplates on the scoop with MS20426A3-5 rivets. The "A" rivets are soft aluminum. Do not use "AD" rivets—they will crack the fiberglass.

Note. Do not attempt to install the induction scoop and filter assembly until the cowling is installed, the throttle control cable is installed, and the boost pump is installed on the firewall. The preliminary drawing shows the filter only a half-inch or so from the firewall. In fact, it must be installed about 4 inches from the firewall to clear the boost pump.

❏ Position the assembly (scoop, filter and funnel) on the right side of the cowling. The funnel should clear the engine mount as well as the throttle control cable. As it is made, the upper flange on the scoop should just ride up on the joggled area of the lower cowling. Check the location of the outlet of the funnel—the three-inch Aeroduct tubing should make a nice bend into the injector.

When you have the assembly located where you want to install it, we recommend that you drill a few holes through the flange of the scoop and the cowling to hold the assembly in place for gluing. You can use Cleco fasteners or screws, and if they have a light coat of oil on them, they can be easily removed after gluing.

The scoop should be glued in place with epoxy. Depending on the fit, you will probably need to mix some cotton flox in with the epoxy. With a few screws holding the scoop in place, you can remove the filter and funnel for the gluing operation.

There is an extra fiberglass piece supplied for the aft end of the scoop. Originally when we designed the part, we envisioned that there would not be a flange on the aft end but that the builder would lay a few strips of glass in on the inside of the cowling and inner aft face of the scoop. The shop that makes the fiberglass parts made the extra flanged piece to stuff in place. Since you have it, it is probably a good idea, because the engine moves around quite a bit and the Aeroduct tubing is short and stiff. The induction scoop should be quite rugged to withstand the vibration.

The opening of the scoop was designed to be about 10.63" from the very front of the scoop to the aft end of the opening. This is also the same place that the sides of the scoop straighten out.

We do not know whether to advise cutting the opening ahead of time or to wait until after the scoop is installed. The opening will be easier to cut ahead of time and the only risk seems to be that the cowling might pull out of shape locally. Since you will not need much clamping pressure, we lean toward cutting the hole before installing the scoop. This way you can easily inspect the glue line along the inlet.

The engine controls kit includes a cable for carbureter heat or alternate air. Many injected engine installations do not have alternate air systems. The choice is up to you. Dave Thurston says he thinks we should have such a system. If you are flying in icing conditions, the induction system can ice over, and the engine will quit due to a lack of induction air. (On the other hand, John Harns has flown his Falco in icing conditions, collecting up to 3/4" of rime ice and he had no induction problems. NACA submerged-duct air inlets are relatively—but not completely—immune to induction icing.)

An alternate air source can be done in two ways. One way is to have a spring-loaded door on the top of the funnel. The door is pulled in by the suction of the engine when the inlet is covered with ice. The second way to do this is to install the cable so that you can manually control the opening and closing of the alternate air door. The funnel is made with flat areas to make it easy to install such a door.

Induction System—Other Engines

For builders installing engines with the carburetor or injector on the bottom of the engine, the induction system is completely different. We have done some very preliminary design work on this. All of the designs are based on using a carburetor air box with a Brackett filter. This will require that the cowling be cut out for the air box, and a scoop built for the cowling. Because of the required size of the filter, this scoop is rather large and ugly. Additionally, carbureted engines must have a provision for carburetor heat.

Some builders have worried about the appearance of such an installation. You always have the option of installing a small scoop similar to that installed on the original production Falcos, but this would eliminate the use of a induction filter. You could even do the installation similar to that done on Luciano Nustrini's Falco. Lord knows, it must not be slowing him down much!

Another possibility is to install a ram-air induction system similar to that on the Swearingen SX-300. The system is a ram-air system, with a small round inlet in the cowling. The air is fed directly into the injector via a tube. No filter is used and the system boosts the manifold pressure by a few inches. This is a very nice system, and any drag of the scoop is certainly overcome by the additional power gained.

The Swearingen aircraft uses a filter. This filter is a round one similar in appearance to the filter we use for the gyro filter, only larger. The filter is mounted up where we install the oil cooler, and it takes air from below the engine baffling. A valve is installed in the intake manifold. This is very similar to the valve we use for cabin heat, except that on the Swearingen, the valve body is rectangular in cross-section, while our cabin heat valve is a tubular valve. This is a very elegant system, and it is one that we would like to pursue when we have time. The way the system works is that the ram air is really the alternate air. Normal take-offs and landings are made on the filtered air. Once in the air, the ram air is selected (with a cable) and left in that position for cruise.

Cabin Heat System

The cabin heat valve that we use is a "chinese copy" of the valve installed on the Messerschmitt BO-209 Monsun. The valve is extremely simple and compact, but it has two faults. For one thing, it is noisy. Since it is an all-metal valve, engine vibration will cause it to rattle. Secondly, the valve is difficult to make so that it seals completely.

The solution to both of these problems is simple. Glue a piece of felt on the inside of the tubular valve body with silicone rubber RTV compound. Hold the valve closed against the felt while the rubber is setting. Lining the inside of the tube will have the added effect of suppressing engine noise, so you should line the entire tube aft of the valve.

The Heat Muff

The cabin heat muff is shown on Drawing No. 722-5, a preliminary drawing available on request. The installation of the muff is shown on Drawing No. 132 Exhaust System Installation.

It is our intention to finalize the design of the muff and have it made. We will include this muff and other parts for the installation of the cabin heat system in a separate kit. Note that the cabin heat muff that we show will only work on the IO-320-B1A or IO-360-B1E engines and their exhaust systems.

The air for the cabin heat is taken from the right front baffle, and the duct is indicated on the baffling system installation drawing. The alternator cooling tubing is also shown on Drawing No. 132. The alternator cooling duct is located on the right front baffle and may be seen on Drawing No. 133 Engine Baffling Installation.

Inverted Oil System Problems

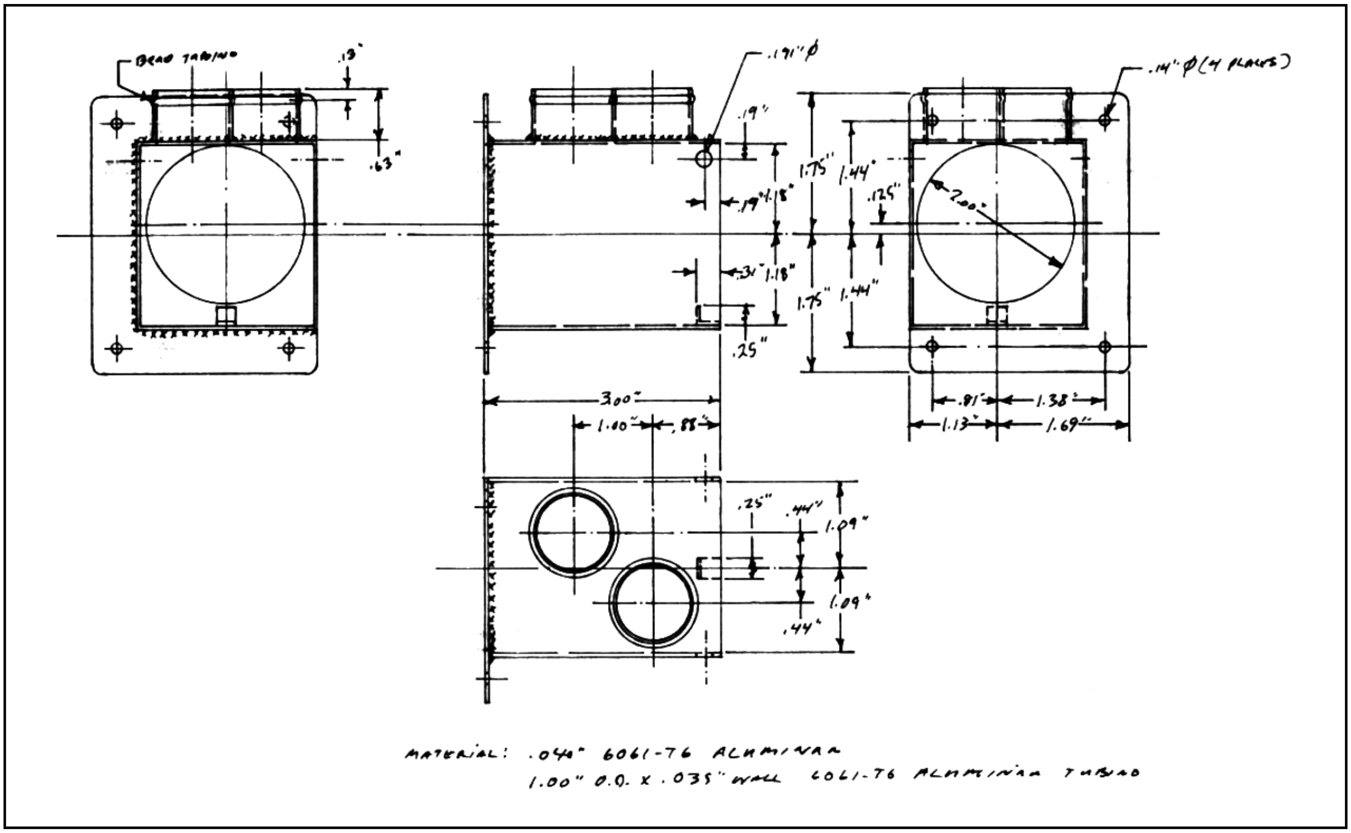
The first special requirement is that the Falco requires the Christen P/N 804-A Angle Fitting on the horizontal screen. If you attempt to use the straight fitting, it will hit the engine mount.

One Falco builder installed a Christen inverted oil system and found that he had to modify the exhaust system so that the aft cross-over tube would clear the oil pickup fitting installed in the bottom of the sump. On that aircraft, the exhaust pipe snaked forward and around the fitting. This created a problem with the installation of our heat muff, and another type of heat muff had to be installed. We understand that the Christen inverted oil system can be installed by welding a boss on the aft end of the sump. If so, this would eliminate the interference problem.

If you cannot do this, you will have to find some other place to hang a muff on the exhaust system. This is likely to be a difficult installation. You should be aware of the possibility of carbon monoxide getting into the muff. Our heat muff has an outer shroud that can be removed for inspecting the exhaust pipe for leaks. Remember that carbon monoxide can escape from the slip joints and ball joints. Obviously, you cannot install a muff for the cabin heat over a slip joint, although it is perfectly acceptable to do this for a carburetor heat muff.

You would normally expect that the positive pressure inside the muff would keep any carbon monoxide outside of the muff from entering it. While this may be true, it is normally a good idea to keep the cabin heat muff away from such potential sources of carbon monoxide. The left tailpipe is an appealing place to hang a muff, but it is immediately downstream of the ball joint. Also, because of the tight fit of the cowling, there is not a lot of space.

It appears that the best solution will be a muff (or two muffs in series) installed on the forward pipes. These should be made of aluminum or light-gauge stainless steel. At this time, you will have to try to work out the design yourself. If you come up with a good design, please let us know how you did it.



Windshield Defrost System

Figure 1 Windshield Defrost Valve Body

See Figure 1, 2 and 3. The defrost system is a diverter valve installed on the aft face of frame No. 1. Hot air from the cabin heat will enter the diverter valve. In the open position, “windshield defrost off,” warm air will pass through the diverter valve as normal cabin heating air. In the closed position, “windshield defrost on,” the cabin heat air will be shut off and the hot air will be diverted up to the windshield defrost vents. Note that the windshield defrost system requires that the cabin heat system also be on.

For noise suppression, the windshield defrost valve may be lined with felt glued in place with silicone rubber RTV compound.

Because of the light forces required to actuate the windshield defrost valve, we do not think the cable housing needs to be supported, but you may lash the cable housing to the “garbage bracket” with nylon tywraps if you wish.

For the windshield defrost vents, look into some of the small, attractive vents used on automobiles. Japanese and European cars seem to have the nicest designs. The Honda Accord has an attractive vent on the deck behind the rear seats. Dave Aronson got something out of a Mazda which looked nice. Most of these are just open plastic vents. We have also seen some which have adjustable vanes which direct the flow of air and which also serve as “on-off” valves. Grob uses a nice automotive vent like this on the glareshield of their motorgliders, but we don’t know who they buy it from. Take your pick, there is no end to the possibilities.

There is also the question of routing of the Aeroduct tubing and the placement of the vents for the windshield defrost. As you probably know by now, things are relatively tight behind the instrument panel. We don’t know where the best place would be, but tubing is flexible, and you can probably route the tubing to where you want the vents.

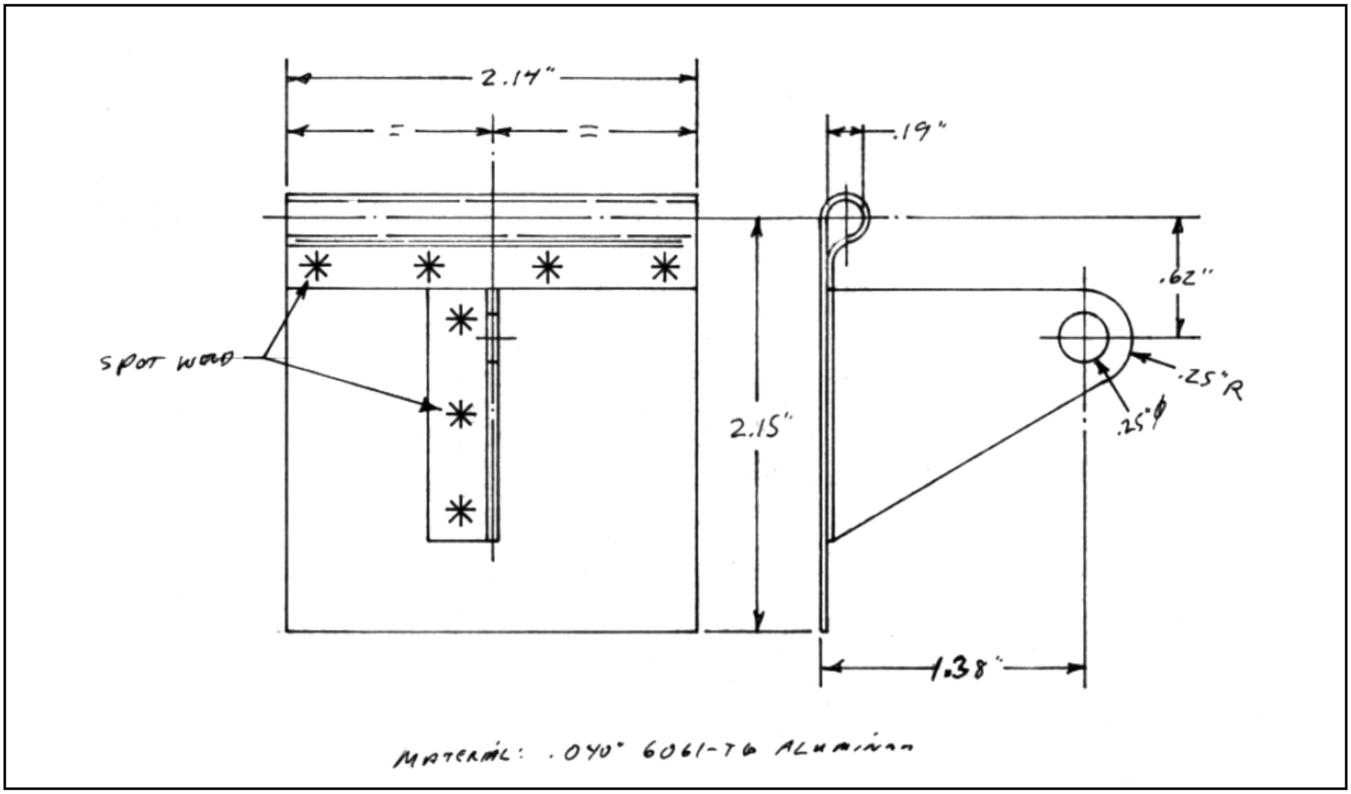


Figure 2. Windshield Defrost Valve.

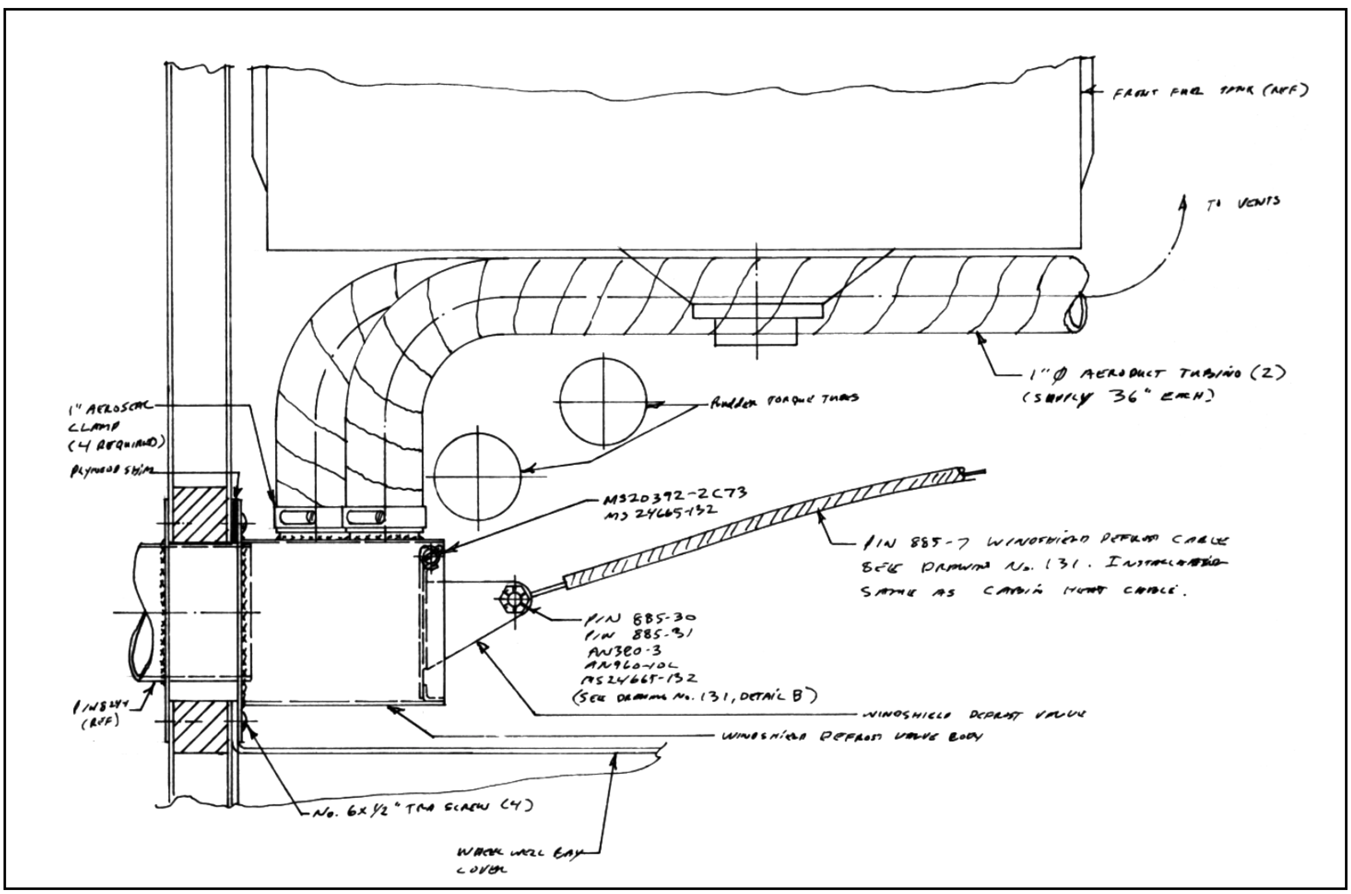


Figure 3. Windshield Defrost Valve Assembly and Installation.