“Aviation in itself is not inherently dangerous. But to an even greater degree than the sea, it is terribly unforgiving of any carelessness, incapacity, or neglect.”

— Aviation Adage

“This statement applies to homebuilt aircraft to even a greater degree.”

— Central States Association.
1.0 Introduction

Just because it's an EXPERIMENTAL, doesn't mean the laws of physics don't apply.

The view from the green side of the dirt is best.

This guide is intended for the owners and fliers of composite canard aircraft that did not build the plane. If you already have made the purchase, one major step has been
completed. In addition, you probably have encountered maintenance issues, parts source questions, and procedural problems that would be known if you had built the plane. Even a supportive A&P or AI has little if any familiarity with some aspects of the plane you want him to maintain. Unless you have a continuing relationship with the builder, some of the rules for safe handling, fabrication techniques for repairs, and parts identification and sources may be a problem for you.

With the increasing number of composite canards being built and later sold, the educational aspect of the prolonged construction process and completing a flyable aircraft are unknown to the next owner. Even if the buyer receives all the builder's documentation, and hopefully he did, much of it is hard to put in comprehensible order.

During the building period, typically many years elapse. During that time, there was an opportunity to read, re-read, and re-read again the construction manuals and product brochures, POH (Pilot Operating Handbook), see and talk to others at Oshkosh, EAA chapter meetings, and “hangar talks” by those more advanced in the building and flying phases. As you attend fly-ins with your “new acquisition”, you are possibly able to quote the features of the plane to by-standers, but the intimate knowledge of how and why something was included or excluded in your plane just is not known.

So, with your continued enjoyment and safety of operation in mind, this guide is intended to highlight many general aspects of the unique aircraft you own, are responsible for, and fly. It is intended to serve as a supplement to the construction plans, owner’s operation manual, and other documentation that you should be intimately familiar with already. It can’t replace the knowledge you would have acquired by building it yourself, but it does offer an opportunity for transfer of knowledge, gleaned from some very knowledgeable builders and fliers who are, in addition, professional subject matter experts in their own right.

In this booklet, you will find a topic listing, presentations, and references to sources for parts. It is not intended to be a substitute for the designer’s composition, the manufacturer’s construction plans, instructional materials or any official documentation. You must also know these materials to fly properly and maintain your aircraft. And just because we didn’t think to include every imaginable technique or procedure, doesn’t mean it wasn’t important enough to mention.

If you are not already a member of the Experimental Aircraft Association, join now. Find the local EAA chapters in your area where members have planes similar to yours, and join this association.

Subscribe to the Central States Association Newsletter for Rutan and derivative canard designs ($25 yearly). March 25, 2004 - The following is the latest Index of the suppliers listed by Terry Yake in the CSA Newsletter:

Index - Terry Shubert
http://groups.yahoo.com/group/canard-aviators/files/
or
http://acs-group.net/ez/

If your aircraft designer/manufacturer has a newsletter, subscribe to it.

Subscribe to Kit Planes magazine.

Attend fly-ins and seek out other canard fliers. Hangar flying can be rewarding and educational.

Find canard aviation chat boards on the Internet. All this leads to being a member of an elite group of similarly minded people. Enjoy the total experience of being an experimental aircraft owner.

**EZ Squadron** — A directory of hundreds of canard aircraft owners from around the world and helpful Articles describing hundreds of incidents are available at the Southern California EZ Squadron website, as well as a posting of the Canard Pusher (CP) Newsletters from Mojave:

www.ez.org

Webmaster is Jerry Hansen in San Diego.

### 2.0 Family Tree

Ever try to find your ancestors and you get the lineage confused, because every generation had a George or Mabel in it. Well, here's a short version of the canard genealogy to keep things straight.

The Wright Brothers designed and built the first homebuilt, canard aircraft. But that was a long time ago and glass and resin were not used.

One of the early Rutan designs was the Vari-Viggen, but it didn't find fancy with many builders. You will see a few Vari-Viggens flying.

Urban Legend: Burt, after four years building the Vari-Viggen, realized it required wood, metal, composite, and electrical building skills and would be too hard to build for most home builders. He decided to design a new version, one very easy to build, and call it a “VariEze”. His first wife is reported to have given Burt an ultimatum, “Either that plane goes or I go!” Burt commented, “I did not realize it would be such a VariEze decision to make!”
Then, Burt Rutan designed a bunch of composite planes. Some of his “children” or their follow-on interpretations didn’t generate sustained interest or prosper like some may have hoped, e.g. the Quickie, Q200, and Dragon Fly.

Burt hit a magic chord with the VariEze (note the correct spelling). This is a plans-built, moldless construction type aircraft, folks, not a kit. [After builders started adding alternators, batteries, and starters, Burt realized there was a risk factor of extra weight and aft-CG and designed the Long-EZ.] (Note the correct spelling.) He used government provided wind-tunnel test data.

Nat Puffer crossed the Long-EZ wing with a 3-place fuselage design and called it a Cozy. Later he sold his hybrid to another outfit, and it was renamed the Cosy Classic. Then, Nat designed the Cozy-IV. (See, just like in real life, some kids leave home and change their names. Other’s are kicked out or are lost in a poker game.)

Burt also designed the push-pull twin engine Defiant, but it cost about twice as much as a Long-EZ and took twice as long to build. (That equates to not many of them being built.)

Dave Ronnenberg had built many Long-EZ’s, and wanted a higher performance version. Using the Long-EZ wing design, he customized a somewhat larger fuselage, updated the construction materials (read this as carbon fiber and an O-540) to bring the Berkut to life. It is a molded, composite structure, kit-built plane, not a plans built plane like the Long-EZ and VariEze.

Another group in Sebastian, Florida designed the Velocity with 4-place seating and a variety of engine and gear options as kit built planes.

Well, that’s about it. If you want to show your savvy, use the spellings above, and pronounce the “E” and “Z” in Long-EZ. After all, it’s not a Long-ezz. Furthermore, the VariEze is also pronounced Vari-E-Z. Is everyone clear on this? The other canard names are pretty straightforward in their pronunciations.

Safety Issue: Styrofoam (light blue) will be eaten away when exposed to fuel or fuel vapors. If repairs are needed, research the manufacturer’s specifications to find the proper foam type, fiberglass type, ply orientation and resin appropriate to use. Don't guess!

2.1 Seats, Foam - Source

Check with Oregon Aero. They build seats with this type of foam and you won't save much building them your self as the cost of material is about the same as they sell a complete, un-upholstered seat core ($299 - June 2004). These seats are very well designed.
3.0 Airframes

On all plans-built, composite canards, the structures are solid core, typically using Styrofoam, urethane, or Poly-vinyl foam blocks as prescribed. Fiberglass, tri-directional, bi-directional, and uni-directional weaves, are called for in lay-up schedules by the designer to meet structural load and dent protection requirements.

Many of the planes for sale probably used resins and weave fillers that have been replaced because a more satisfactory alternative was found or because the original material was no longer produced. Compatible substitutes are probably available, but you typically won't know how to proceed without expert consultation with the designer.

Remember: Two like opinions by two unknowledgeable people still yield a bad direction, if followed. Search for factual data and knowledgeable judgments.

This is an important aircraft integrity issue! So, here is a short tutorial on resins and fiberglass from Gary Hunter, the epoxy guru with over ten years experience in customer service with Shell Chemical.

3.1 Gary Hunter - Working with resins and the weather

“If you are working outside with no roof, I can understand your frustration.

One must avoid having a lay-up rained on. However, if you are under-roof, or better yet inside a garage or a building with closed sides you needn't be so picky.

If you are working in a building with the doors open for ventilation, the relative humidity in the building will certainly come close to what it is outside. Although, high humidity conditions are not the best for working with epoxies, some resin systems will tolerate it fine. Some resin systems are susceptible to "blushing" and you will notice a milky appearance to the resin as you work with it. Most of the time, as the resin cures, this milky appearance goes away leaving an oily like film on the surface of the cured laminate. It looks and feels terrible, but not to worry, this film will wipe off with warm water and a washcloth.

The biggest concern I have is applicator related problems, and how he or she responds to high humidity conditions. If you are a sweat hog like me, dripping beads of sweat into your work can be a real big problem. A few drops of sweat on a laminate that has already been completed but not fully cured is not so bad - just don't rub or squeegee it into the laminate - simply blot it and let it dry. Sweating on the dry fiberglass, or a layer of the laminate that is in the process of being wetted out is a big NO-NO.
This is one reason I advocate you find a way to "temper" the air in your shop. Your project will go a lot faster, and you will enjoy it more – both in the winter and the summer."

3.1.1 Resin types

Epoxy Questions

Technically, in the context of our canard aviation community, there is absolutely no difference between what has been referred to as a non-structural epoxy and a structural one. They are all from the same molecules.

Numerous people had asked Rutan Aircraft Factory about using West Systems Epoxy. After all, it was readily available in most parts of country - and the world for that matter. Well, we all know that Burt Rutan is rather liability conscious, and if a resin system had not been tested and flown in an actual prototype or part of some sort, it was not approved for his aircraft designs - PERIOD.

So, if I recall correctly, one of Rutan's Canard Pusher newsletters, responded to the builder inquiries and West Systems was dubbed a "non-structural" epoxy. It was OK for making micro fill and wheel pants and such. But, no major structural components.

Furthermore, the makers of West System (Gougeon Brothers - pronounced goo-zhan) did not seem to promote the use of the West Systems product line for aircraft construction.

Gougeon Brothers is a customer of mine, so, about 3-5 years ago, I quizzed them on why this was so. They said that in years past their insurance underwriter did not want the liability associated with homebuilt aircraft. The product was intended for the boat building, repair and restoration market. However, they had recently secured another insurance underwriter without such reservations about homebuilt aircraft. In fact, their website had a photo gallery of the many different projects their customers had completed using the West Systems epoxy, and many aircraft were included - mostly wood / fiberglass aircraft, like the KR2s, and Ospreys and such. I don't recall seeing any VariEzes or Long-EZes. If you visit the Gougeon's West Systems home page

http://www.westsystems.com

there are numerous examples of all composite structural articles being made from the West Systems product line.

At about the time I was quizzing Gougeon about the West Systems epoxy, they were introducing their new Pro-Set epoxy product line. Apparently, they had recognized a new market was emerging and decided to put their best foot forward. This product line was developed for more demanding end-uses including all composite aircraft. Rutan did
approve one of their early formulations for construction of his plans designs - the Pros-Set 125 / 229. The website for Pro-Set shows a photo of the (Rutan design) Proteus that was made from Pro-Set resins formulations. http://www.prosetepoxy.com

Note the statements about post cures in their literature.

Frankly, I cannot understand why anyone would pay so much for the convenience of being able to buy an epoxy at the local marine or auto supply. West Systems is at least $3.00 per lb. more expensive than the most costly alternative "structural epoxy". But, some people drive Fords, and some people drive Mercurys. [High “Hazardous Materials” fees by UPS are reduced when you purchase West Systems locally for small jobs and repairs.]

One thing is for certain. Gougeon Brothers is perhaps the industry benchmark for technical support. Their on-line literature, books, manuals, and newsletters are top notch - excellent reading. They even sell ratio pumps for their Pro-Set resin systems.

3.1.2 Resins - Characteristics

1) Difference between EZ-Poxy and EZ-Poxy II Should I switch to EZ-Poxy II in mid-project? Are they compatible in cured form?

Actually, what you are referring to was called SAFE-T-POXY and SAFET-T-POXY II. The SAFE-T-POXY II uses exactly the same resin, but the hardener was reformulated just a tad to give a lower viscosity to help wet out. Today they are called EZ-POXY 10 Resin and EZ-POXY 83 (the regular Safe-T-Boxy hardener) and EZ-POXY 84 (the Safe-T-Boxy II hardener). You can switch from EZ-Poxy 83 to EZ-Poxy 84 but do not blend them together. They are 100% compatible in the cured form.

The non-MDA version was never called a Safe-T-Boxy or EZ-Poxy. It was called EPOLITE 2427 A&B from Hexcel. It received mixed reviews and very little was ever sold. I doubt you will be able find it anymore.

2) Can these parts warp? Does post-cure stop this? If so, temps and times recommended please. Do they REALLY take a year to cure or am I being fed some false information?

Yes, parts can warp. Yes, a post-cure can HELP to stop this. You are receiving mis-information.

Curing of epoxies is a chemical reaction. All chemical reactions are thermally dependant. With the epoxies we use to build our airplanes, ambient temperature cure conditions provide sufficient heat energy to allow the reaction to start. As the reaction progresses it requires more and more energy to perpetuate the reaction. At some point, the available energy from ambient temperature conditions is insufficient, and the
reaction stops. For most resins systems, the reaction stops at a point that gives the cured resin a Tg (glass transition temperature) of about 125-135F. Most of this occurs in the first 24 hours of cure and continues very slowly thereafter until it finally plateaus in about 2 weeks.

The chemical reaction can be re-activated by increasing the temperature conditions. This can happen today, tomorrow or a year from now. It can happen deliberately, by placing the object in an oven and baking it (called a post cure.), OR - it can happen on its own, when the airplane is parked on the ramp during a hot summer day. It can happen in the garage during storage too. All that is required is more heat energy than what was available when the part was initially cured.

If a cured wing panel is quickly exposed to elevated temperatures in excess of its current Tg, the cured resin can weaken and become rubbery. If the wing panel is not properly supported while it is in this weakened rubbery state, it can sag under its own weight. As the wing panel absorbs the heat energy and the chemical reaction is re-activated, the resin will cure and additional amount resulting in a higher Tg. Any warping or sagging the wing may have encountered during this elevated temperature state will become permanently set into the wing panel. By storing the wing panels leading edge down, one can minimize if not completely eliminate the possibility of inadvertent warpage during storage.

In many cases, wing warpage can be reversed by quickly exposing the wing panel to an even higher temperature and weighting or forcing the wing back into the proper shape. Similarly, one can induce a deliberate warpage or twist into a wing panel to correct a rigging or trim problem.

In actuality, an epoxy resin / curing agent reaction is never complete until it has been cured at or slightly above its known maximum glass transition temperature for a minimum of 2 hours. Some of the approved resins are capable developing a Tg as high as 210F. Because of the foam cores and other considerations it is not possible to cure our airplanes at temperatures at or above the maximum Tg of the resin system.

I recommend a post cure schedule that SLOWLY increases the temperature up to 140 - 150F over a span of 2 hours and a dwell or hold time of at least 4 hrs, and perhaps as long as 12 hrs, the longer the better. A very gradual cool down is important, too. This will drive the Tg of most of resin systems up to about 180-190F.

From: "Hunter, Gary A RES-RES" <gary.hunter@resins.com>
Subject: Epoxy resins and temperature

In general, do not try to do anything with epoxies below 65F. You are just asking for trouble if you do. I would invest in a heater of some sort. Even if it is for spot heating only. Some small jobs can be done with the assistance of IR heat lamps.

Timing is everything. Be smart and don't start an epoxy job late in the afternoon if the
shop temperature is going to drop during the night. Always start the job early in the morning so it gets a chance to cure as much as possible during the warmest part of the day. And use heat lamps. Become a diligent weather forecaster and plan your shop activities for the warmest days - not the coldest.

Gary Hunter  
Technical Service Representative  
EPOXY RESINS TECHNICAL INQUIRY  
RESOLUTION PERFORMANCE PRODUCTS  
Toll Free in North America - 800-832-3766  
International - 281-544-6010  
Facsimile - 817-421-7515  
Email - tec.epon@resins.com

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3.1.2.A Molds – Suggestions

Glass Cloth for Molds

1) Use cheap glass that's easy to work. Try E-1581 or E-3743 from http://www.discountcomposite.com/inven.html.

7781 would work but it's a tight weave, hard to get the air out. Anything from Discount Composites is going to be a LOT less than any marine cloth.

2) Use epoxy. Polyester and Vinylester shrink at different rates from epoxy, if you're going to make epoxy parts, use epoxy molds.

3) For the same reason, use epoxy gell coat.

4) You want the mold stiff so it won't change shape. For that, it needs to be thick. Most people take THAT to mean it needs a gazillion layers of glass. It doesn't. Gell coat, 2 or 3 plies of glass, 1/2" thick epoxy/microballoon "syntactic foam" dough, followed by 2 or 3 more plies of glass.

5) Mold release. Make sure your plug is perfect - lacquer, wet sand to 600 or more. Johnson's floor wax, a gazillion coats. Then PVA, spray on a gazillion layers.

6) Extend your mold well beyond the part line.

3.1.2.1 Fillers and Finishing

Fillers -- Just a bit of materials correctness here. As a builder, it is important to know your materials (and maybe this is more than you wanted to know).
Micro-balloons are not silica. They contain silica as a component. Silica is silicon dioxide with no other components. Silica glass (or fused silica) is extremely difficult to make requiring graphite or tungsten or molybdenum furnaces operating in an inert atmosphere at over 2000 degrees C. Fused silica is unique in that its expansion coefficient is almost zero (5x10^-7/deg C). Fused silica is commonly used as the containment envelope for the plasmas in mercury vapor and halogen lamps. Micro-balloons are a silicate based glass known as C-glass.

Glass composition - Type of glass
SiO2 Al2O3 CaO MgO B2O3 Na2O+K2O ZnO
C-glass (%) 65~72 1~7 4~11 0~5 0~8 9~13 0~6
E-glass (%) 52~56 12~16 16~25 0~6 5~13 0~0.8

One of the carnardians mentioned that fumed silica (which IS silicon dioxide) causes lung damage due to silicosis, which is similar to asbestosis and not curable. One should wear a mask whenever dealing with any airborne particulates (e.g. micro balloons, fumed silica, sanding dust, etc.) to keep the small particles out of your lungs, but fumed silica will not cause silicosis. Silicosis requires the presence of the crystalline form of silica such as quartz, crystobalite, etc. Colloidal silica (fumed silica) is considered as a nuisance dust by OSHA. For the MSDS go to: http://www.westsystem.com/webpages/userinfo/safety/MSDS406.pdf

For a guide to fillers and the effects of fumed silica additions, (just takes a pinch to reduce the sag tendency - about 1 part colloidal silica to 10 parts of micro balloons) go to this web site that I found: http://www.duroplastic.com/FILLOVERVIEW.htm An excerpt follows:

Typical addition levels of filler to Duroplastic resin systems, are given in the following table. In each case, the filler is given in a ratio to resin in mass Resin is taken as 100 parts.

<table>
<thead>
<tr>
<th>Adhesive Mix</th>
<th>Filler Mix</th>
<th>Casting (for bonding)</th>
<th>(for filling &amp; fairing)</th>
<th>(Thin resin)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capolite</td>
<td>15 – 20</td>
<td>25 - 30</td>
<td>5 - 15</td>
<td></td>
</tr>
<tr>
<td>Glass Bubbles</td>
<td>15 – 20</td>
<td>25 - 30</td>
<td>3 - 8</td>
<td></td>
</tr>
<tr>
<td>Calcium Carbonate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wollastonite</td>
<td>NA</td>
<td>NA</td>
<td>50 - 250</td>
<td></td>
</tr>
<tr>
<td>Colloidal Sillica*</td>
<td>3</td>
<td>2 - 5</td>
<td>DO NOT USE</td>
<td></td>
</tr>
</tbody>
</table>

* Generally used in combination with other fillers - Marc Borom, AZ

ANOTHER BUILDER’S EXPERIENCE - UPDATE 1976 PRACTICES
Finishing - Pre-Paint Process - Finishing Composite Surfaces

I will preface this with a quotation from the guy who made my life a whole lot easier!

"Technology is changing in the composite industry so fast it's next to impossible to keep up with it. If it took me more than four days to repair a corvette or a few months to do a show car from start to finish I would be out of business."

My composite guru, Rick Castalano, agreed to do a hands on lecture on show quality finishing composites. We agreed to work on the upper surface on one of my Vari's main wings and winglet for the demonstration. Up to this point I had been filling and sanding using dry micro for over 8 months with very little to show for the effort. As you are all extremely aware the contour of the wing is more than for good looks, it is critical for a smooth and balanced flying machine.

Rick has been in the business for 40 some years and has finished more competition show whatever's than you can imagine!

The first thing he asked me was what materials and tools I was using. I explained I was following Rutans instructions to the Nth degree. Dry micro, no more 80 grit sandpaper, etc., and absolutely NO BONDO! Long boards with sandpaper attached to get the lines "just so", etc.

He then explained to the group how times have changed since 1976! That's when Bert Rutan first turned us all on to this method of building airplanes. Now, there are finish products available that are strong, flexible, inexpensive, and could be called BONDO!

I explained that I was sort of cheating by using very small electric sanders on occasion, contrary to Rutan's rules.

He shouted to crowd, "Hooray! Tim's learned something that not only saves time and money, but doesn't compromise safety during the finishing process."

Now, save the following information because this stuff is not only going to give you a show quality finished airplane, but will literally take YEARS out of the finishing process.

He walked out to his car and came back in with the following:

2- Blue steel straight edges 8" long (get various sizes from 2" out to 36", the are cheap but the 8" is the one you will use most)
1- Plastic palette about 24X24 (get two, they are used for mixing and one will wear out).
1 - Gal of EVERCOAT Z-Grip (a light weight filler that applies like butter, sets up according to how fast you want it to, and sands like a dream. (It took 5 to 7 gal's to finish mine. LongEze's will require more)
1 - Quart of Evercoat Glazing Puddy (Small area filling)
1 - 3 foot flexible (plastic) long board
Lots of high quality sandpaper starting with grade 32 and to 600 grit with adhesive backs, or buy the spray stick stuff
1 - small square electric hand sander
2 - Semi soft sanding blocks
2 - Gallons of Acetone (for cleaning)
Lot's of Paper Towels (for cleaning)

Everycoat products are purchased at any good auto body supply store along with the rest of the stuff. Shop around and you will find better prices at the major chains, roughly about $15 per gal to $10 at chains. There are all kinds of other brands and all are probably just as good (like epoxies) but this is what I was instructed to use from our Guru and I am very happy with the results.

Rick explains the one basic key is to start with a CLEAN working surface. Acetone each area your working on just prior to filling that area.

Place a small batch of the Z-Grip in the center of the palette (about the size of palm of your hand. Then add a ribbon of the hardener (comes with the Z-Grip) from top to bottom. Read the directions, but I found you don't need as much hardener as they recommend. It sets too fast if you use too much and you are stuck with a blob of sculpture in a matter of minutes. Better to use less and enjoy the long working time and easier application.

Rich places a huge blob on the palette, adds the hardener, and mixes them together on the palette using the 8” blue steel straight edge. In a matter of seconds the stuff looked all one color, and he is filling a large section of the top wing (about two feet across) starting at the leading edge and smoothly working the stuff back to the trailing edge.

He proceeded up the winglet, again starting at the leading edge and working back. In about 5 minutes the stuff was starting to set so he explained to stop right there and clean off the palette and straight edge with the acetone and paper towels.

Note: It is very important that you clean the palette and the straight edge after each and every application! Keep the edge of the steel as clean and sharp as possible. You can rub the edge against 80 grit paper to sharpen it.

With the palette and straight edge now clean (3 minutes of work) he instructs us to feel the heat exotherming from the fill. He then pulls out the long board, applies a strip of 32 grit sand paper to the back and begins sanding and contouring at 45 degree swipes!

Tip: The 32 grit is used to cut through very quickly to get the basic contour very quickly, and before the filling has a chance to really get hard. Makes sense if you think about it.

He then gradually sanded the surface with lesser and lesser grit sand papers until he got to about 120 grit. All this took just under 30 minutes and when he was done the
surface was smooth as a baby's butt and the shape of the wing was a work of art. He had completed more in that 30 minutes than I had in the previous month. He stood back and announced to the group that this surface was now ready for primer and paint (provided the rest of the plane was done).

I can't tell you how easy this stuff is to work with. You have to try it. The expense is nothing compared with how much fun you will have finishing your planes using this method and these products.

There will be those of you who say this stuff won't bond to the glass and that later it will peel off. All I can say to that kind of thinking is, "BS." There are million dollar yachts plying the seas using this very same product and you don't see them coming apart. My plane has been flying now for three months with no sign of delamination, NONE!

The plane was completed 5 months later with a beautiful paint job, also done by me, and I've never painted anything more than a house before.

Tim LoDolce
VariEze N26FM
tiger@telis.org

3.1.2.2 Delaminating and Repair

Your owner's construction manual is the best reference for this topic. Especially for the moldless construction technique used on the VariEze, Long-EZ, and Cozy type aircraft, you should test the structure for any signs of delaminating periodically, at the condition inspection minimally. In some cases you may see a slight “bubble” or bulge in the skin when the light and viewing angle are just right. At other times, the “quarter test” should be used to detect a variance in the sound of the quarter tapping on the fiberglass skin. If it sounds hollow, then a delamination has occurred. Some delaminations may be repaired by drilling a tiny hole and injecting resin (of the same type used in construction) with a syringe. A weighted or clamped piece of wood over the affected area should restore the structural integrity if it is not too large. If the delamination is larger than the size of a dollar bill, then fiberglass removal and re-construction is advised.

In some of the early VariEze's, Urethane foam was used extensively in the fuselage. It does not have the improved bonding qualities of Styrofoam or Poly-vinyl foam as prescribed later, and should therefore, be checked more often for fiberglass-foam delaminating.

Strut Rebuilding After Brake Heat Melt-down

You will need some expert composite assistance with the epoxy and glass.
On all the strut repairs I did, we ground the damaged strut end down to a taper and used Long-EZ spar UNI strips for the repair. The strings in the glass material should be removed if possible.

Starting at zero, 14 inches up, the outside of the strut was tapered gradually down to one-half thickness at the bottom using a saws-all and grinder. Approximate cut lines were marked on the front and back of the strut.

The Large UNI strips were applied using a little flox in the epoxy. They were custom cut graduated in length to attain the proper thickness.

Peel ply and masking tape were used to conform the strips to approximate the previous shape. You need above 70 degrees for cure.

After cure the peel ply was removed and the existing axle bolt holes were used as guides for drilling the axle bolt holes in the new glass. A little sanding with the grinder on the upper side matched and regained the nice strut shape.

Then the inner side of the strut was removed and tapered from zero at 14 inches up, down to half thickness at the bottom.

Again the UNI strips were applied vertically and smoothed to shape with Peel ply and masking tape.

After cure the bolt holes were drilled back through.

The per-plans layers of additional glass wraps were applied around the strut up to about 16 or 18 inches. We actually did this after applying the inner UNI strips but it is easier to do after the entire lower strut is cured and shaped. After cure the bolt holes were visible and were drilled.

The bottom four or five inches of the strut should all be new glass, with the old strut point ending at the point of damage.

On one of the struts I have done, the inner bottom portion of the strut below the damage stayed attached and was useable for mating purposes, ground or sawed to half thickness.

If it is not usable below the damage, extend the new glass UNI down matching the other strut, and trim to proper length.

The axle will then be reinstalled to the rebuilt lower strut per plans.

A heat shield is an easy addition here, not to preclude proper EZ brake usage.
Wear a mask and goggles, and seal around your neck and wrists well. A fan can be used to some advantage to direct the cloud of ground fiber away from you. Additional experience from others in the group would be appreciated.

--Bill James, Fort Worth

3.1.2.3 Release Agents

**Saran Wrap, Duct Tape, Grease** as release devices. Small parts fabricated in molds use “mold release” compounds to make life easier when removing the cured parts. Often, the idea can be applied when doing composite repairs or when fabricating a part by making the layout on a table or a piece of glass. For a smooth finish, ready for filling or painting, Saran Wrap is cheap, convenient, and ideal. However, one problem with Saran Wrap is the difficulty of seeing it during removal after curing the part. Using colored or tinted Sara Wrap makes this part of the job much easier. Clear Saran Wrap can be overlooked. That is, it can be overlooked until you apply the paint. Then you see it very quickly!

NOTE: One reason for using peel ply is to assure the part will have a finish coat of resin over any glass as when replacing fuel sumps to avoid any "channeling" or “tunneling" of fuel through the glass areas causing leaks.

Both of above taught by Chuck Busch, San Diego, CA

Also, all this talk about using duct tape as a release for small glass parts (wheel pants, prop spinner) hasn't brought up the fine qualities of axle grease. If you will apply a very thin coat of axle grease over the duct tape, the breakaway effort is much less. Just wash the part with soap and water thoroughly to remove the grease.

Terry Yake

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I have found that Partall wax works well. It is applied by wiping on a layer, waiting a few minutes for the wax to harden, then buffing off the surface to a shine. Then apply a layer of Safelease (a liquid wax), which works very well even on very small and intricate molds. I think the duct tape and some of the Safelease should take care of all of your "stuck part" woes. You can find the products at: [http://www.cstsales.com/Vacuum_Bagging/vacuum-bagging-supplies.htm](http://www.cstsales.com/Vacuum_Bagging/vacuum-bagging-supplies.htm) They also have instructions on how to build your own molds.

Jaques Palin

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3.1.3 Re-painting - CAUTION

When you bought your composite canard, maybe it wasn't in very good cosmetic shape. So, you decide to re-paint it or have someone do it for you. Be very careful!

The fiberglass covering of your plane is part of its structural integrity. If you, or the paint shop, sand or sandblast into the fiberglass it can render the part unsafe and no longer airworthy.
The paint system needs to provide a UV barrier as well as just enough paint to provide a uniform coloring. A properly filled surface may not require another primer. Mike Melville used a UV protective paint over a well filled and finished surface without a paint primer.

White is the prescribed color by all the composite designers. That is to minimize the heat absorption and surface temperature of the aircraft surfaces and prevent the resin from heat damage.

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SOLAR ENERGY HEAT ABSORPTION
EFFECT OF PAINT COLOR

High heat absorption can damage radios, instruments, and deform composite aircraft. "They" say that Burt Rutan refuses to fly in an EZ not painted white.

Gary Hunter: For most resins systems, the reaction stops at a point that gives the cured resin a Tg (glass transition temperature ) of about 125-135F.
This chart, provided by the DuPont Corporation, was adapted from “Soaring Magazine”.

<table>
<thead>
<tr>
<th>TEMP</th>
<th>COLOR AND PEAK SURFACE TEMPERATURE (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>°F.</td>
<td>WHITE YELLOW BLUE ORANGE RED GREEN BLACK</td>
</tr>
<tr>
<td>80</td>
<td>128 137 140 163 178 180 196</td>
</tr>
<tr>
<td>90</td>
<td>140 146 152 176 190 192 208</td>
</tr>
<tr>
<td>95</td>
<td>145 159 165 180 195 200 215</td>
</tr>
<tr>
<td>100</td>
<td>150 154 158 188 200 206 221</td>
</tr>
<tr>
<td>110</td>
<td>161 170 177 200 215 219 235</td>
</tr>
</tbody>
</table>

Temperature of a black surface can reach 165°F with ambient temperature of 55°F.

No chemical paint strippers are permitted! Keep the MEK at your mother-in-law’s house. These chemical compounds will penetrate the micro-holes in the resin and eat away the underlying foam, making the structure no longer airworthy.

**Structural Integrity Warning!**

When removing paint from the surface of a composite structure, never remove any part of the fiberglass skin.

Never use chemical solvents to remove the paint. (Some types of foam core portion of the structure can be destroyed!)

Also, see Paragraph 3.2 concerning the weight and balance of control surfaces.

Also, see Paragraph 3.1 concerning the general issues of foam, fiberglass, and resins.

3.1.3.1 Elevators - Buying - Source

The elevators are the hardest part to hotwire of all the EZ parts as they are so small and have a lot of curves. These need to be nearly perfect or they can easily be overweight due to filler or misshaped.
There are vendors out there that will hotwire these for you. I have used Featherlite and what I received is perfect. I think they want 50 bucks or so a set, but really when all is considered, it is well worth it. Give them a call and see what they can do for you.

Feather Lite 1327 South State Street Airport Ukiah, CA 95482 (707) 462-2939

3.1.4 Canopy

The Plexiglas canopies are made in a chamber that heats and applies a vacuum to form the shapes required. They have come from various small company sources over the years. A very few are made by the aircraft builder. Yours may be clear or tinted, and vary in thickness from others’. In the1980’s a popular manufacturer was Dayton Airplane Factory in New Carlisle, OH. They are no longer in business. There were subsequent manufacturers in that area north of Dayton, OH, but they are no longer advertising. The only canopy company listed in recent advertisements is Airplane Plastics, in Tipp City, OH, near Dayton and New Carlisle.

See the classified ads in Kitplanes and Sport Aviation.
Try Todd’s Canopies, Todd Silver www.kgarden.com/todd (954-579-0874)

3.1.4.1 Plexiglas Canopy Repair

One additional word of caution. Polymethlymethacrylate (PMMA) or Plexiglas is extremely sensitive to stress corrosion cracking. Whenever you drill into Plexiglas (either for attaching or crack-stopping) you should observe two rules taught to me by a research scientist whose specialty was Plexiglas:

1) Avoid corrodants - clean the drill with a good detergent and then rinse well with rubbing alcohol and allow to dry. The reason for doing this is that small amounts of oil can stress corrode the drill hole and radial cracks will form and propagate into the bulk plastic.

2) Minimize heating - drill very slowly with a sharp drill. The reason for this is that Plexiglas responds like glass to thermally induced stress. Drilling too fast will heat and soften the plastic at the drill hole wall. If the temperature of the inside diameter of the hole gets above the glass transition temperature of the plastic, the surface of the drilled hole will go into hoop tension on cooling. Couple that with some oil contamination (see rule #1) and you will get those radial cracks some days later which can really wreck you day at some time in the future. By softening, I do not mean that the plastic will get gummy. It just has to get warm enough to become stress free at the highest temperature reached.
Methylene dichloride (commercially shortened to methylene chloride), by the way, is not the cement, it is the solvent. You can use pure methylene dichloride to bond two pieces of Plexiglas together by allowing the surfaces of the pieces to be joined to dissolve (soak) in a shaped tray containing methylene dichloride. If injecting straight methylene dichloride works to join cracks, I would be interested to know. In another life, I made many Plexiglas underwater camera housings using the soak and join technique.

Acrylic cement, as I know it, is a solution of PMMA in methylene dichloride. Such a cement would carry additional PMMA into the crack for joining.

Also, methylene chloride can cause corrosion cracking of PMMA by dissolving some of the surface Plexiglas and causing cracks as the solvent evaporates.

There are no simple solutions. Marc Borom, 8/02

For cleaning the canopy, I have used Pledge and a soft cloth. The similar optic factors are supposed to render slight cracks invisible. In 13 years, I have had no negative effects from Pledge. MAH

3.2 Control Surfaces

These are the most important components of your plane!

They are subject to the most stringent fabrication requirements in the whole plane. The reason is the vital concern for aero-dynamic flutter. The designer’s specifications and requirements must be kept in mind and certain balance criteria met to prevent in-flight flutter and catastrophic failure of a flying surface and probable death to the occupants. Uncorrected flutter can cause a composite, metal, or wooden airplane to disintegrate in seconds!

During the initial flight testing of the plane, procedures are specified to verify the stability of the control surfaces. After those tests have been completed, any change in weight or weight distribution requires the balance and flight tests to be successfully repeated.

Safety of Flight Issue:

If you remove or add any (read this to be even an ounce) of weight to the ailerons or elevators, or sand any portion of the ailerons or elevators, or add or subtract any paint to any portion of the top or bottom surfaces, the designer’s balance criteria must be retested successfully. Flight testing is defined in 5 knot increments to Vne and must be re-done to re-establish the stability requirements.
This flight test data is to be recorded in the logbook. **Pay attention here.** And you thought you wouldn’t need to become a test pilot. Failure to pay close attention to this will yield catastrophic flying surface failures and death to the occupants! Is this clear?

There are two sides to owning an EXPERIMENTAL aircraft. 
One is before you buy it. 
The other is after you buy it. 
Make sure you don’t buy the farm after you buy the airplane.

### 3.2.1 Wing Trailing Edge Fences

Testimonial by– Tim LoDolce (Flying Tiger) (October 26, 2001):

I installed a set of TE fences on the VariEze about 20 hours ago after talking with Klaus Savier about them. I think he was the first one to install them permanently on his VariEze. He claimed I would see a 10 kts lower approach speed with much more aileron authority and he was absolutely on the money!

Previous to the trailing-edge fences my approach speeds were around 90 kts that makes for some long roll-outs after landing.

I also found the airplane tended to start a very mild Dutch roll somewhere below my 90 kt. approach speed but not anymore. The fences are a real significant safety improvement to our canards.

I now approach at 80 knots, and by short final I'm getting down to 70 knots with full control authority.

The fences offer much improved aileron authority in all phases of flight including crosswinds. I also have not found any loss of top speed from the fences. I made mine out of 2 ply's of BID fiberglass cut in long triangles that extend 1 1/2 inches beyond the trailing edge of the wing and they are 3 1/2 inches from top to bottom on the back end. Mine extend about 2 1/2 inches above the horizontal of the wing and 1 inch below. I have seen them cut in triangles and teardrop patterns and both are affective.

PS. I did ask Klaus at Reno this year if they would work on a Long-EZ. He told me he had now tested them on the Longs and found the same improvements. The placement is a little different for the Longs.

For more information see: [www.lightspeedengineering.com](http://www.lightspeedengineering.com)

Note: Canard stall, leading to high sink rate, is another limiting factor in approach-to-landing speeds. It’s one thing to maintain aileron authority at slower speeds, but yet another to have positive pitch control margin all the way to the tarmac.
3.2.2 Vortex Generators

TYPE 1 -- The early Long-EZ’s used the GU canard airfoil, and it was susceptible to “rain fade”. When the plane encounters moisture (virga, clouds, light, or heavy rain), canard lift reduces, with a resultant loss in altitude without adding pitch control input. The sensitivity to moisture varied from builder-to-builder, depending on imperceptible manufacturing differences. Some planes became “humidity sensors”, while others required only a slight pitch correction to maintain altitude in visible rain. This is the reason the Roncz canard was offered as a replacement design. Did you flight test your canard design in light rain?

Vortex generators have been installed by some builders to reduce the moisture-induced loss of lift. You will see this on some of the canards. The size, number, shape and location on the canard are critical elements. A thorough design, fabrication, and test flight program are the necessary steps to incorporating this modification.

TYPE 2 – Jim Price, working with the University of Michigan, developed vortex generators to increase slow speed performance of his Long-EZ in preparation for his successful world altitude setting effort (35,022 Feet, I believe.) In this case, Jim has vortex generators on the wings as well as the canard. However, the vortex generator placement on the canard is not the same as those used to reduce rain fade. Again, this requires detailed engineering knowledge and a carefully planned and executed flight test program.

3.2.3 Long-EZ Aileron Rod-end “Airworthiness Directive”

I have learned a lot about this mod since CP 103 first came out. If you are going to comply with this CP, here are some hints.
First thing is, do not use HM-4’s. Wick’s has a rod end that has a 3/16" hole in the ball and is in every other way equivalent to the HM-4. This will save having to drill out all the bell cranks. Wick’s part number is XM-3 (I know it doesn’t make sense unless the dash number spec’s the hole in the ball, but it is a 1/4-28 thread) They are $8.45 each, so the cost is a push if you consider the savings on the other hardware that can be re-used. Don’t forget to buy new jam nuts, though. (Thanks to Ken Miller for this tip)

Second, check to see if you have the original CS-1 aluminum inserts or the later CS-50 steel inserts (usually attached with pop rivets). The CS 50 inserts are too short to rework, they just don’t have the room to fit the larger, longer rod ends.

Last, Take your current push rods and measure the distance from the center of the hole in the ball to the insert side of the jam nut AS IT IS INSTALLED. The minimum it can be is .65”. Shorter than that and the larger rod end won’t be able to be adjusted down enough. Then measure from the insert side of the jam nut to the center of the head of the first rivet. Less than 1” must be added to the .65” i.e. center of ball to insert side of
jam nut is .70", the minimum distance from the inside edge of the jam nut to the center of the rivet is .95".

Clear as mud right? My offer still holds, If you want to comply with the CP and you believe your current push rods can be retro fitted, I'll do the rethreading for free.

Contact me at fly.ez@verizon.net for shipping info. -- Rick Girard 09/02

3.3 Fuel Tanks and Fuel Leaks

Fuel tanks are integral to the airframe structure. Resin is applied liberally during the construction process to seal the inside of the tanks. However, once in a great while, someone will discover a leak. Strangely at first, the leak may appear well away from the tank walls before the fuel finds itself visible to the owner. Capillary action can make the leak travel or tunnel to far away places, and even appear in the nose of the plane. You'll ask, "What is causing that? There's no fuel up there." The glass fibers serve as tunnels for the gas that penetrates the resin coating of the tank. This is one key reason for using peel-ply over the finished surfaces, to assure a resin layer seal over all glass.

One technique for diagnosis is to partially fill the leaking tank. Then tilt the fuselage at various angles and leave it alone for several hours to see if the leak appears at the exit point. This will take days to find the source of the leak, but it has shown to be effective.

And now the repair process. Of course, you will need access to the suspected area, whether it's on the fuselage side surface or somewhere else on the tank surface. There went the paint job. And you will need to learn how to repair composite structures to finish the job.

Don't try to adhere Vinyl Ester resins to Epoxy resins. Although both are fuel resistant, resins bond best to themselves but not so well to each other.

Once the tank has been soaked in fuel, it is difficult to get most things to bond to the inner surfaces, even after sanding and abrading.

Recommend you buy some Pro-Seal - fuel tank sealant as used in aluminum tanks. This product has been specifically formulated for doing just what you want it to do, i.e., seal leaks.

It bonds extremely well and remain flexible yet fuel resistant. It comes in two grades, one grade is rather viscous and gooey to be daubed or troweled into place with an applicator stick. The other is brushable, and intended to be used to line the entire inside of the fuel tank. Take your pick based on what you want to do.

They are both about $40 - You will only need small portion, so don't plan on mixing up the whole container. You might look around for another builder that may have some left
over from sealing his tanks, or you can sell him your leftovers.

First, remove all the garbage from previous attempts to seal the leak. Scrape it, sand it, grind it, whatever; get rid of it.

As mentioned, the tank inter-skin is fuel soaked. It is highly recommend you find some way to allow it to dry out for day or two. This is especially important for the area you found is leaking. Any fuel weeping from the leak area will definitely keep anything from sticking - especially if was mogas.

Apply a heat lamp, from a distance or even just a 40-watt light bulb to warm up the surfaces and drive out any residual fuel. Don’t let it get too hot, no more than about 140F. As a rule of thumb, (perhaps hand) if you can hold your hand flat on the hot surface to the count of ten, the temperature is below 140F.

Allow it to cool before applying the Pro-Seal. That should do it.

Gary Hunter - EAA Technical Counselor

Addendum (MAH) – The gas sumps (blisters under the wings) of a Long-EZ can leak. A fault in construction caused both of mine to leak after 17 years. The rear edge of the sumps were installed over the flexible edge of the fuselage/cowl connection area subjecting the sumps to movement when installing or removing the lower cowl. After four months trying to fix the problem, the old, very thin sumps were replaced with new Feather-Lite, prefabricated sumps for $25 each. The new sumps are heavier. Peel ply is a must during repair.

3.3.2 Fuel Caps

Fuel cap quality generally has improved over the years. Early ones were held in place by a Zusz fastener with an “O” ring that needs lubricant. Some models employ the thermos bottle expansion technique. Still others are adapted from production aircraft or possibly from motorcycle fuel tanks. In any case, all types should be tethered to the aircraft to prevent in-flight loss. This chain can serve as a ground during fueling. Check your plane for the tethers. This is a flight safety issue! When the cap departs the plane, there is a high probability that it will hit the prop, catastrophically damaging the propeller and causing a forced landing, right now!

Fuel caps lost in flight have caused off-field landings with lives lost. Make sure the fuel caps on your plane are tethered!

(MAH - Note: Leaking gas caps are the main source of water in gas tanks, not condensation. Old, dry “O” rings, poor fit, and failure to secure tops allow water to enter the tanks. A Long-EZ departing Sun ‘N Fun barely made it back for a landing on a closed runway after taking off without draining sufficient fuel during his pre-flight check.
It had rained heavily during the night, and his tanks caps were not secured (to avoid venting gas from tank vents). That is another case of having too much fuel in the tanks. When Long-EZ gas tanks are full and parked nose down, expanding fuel flows out the vents and into the rear seat if fuel caps are tight. The ezes are the exception to the adage: “The only time you have too much fuel is when there is a fire.”

3.3.3 Fuel Gauges

Almost all canards utilize “coffee urn” sight gauges for all of the fuel tanks, left, right, and possible header. They are simple and accurate, though hard to read. Because the original plans had you squinting to see through epoxy and several layers of fiberglass to read the fuel levels, many builders added white plastic backgrounds and a clear outer layer. The material for the visible portion of the gauge is made of plate glass or a non-crazing plastic. Inside the gauge, a piece of red material is supposed to float up and down with the fuel level. Sometimes, this indicator sticks to the side of the gauge and does not perform its intended function. A few builders use in-tank electric (capacitance) sensors and have the advantage of reading the fuel levels from gauges on the instrument panel.

Suppliers:

a. Vance Atkinson still sells the clear gauges, and would have repair parts if needed. Email: nostromo56@home.com

b. Wicks Aircraft and Aircraft Spruce and Specialty catalogs have the capacitance type gauges.

c. Aerospace Logic – Toll free: 866-261-9506/$180 for a two tank, digital instrument without sensors

3.3.4 Fuel System Debris Screens

Especially on plans-built aircraft, there is an opportunity to get tiny pieces of foam into the fuel tanks during construction. If you are a second owner, hopefully all the debris of the building process has been removed by now. But, it is still a good practice to check the gascolator regularly for foreign material. There is a risk of contamination from fuel suppliers.

The tanks should have screens located at the tank exits. These may be tealeaf strainers or copper/stainless steel screen door material that was floxed into place during construction. The important note is the size of material weave and what can be screened. The next opportunity to screen debris is in the gascolator. You will be checking that during each condition inspection and at other times considered necessary.
If your engine uses an Ellsion Throttle Body Injector (TBI), there should be another filter that probably was adapted from an automobile. This one is able to filter out very small particles (70 micron) that could block holes in the TBI fuel nozzle.

Then, finally, a very small screen – the last chance filter – is part of the carburetor or TBI. Repair parts are available from the manufacturers. Most will want to perform the maintenance to guarantee performance and keep warranties in place.

4.0 Brakes

4.1 Brake Calipers --The heavy duty brake calipers on the Long- EZ (caliper assembly 30-133).

Here are the parts numbers for the seals: All three part numbers identify the same O-ring.

Cleveland part number 101-05200 (not listed in Spruce catalog)
MS number MS28775-224 (also not listed in Spruce catalog)
AN number AN6230B-2 (this one IS listed in the catalog)

5.0 Engines and Spark Plugs

Some cowlings are so close to the top of the engine, especially #1 cylinder, that you need to be careful that the spark plug and wire don’t rub. The popular Champion REM-37BY is a bit shorter and may help create some extra clearance. If your plane has an electronic ignition, the spark plugs have been specified by the developer.

5.0.2 Exhaust System - Springs

Exhaust springs

Stainless Steel Springs for the Sanders type exhaust systems use the Yamaha steel springs. The two-in-one out system uses a stub pipe on the cylinder with a slip joint over the stub. I had no problem at the local Yamaha dealer. The springs are used mostly on the dirt bike exhausts.

5.0.5 Electronic Ignition

Check Rose (Electroair) and Klaus Savier - both have good references from canard group.

Jeff Rose Electronic Ignition
$800 (4 cylinders) Single Unit
$1,400 (4 cylinders) Double Unit
www.fly-gbi.com
(423) 622-8825

Light Speed Engineering (Klaus Savier)
[Manufacturer of electronic ignition modules - $1,000 and up for 4 cylinders]
P.O. Box 549
Santa Paula, CA 93060
eEMAIL: klaus@lightspeedengineering.com
http://www.lsecorp.com/

5.1 Engine Repair – New Cylinder

When is oil consumption too high? Lycoming says:

“The maximum allowable oil consumption limits for all Textron Lycoming aircraft engines can be determined by using the following formula:

\[ .006 \times \text{BHP} \times 4 / 7.4 = \text{Qt/Hr}. \]

(Consuming one quart every three hours is too much oil consumption for the O-235-L2C!)

When a compression check of 30/80 or other inspection results in a need to overhaul or buy a new cylinder, use the Internet to shop for prices. A new, Superior Millennium cylinder may cost slightly more or even less than a re-built cylinder and give you a lot more security and peace of mind. Shop for price. Aircraft Spruce charges $300 more for a Millennium O-235-L2C cylinder than J&J Aircraft Parts (TX), Mattituck (NY), or Varga Enterprises, Inc. (AZ). All three are Superior Millennium distributors and deliver UPS to your door. And in 2004, Varga charges $48 more than J&J Air Parts in Texas.

J&J Air Parts (Pleasantville, TX) - $1,100 plus $30 for exchange for rocker arms. This was the only source that offers trade in on Rocker Arms. Check web site for 800 number.

Superior Air Parts and Labor inclusive Warranty (Manufacturer)
http://www.superior-air-parts.com/

Varga Enterprises, Inc. (Chandler, AZ) Distributor
http://www.vargaair.com/
800–642-1572

One overhaul shop in OK quoted $200 more for a re-built cylinder than the cost of a Superior Millennium new cylinder.
UPGRADE O-235-L2C vs. REBUILD

When considering a rebuild, check the following:

SUGGESTION - SEE TESTIMONIAL FOLLOWING E-MAIL SUGGESTION

Putting in high compression pistons, ceramic coatings the pistons/exhaust, porting/balancing, Teflon coating parts, etc. When I was in the Venture Cup race, I talked to a number of 0235 Long-EZes who were pushing 140+ hp from these engines and were really "flying" out there (about 40-50 mph faster than I). The cost to upgrade the engine was not that much above a rebuild, and considerably cheaper than the cost of changing out to a O-320.

This is the site some of the racers told me about.

<http://lycon@lycon.com/>

Performance coatings

<http://www.performancecoatings.com/enginecoatings.html>

From: Paul Werner  <ezepilot@pacbell.net>
VEZE N6112Q  - Gnoss Field - Novato, CA
Subject: Re: Rebuilding O-235 Engine

Ly-con did a major overhaul on my O-200 for my VEZE with some of those mods and it tested out on the dyno to 126 HP. The engine runs much smoother then before too. After one year and 130 hours I had a slightly burnt exhaust valve. I flew down to Ly-con and took off the cowl. They bored scoped it and said yes this valve should not have burnt like this. They removed the cylinder and repaired it like new and put it all back together for free. I just inspected the work to see that all the baffles were on to my satisfaction and I reinstalled the cowl and off I went. I guess you could say I am a happy customer. I now have three hundred hours on the engine and it is perfect. It still runs smoothly and I only add one quart of oil between my 25 hour oil changes.

What you should know about installing new cylinders

Break In - As the owner or pilot, you need to do a couple of things to assist the ring seating.

First, you should use straight mineral oil during the initial break-in period, because it has less lubricity than normal ash less dispersant oil and therefore provides increased friction to aid in this seating.
Second, you should operate the engine at high manifold pressure during the initial break-in period, in order to push the rings out against the walls as hard as possible to aid in the seating.

Try to keep ground runs to an absolute minimum. This is most important with engines that have not been run in a test cell, and will be run for the first time on the aircraft. All factory new and factory-remanufactured engines will be run in the factory test cell for 30 minutes to 2 hours. Some large overhaul shops also give their newly overhauled engines a test-cell run before shipment, but most shops don't. So be sure to ask if your engine was run and for how long.

All ground running should be done with all cowlings and baffles in place. A decowled engine receives very little cooling air. Running without the cowling can damage the new cylinders.

Preparing for the first run

Fill the engine oil sump to rated capacity with straight mineral oil, preferably 40 weight. We find 40 weight is better than 50 weight as the lighter oil will flow a little faster and carry off heat a little better. Dissipating heat is a major concern during break-in. You should use 50 weight oil if the ambient temperature will be above 80F. However, hot weather isn't ideal for break-in.

Remove a spark plug from each cylinder, preferably a bottom plug. Hook the aircraft up to an APU and crank the engine with the starter motor for a period of one minute. This will allow the engine's oil pump to distribute some oil throughout the oil galleys of the engine. If the engine is equipped with a turbocharger, remove the oil discharge line from the turbo and make sure there is oil flowing out of the turbocharger.

If the aircraft is equipped with an electric boost pump use it to pressurize the fuel system to look for leaks. Run the pump on "high" or "emergency" speed with full throttle and mixture at idle cutoff.

**First run (30 seconds to 1 minute)**

Keep this run to minimum time necessary to complete task.

Start the engine and run at 1000 RPM or less for approximately 30 seconds to one minute. Immediately after startup, make sure that oil pressure starts rising and goes to the upper part of the green arc. If it stops in low green or lower, shutdown immediately and determine source of problem.

Check that idle RPM is approximately correct (usually about 600 RPM at minimum throttle), that both mags work, and that idle manifold pressure is in the vicinity of 12 inches (if the engine is equipped with a manifold pressure gauge). Check idle mixture at
shut down: as you slowly pull the mixture control, you should get a slight RPM rise before the engine quits.

After shutdown, check for oil leaks and make adjustments to anything that is grossly in error. Let the engine cool down completely.

Second run (1 to 2 minutes)

Keep this run to minimum time necessary to complete task.

Start engine and allow warming until oil temperature needle comes off of peg. Do normal but brief run-up, checking mag drop. However, do not cycle the prop at all.

If the engine is equipped with an electric boost pump, make sure that it will boost pressure, even to the point of starting to flood the engine. If the aircraft has a two-speed boost pump controlled by a throttle switch, it may not be possible to get high boost at idle throttle position, but even low boost should bring up the pressure a bit.

With the throttle pulled back to idle check for correct idle speed -- 600 RPM for most engines but consult your manual in advance to be sure. Slowly pull the mixture out to shut down the engine, there should be about a 25 to 50 RPM rise if the mixture is set correctly. A greater rise indicates to rich an idle mixture, a lower rise or no rise at all indicates to lean an idle mixture.

Shut down and check for leaks. Make any indicated adjustments. Let the engine cool down completely.

First flight (30 minutes)

Pick a time when you will be able to taxi right to runway and take off. If necessary, make prior arrangements with tower. Start engine, taxi out, do a normal run up but do not cycle prop. If everything appears okay--oil pressure high in the green and oil temperature off of peg--initiate takeoff on longest runway available.

On carbureted aircraft without an engine-driven fuel pump, watch for any indications of mixture problems which may cause a rough-running engine. On aircraft with engine driven fuel pumps (including all fuel injected engines), monitor fuel pressure or fuel flow closely. If too high (way beyond red-line), reduce to red-line with mixture control. If too low (two gallons-per-hour short of red-line or less), abort the takeoff and determine the reason.

Closely monitor RPM. If it doesn't get within 100 RPM of red line and there is sufficient runway available, abort the takeoff. There could be a problem here if the tach calibration is off to the low side, which is where most mechanical tachs are. Some have suggested doing a tach check on the second ground run with a digital tach checker such as the
Cardinal tach checker. However, I prefer to avoid getting RPM up in the 2000+ range during the ground runs.

If the aircraft is equipped with a multiple probe EGT and you are is able to monitor EGT in addition to the above-mentioned items, abort the takeoff if any single EGT exceeds 1500 degrees.

Also abort the takeoff if anything sounds, smells, or feels unusual, even if you can't quite "put your finger on it." You should be "spring-loaded" to abort this takeoff, continuing only if everything seems very close to "just right". This is a good rule for all takeoffs, but especially the first takeoff on a new engine!

After takeoff, make a shallow climb and maintain the highest climb airspeed with which you are comfortable. Once you get to a safe altitude, you should make your climb very flat--around 200 to 300 feet-per minute. The goal is to keep as much cooling air flowing over the engine as possible. Circle above airport for 30 minutes (to be on the safe side). For a normally aspirated, do not get much above pattern altitude so that power output remains high.

On fixed pitch propeller aircraft, keep the RPM at the top of the green. On controllable pitch aircraft keep MP at the top of the green or higher and high RPM as well. If you have cowl flaps, keep them wide open. Use maximum rated continuous power if that can be done without over-tempering the engine; otherwise, reduce power only to the extent necessary to keep cylinder head temperature and oil temperature in the green. Use full rich mixture to help keep CHTs down.

After 30 minutes make normal landing, carrying as much power as possible during approach. Taxi as quickly as prudent to parking and shut down immediately.

Holding this first flight to 30 minutes over the airport just above pattern altitude is a concession to safety. The first flight would be better extending for a couple of hours, but I have been surprised too many times by problems to stay up very long or get very far away from the airport.

Un-cowl and closely inspect the engine for any signs of problems, leaks, cracks, etc. Pay close attention to those things that might have come loose such as clamps and fittings. I have been amazed at how many things can get loosened up after the engine starts providing some vibration. Make adjustments dictated by flight test results. Let cool down completely.

Second flight (1 1/2 to 2 hours)

This is a fun one! Take off normally. Stay low and carry as much power as possible, especially MP at very top of green or higher. Use rich mixture to keep CHTs in line. Staying at low altitude is important if the engine is normally aspirated because this allows for the greatest MP. We have seen problems with high altitude break-ins.
For me this flight is great fun because it means I get to whip up and down a gorgeous section of the California coast at 500 AWL (above water level) with the airplane balls-to-the-wall, an expression, by the way, that originally came from having the ball ends on the early throttles all the way forward towards the firewall.

After two hours, I return to the airport. If I find no problems and nothing that needs adjustment, I turn the aircraft over to its owner. I instruct the owner to fly the airplane "hard" for the next eight hours, keeping the MP as high as possible and (if normally-aspirated) avoiding any high-altitude flights, preferably staying below 5,000 feet.

Finishing the job

How can you tell when an engine is broken in? In the old days, it used to be when the oil consumption stabilized, which is still a good indicator. With today's sophisticated probe-per-cylinder engine analyzers I can often see individual cylinders seat. When the CHT on any cylinder drops about 50 degrees in the space of a few minutes with no change in engine operating conditions, that cylinder has seated. I almost always see Cermicrome seat within an hour. Standard nitrided steel cylinders take three to four hours, and channel chrome a couple hours more.

At five hours, change the oil and filter, or clean the screen. Refill the sump with fresh mineral oil. At ten hours, drain the oil again, change the filter or clean the screen, and refill with whatever ash less dispersant oil you are going to use. I recommend Aeroshell 100W unless operating circumstances dictate a multi-weight oil. Give the engine a thorough going-over. Put a torque wrench on every exposed nut and bolt and check torque. I am amazed at how many loose bolts we find. If anything is dramatically loose, do whatever is necessary to check the bolts around the one with loose torque.

Some recommend continuing break-in procedure and oil for up to 25 hours. My experience is that if the engine isn't broken in at 10 hours, it just isn't going to happen. The only exception is channel chrome jugs, which may take slightly longer.

If the engine hasn't broken in after 10 hours, you either have to put up with the high oil consumption, or pull the cylinders, break the glaze with a hone, check the rings for damage and correct material (personally I would install new rings), reinstall the cylinders, and start all over from scratch.

But if you do the right thing during those first critical 2 or 3 hours of break-in, you'll get good ring seating and low oil consumption every time.

John Frank is the Executive Director of the Cessna Pilots Association. He's a 14,000-hour ATP-rated pilot and an A&P mechanic with inspection authorization.
5.2 Oil Filters and Oil Cooling systems

Oil coolers are typically specified by the designer for the specific engines. But, many builders use alternative engines that require them to find a suitable oil cooler. If your plane has a larger-than-specified engine, you can bet that oil cooling was an issue to resolve in the flight test period. Both the oil cooler capacity, the size of the connecting hoses, and its placement within the engine cowling are factors in how well it works. Stewart-Warner and Positech are typical cooler brands.

In an effort to mount the engines as far forward as possible for C.G. purposes, there wasn't room for an oil filter in the standard position. Instead, an oil screen is used and requires additional maintenance as prescribed by the engine manufacturer. Alternative hook-ups have been developed to allow retrofitted installation of filters. Your plane may have one of these. The components for the oil filter may have come from stock airplane/engine combinations that normally use them, or from a small parts manufacturer that saw a business opportunity. You may even see automotive-style remote oil filter adapters installed, and they will also be of the remotely mounted variety.

B&C Specialty makes the adapter that fits on the engine, but turns the filter 90 degrees for firewall clearance. Wolf and the other developers remotely mount the filter with hoses attaching it to the engine. In any installation, use an aircraft approved filter.
5.2.1 Parts sources:

My favorite website for ordering hardware.

Hi grade bolts source - www.mcmastercarr.com

Cowling Attachment Screws (TORX)

http://www.fastenerwarehouse.com/barnhill/security-fasteners.html

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Another recommended source for aircraft parts:

http://www.aeroaviation.com/

I found Aero Aviation (800) 362-3044 to be the lowest on prices, and very good to work with. MetaSearch: 30 sources of Aircraft Parts in links.

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a. Oil Coolers:

Aero-Classics at Pacific Oil Cooler's web page: www.oilcoolers.com

Wicks Aircraft

Aircraft Spruce and Specialty

Positech International, Inc.

Other cost comparison information (as of October, 2001):

<table>
<thead>
<tr>
<th>Oil Cooler</th>
<th>Model Number</th>
<th>Cost</th>
<th>Heat Transfer</th>
<th>$/Heat Transfer</th>
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<tr>
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<td>8000075</td>
<td>$185</td>
<td>320 BTU/min</td>
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<tr>
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<tr>
<td>Stewart-Warner</td>
<td>8406R</td>
<td>$379</td>
<td>350 BTU/min</td>
<td>1.083</td>
</tr>
</tbody>
</table>

b. Filter adapters:

B&C Specialty, Newton, KS:

Air Wolf
Vernatherm Valve Operational Inspection

The Vernatherm is stamped with the operating temperature on the back (usually specified as 85° C or 185° F). It will operate by expanding (lengthening) to close off the hole in the engine and redirect the oil flow to the oil cooler. How far does it lengthen? About 3/8". You can get it to expand using water, BUT use oil, which is more stable than water for stove top heating. Also, use a thermometer to check the oil temperature. You can use a simple basting thermometer (Cooking type with a pointy probe... Ask you Wife!) Inspect the dome for wear and ALSO inspect the engine where the dome fits in. Next inspect the crimp end nut to make sure it is secure. There is an AD against the OLD model for an inspection. The New model has a roll pin through the crimp nut on the end, ergo no AD.
6.0 Propellers

This is a subject area where you will see a lot of variations from plane-to-plane. The propellers used on most of the canards are fixed-pitch and made of wood or a combination wood/fiberglass.

Notice there are no canard pusher planes with metal props, because of unknown metal fatigue issues. Some Velocities and Cozy’s have variable pitch propellers, and some highly customized performance machines will employ carbon fiber material. Most props are produced by very small companies – maybe one person – and require technical skills to design and artful work to fabricate.

For the Rutan aircraft, Burt dictated wood, as it was the lightest and most tolerant of the unknown structural forces encountered at the rear of the experimental aircraft.

Propeller damage is usually caused by something in front of the propeller finding its way through the prop arc while it’s turning. Runway stones are picked up and damage the painted surfaces.
[Most canard drivers leave the air-brake down while taxiing to reduce the danger of the front wheel throwing up rocks.] Errant cowling screws are a favorite to leave a gouge. Fuel caps and broken exhaust pipes have been known to break a blade with sometimes-catastrophic results. Even a few valve pieces have departed via the exhaust pipe and caused severe damage. Longitudinal splitting may be caused by some of the above items, but blade flutter and ground handling accidents can do it too.

Your task is to know the materials of your propeller and to take care of it appropriately. Small dings and scratches through the finish need to be repaired immediately. Otherwise, oil, fungi, and other contaminants will infiltrate the structure to discolor and weaken it. Inspect the blades for longitudinal splits and gouges before every flight. Some splits can be repaired. Some can’t. If you find one, ask someone knowledgeable about an acceptable repair technique.

NOTE: Clear finish urethane paint is an acceptable repair material for scratches. A mixture of cotton flox and epoxy resin is suitable for filling repairable small gouges. Repairable splits possibly can be repaired with epoxy resin. Two part epoxy is an acceptable repair material for gouges, according to Bruce Tifft.

In your Operator’s manual and/or the prop manufacturer’s information, you will find a requirement to re-torque the prop bolts periodically. Seasonal humidity variations where the plane is based, altitude/humidity influences, and trips to varying climates, cause wood to shrink and swell.

Perform this maintenance item religiously.

At the time of the annual condition inspection, remove the propeller. Check the finish around the hub for discoloration, charred areas, crushed wood, and material migration.
This will indicate how well the prop bolts were torqued. Refinish if necessary before re-installing.

Rain erosion is another issue with wood propellers. Many props have leading edge protection to protect the wood. Some may not have anything but the painted finish. So, if you fly in rain, reduce the engine RPM to reduce the damage to the prop leading edges.

[At approximately 1,000 RPM, rain and hail did not affect the wood, did erode and pit the plastic protector on the five or six inches nearest the tip. Low RPM is a must! - MAH]

Note: Measure across any set of opposed holes in the prop flange center to center. If it's 4 3/8", it's SAE 1. If it measures 4 3/4" it's SAE 2.

6.1 Propeller Manufacturers

Prop manufacturers can usually be identified by the shape and materials of their propellers. Only a few have the manufacturer’s name posted on them. Here are some of them:

Lightspeed Engineering, Klaus Savier, (typically large diameter carbon composite) These will be seen on the Berkut and a few Long-EZ’s and on Klaus’ VariEze.

Great American, company no longer in operation (typically, 16 to 32-ply wood laminate, clear finish) Mostly found on Long-EZ’s and VariEze’s.

Catto Propellers, (two and three-blade wood core with fiberglass outer layers, painted finish)

Performance Propellers, (two and three-blade wood laminate, clear finish)

Culver Propellers

a. Gary Hertzler, Mesa, AZ, mailto:hertzler@yahoo.com


c. Performance Props, 602-394-2059

d. Ted's Props, Ted Hendrix, now out of business (business bought by Robear in Chicago area, but different style and nothing like Ted’s Props. Negative business performance history.)

e. Warnke Props, 602-682-2550
f. B&T, Bruce Tifft, business sold, now try Featherlite: fthrlite@pacific.net or phone them at (707) 895-2718 (may no longer be making props)


h. Prince Aircraft Co., P-Tip props, Waterhouse, OH, 419-877-5557, propellers@aol.com

i. MT Propellers, electrically adjustable, 386-736-7762, mailto:mtpropusa@aol.com

j. Ed Sterba Aircraft Propellers: 941-778-3103

k. Amar Demouth propellers (410) 461-4329, metal leading edges

SAE1 versus SAE2:
The bolt circle (BC) diameter of SAE 1 is 4.375 (4 3/8).
SAE 2 is 4.75 (4 3/4).

6.2 Fixed/Variable Pitch Propellers

Almost all the canards utilize fixed pitch propellers for the reasons mentioned above. Other reasons involve engine modifications or electrical circuitry for pitch control. All this adds to aircraft weight. Follow the manufacture’s specifications! The performance of these planes is excellent as they are.

6.3 Material – Metal, Wood, and Wood-Composite Propellers

In our EXPERIMENTAL aircraft, you don’t want to experiment with the things that push the plane forward and keep it flying. The propeller dynamics at the rear of Rutan-type aircraft have never been analyzed sufficiently to understand the vibration forces that must be withstood by the propeller blades. Wood or the combination wood/fiberglass materials are more tolerant of these unknown forces, and therefore, are prescribed.

Metal propellers are unique to each airframe/engine combination and undergo testing that is not possible for a Homebuilt.

6.4 Wood Prop Care
(Compilation of Information Bruce Tifft provided with his propellers)

MOUNTING PROCEDURE:

Apply a light coat of beeswax or paraffin wax to drive lugs and center spud extension. Care should be taken to keep propeller hub face parallel to the flange face while
tightening the bolts. DRIVE LUGS ARE A MUST!

TORQUE:

Torque to 250 inch pounds and check after the first flight is completed. Recheck every 10 hours until completion of 50 hours of flight time on your new prop. Then, check torque every 25 hours.

TRACKING:

Carefully track your propeller. Get it perfect. Do not settle for 1/16” being close enough. Tighten all bolts to 250 inch pounds. Check track. Back off the three bolts on one blade and continue to tighten other three up to 350 inch pounds, each time tightening the other three to 250 inch pounds until it tracks perfectly. You will be happy with the smoothness you will gain.

Place a stick on wing held in place with a bean (shot) bag. Align stick one inch from end of prop. BE SURE MAGS ARE OFF AND PROP TORQUED TO 250 INCH POUND. Rotate prop to determine if prop to stick gap is equal and track is equal. If not tracking exactly, a slight variation can be corrected with differential torque on lugs until in line.

If track is too uneven, a piece of folder stock may be used as a shim between prop flange and prop face to even up track.

UNEVEN GAP:

Check if crank flange is bent. Remove prop, rotate 180 degrees, then replace prop. If opposite end of prop is now farthest from stick, you have a bent crankshaft or bent flange. Both are expensive to correct.

When finished, be sure proper torque (250 inch pounds) is maintained on all lugs.

MOISTURE:

Always leave a wood prop in a horizontal position when you park your plane. It draws moisture to the bottom blade if vertical and will vibrate until weight is equalized. If you do not fly for a long period, rotate the prop 180 degrees occasionally.

PROPELLER CARE:

Automotive paste waxes can be used to clean the finish. No other care is necessary.

IT IS ESSENTIAL TO COVER THE CENTER HOLE OF THE PROP. If you are not using a spinner, use an aluminum plate under your crush plate or moisture can soak in the center hole and damage the hub area. [This advice is recent.]
(MAH comment: Since 1992, I have used a wine bottle cork in the center hole with excellent results. It weighs less than a plate. For eight years, my Long-EZ was parked on a ramp in Miami, Florida. Sun and weather will take their toll. Cover the prop to protect from sun damage while leaving room for ventilation. Tony Brazier makes a cover for the Long-EZ that covers part of the nose, the canopy, and the prop and sells for just over $100.)

Ref: Tony Brazier, Custom Cabin Covers
P.O. Box 77031
Ocala, FL 34477
Phone/FAX: (352) 237-1811

ROCK DAMAGE:

Light impact damage can be repaired with two part epoxy filler available in tubes. Always carry JB Weld or a Duro epoxy kit. Fill small chip holes and small voids, clamp with a rubber band until cured, and sand the hardened epoxy to fit contour. Although the epoxy is very dense, the amount of imbalance resulting from small repairs is negligible.

PLASTIC LEADING EDGE:

This type of leading edge is effective in preventing small rock damage, and if damaged, is easy to repair with JB Weld. However, rain and hail can cause serious wood damage. When entering rain, decrease the RPM as much as possible because rain can damage the wood behind the plastic. At idle, little damage, if any, will occur to the wood because the prop is not creating thrust or drag. In rain, hail, sleet or snow, throttling back (1,000 RPM) can reduce damage to your prop.

PAINTING OUTER TIPS:

If you wish to paint the outer three or four inches of the tips, make sure an equal amount of paint is applied on each side to maintain the balance of your prop.

SAFETY OF FLIGHT ISSUE:

Propellers are held onto the prop extension by six #7 bolts. The properly torqued bolts apply a prescribed compression of the wood material within the yield strength of the bolts. It’s friction that keeps your prop on the airplane, not shear forces on the bolts. Wood propellers breathe, or swell and shrink with humidity changes. It is therefore imperative that you follow the manufacturer’s recommendations for periodic re-torquing the propeller bolts. Even flying from one climate to another may trigger the requirement to re-torque the bolts.
6.5 Prop-Torque

Prop bolts torque check

The clamping force gradually changes with time. This is because the prop wood is made of round grains filled with air. The grains gradually collapse from the pressure, which reduces the clamping force. The bolts are unchanged. They don't rotate. But they no longer apply the force required to prevent micro prop movement.

Prop bolts are merely clamps. Then never are used as shear pins, until just before catastrophic failure. Your best action is to periodically recheck the torque. Make sure you rotate the bolt when checking torque. I use torque wrench and torque all fasteners to 20 ft lbs. 1 month later the wood has collapsed a bit and the effective torque is down to 15 ft lbs. If I place a torque wrench on this loose fastener, it may read as high as 20, then drop to 15 after the bolt starts to rotate. That initial 20 is called "breakaway torque" and you must overcome it before taking a torque reading.

Periodically you will hear of someone with broken prop bolt. They tend to describe the bolt as the problem. The bolt is actually lightly loaded and sees no unusual forces. It's not until the prop is loose that the bolt sees very high shear and fatigue forces.

The most critical component of your prop is the large "pilot bore". Usually 2 1/4" diameter, it needs to be a snug fit (interference fit). If it is not snug fit, you are at much greater risk of prop related failure. When you first place your prop on engine, leave the bolts off. Wiggle the prop around to see if you truly have snug pilot fit. If you don't, place some flox mix in bore, and reinstall. Torque bolts. Let cure, then remove prop, balance while locating on bore, then reinstall, retorque.

See my web pages below.

7.0 Electrical System and Wiring

Burning (or smoking) insulation will typically release toxic fumes.

PVC: Incomplete combustion (smoking wires) gives, carbon monoxide and hydrocarbon oxidation products including organic acids, aldehydes and alcohols. Flash Point: 806 F (this is for one type of PVC, others are similar) (Flash point is when it starts to actually burn. FLAME)

Please refer to NASA selection guide for insulation material
http://www.nepp.nasa.gov/npsl/Wire/insulation_guide.htm

FEP and PTFE Advantages:(Dupont TM Teflon)
-Excellent high temperature properties.
-PTFE Teflon is preferred for solder applications.
-FEP is preferred for jacket material.
-Non-flammable
-Good out gassing characteristics
-Most flexible of all insulations
-Good weather ability, resists moisture absorption and atomic oxygen erosion

Teflon does breaks down when at HIGH temperature and releases hazardous byproducts. (The temperature that would cause Teflon to break down would probably be the result of some other material burning)

I have seen an industrial panel with Teflon and PVC following a short circuit failure. The PVC panel had secondary wiring melt and additional cascading failure (The entire inside of the panel burned). The Teflon had a group of wires damaged with NO resulting fire.

It would be better to design you electrical system to prevent short circuits from causing fires. A well designed and protected electrical system has very little chance of causing a fire.

Teflon is a better choice in by opinion. -- Dennis Blomquist, 9/02

7.2 Alternators

For trouble shooting help, this web site may be of assistance.  
http://avionicswest.com/snap.html#Alternator%20Noise

7.3 Avionics

**Terra Transponders** -- Free flight Systems stopped upgrading TRT 250 in 1998. No avionics shops have been found that will do the upgrade. Free Flight Systems said the reason they don't upgrade the TRT 250 is the problem thumb-wheel switches. They did agree (thank you Free Flight) to send parts to do the upgrade. So, if you are able to make the modifications yourself, this may be a solution.

Encoders

Most new equipment does not accept gray code inputs, which the majority of encoders provide. Instead, they require serial or icarus info.

The exception to this rule is Garmin; they take in either because although serial data is better, faster, and more reliable. The FAA says you have to have the ability to use gray
code. The 430/530 takes both in and then allows you to configure it in the menu to use only serial. I imagine that the FAA is behind the times.

I always recommend the SAE-5-35, made by Sandia. It has proven itself time and time again, and it is what I use.

"Chris Riddell" <chrisriddell@approach-systems.com>

7.3.1 Ground Plane

Cheap and EZE Ground Plane for Good Quality Radio Performance

…He built in a ground plane with multiple X patterns of wires that he buried in the fill on the belly. I was saving the blade for a last resort as I figured it would create some drag. Plus, I would have to come up with a ground plane to make it work.

I came up with a killer EZE way to make a ground plane and it hit the bulls-eye for performance. I mounted the blade on the belly about half way between the bottom of the pilot seat back and the back seat back or 6 inches behind the rear edge of the landing brake.

I bought a piece of scrap carpet (42”x20”) for 5 bucks and a piece of screen door aluminum screen from ACE Hardware.

I glued the screen to the bottom of the carpet with a double dose of rubber type contact cement. Then I trimmed and fitted the carpet so that it covered the whole floor of the back seat including all the way up under the rear seat cushion.

This was now about 42” long by 20” wide and my blade was right in the middle underneath. The 2” of foam between the blade antenna and the ground plane do not hurt the performance.

I attached a ground wire with a couple large area washers and a #10 short bolt and nut with a spade connector so no copper comes in contact with the aluminum screen.

Also, the heads of the bolts that hold the blade on come through the floor and the screen makes contact and an extra ground connection at those points, too.

I am really surprised how well this works. I talked to Norcal from 40 miles out with a loud and clear check, and I tried it on all frequencies with perfect results.

The blade antenna is Aircraft Spruce part number AVT-4.

Paul Werner
7.4 Gyro Instruments Repair

User reports of good service.

Attn: Mike McIntosh
Rudy Aircraft Instruments
Rt. 1 Box 424
4711 Old Bowman Road
Rudy, AR 72952 (Arkansas)
U.S.A.

Tel: 479-474-8759
Fax: 479-474-3306

8.0 Wheels/Tires/Brakes and Brake Fluid

Some aircraft use DOT 3 brake fluid (red in color and common in automobiles) and others utilize DOT 5 (clear Silicone). The apparent reason for the shift to silicone is to reduce the probably of fire when the fluid comes in contact with a hot brake disk.

However, is it not a simple conversion from one type to the other. Read the following notes on the process and precautions.

1. DOT 5 Silicone should not be mixed with other brake fluids that are Glycol-based.
2. If you change from a glycol-based fluid to DOT 5 Silicone, you have to flush the brake system thoroughly as already suggested, and also replace all the rubber products in the system that have absorbed the glycol-based fluid.
3. There is a DOT 5.1 brake fluid that is glycol-based, not silicone-based. Be careful.
4. DOT 5 Silicone was developed to reduce water absorption, and therefore increase the length of time between brake fluid flushing and replacement. Glycol-based brake fluid should be replaced every 2-3 years. Silicone-based is much longer.
5. The "red stuff" is MIL 5606 or a replacement such as Chevron Aviation Hydraulic Fluid A. It is petroleum-based. It is commonly used throughout an aircraft and its viscosity remains relatively constant over a wide temperature range, including down to less than -65 degrees F.

If you mix a large amount of DOT 5 Silicone with a small amount of Red Hydraulic Fluid, you get horribly sticky goo.
When changing from Red Hydraulic Fluid to DOT 5 Silicone, you have to flush the system well, and replace all rubber products in the system. There are no problems with putting DOT 5 Silicone in a new system. It would be wise to label the reservoirs "DOT 5 Silicone only".

DOT 5 Silicone was originally developed for the U.S. Military to reduce the need of changing the fluid to once every several years - I forget exactly how many. Red Hydraulic Fluid should be replaced about every two years because of water absorption.

--Garth Shearing, Victoria BC Canada
8.2 Long-EZ Nose Wheel Axle Bushing Rotation

There are two aluminum spacers on the Long-EZ used to center the nose wheel between the forks. These spacers tend to spin and cause inappropriate wear. It’s easy to stop the spinning by pinning the spacers, but the bearings’ inner races may be spinning on the spacers too. To correct both problems do the following:

This method is exactly the way wheel bearing pre-load is done on a Harley Davidson motorcycle. It works great, and it’s recommended to use Harley’s method for setting end play tolerances. Fabricate a center spacer to fit between the ones on the wheel assembly. Clean the bearings thoroughly, assemble the wheel, bearings and the three spacers with no grease in the bearings, and use a dial indicator to check end-play. Harley specs .004 - .016" (.1 mm - .4 mm). A Long-EZ builder recommends going for as close to 0.004" (.1mm) as you can get. When you’re satisfied disassemble, grease the bearings and reassemble. Good to over 100 mph with no wheel wobble, says the builder.

To pin the spacers, drill a small hole in the fork that penetrates the spacer. Tap this hole for a tiny screw long enough to go through the fork and into the spacer. Or, another method is to cross-drill the spacer perpendicular and off-center from the axle hole. Use 0.040 safety wire through the hole and around the fork.

8.2.1 Electrical Nose Lifts

There are several manufacturers of electrical nose lifts for canard aircraft. Some pilots may want the latest gadget, some may have a bad back, and some may be getting old - with or without a bad back! It does get harder to climb up into a Long-EZ. After his 74th birthday, one pilot started using a big tin can with a string to haul it up after getting in.

Three sources of electrical lifts are:

1. Bill Oertel, 3216 Broco Lane, Norco CA 91760-1817 - 909-734-7569
2. Steve Wright, and
3. Jack Wilhelmson, http://www.eznoselift.com/ E-mail: wilhelms@isg-scra.org

8.3 Long-EZ main gear attachments/hard points

The best installation is with a flanged bushing, with the flange faces mating against the landing gear "support tube" (for lack of having that part number at my fingertips). The flange faces "face" each other when the extrusions are installed in the fuselage.

The bushings needed for this are P/N NAS77-6-25, which are a steel bushing with cadmium plating. For the hole in the mount, you will need to precision ream the hole for the bushing to 0.5000 inch - if you don’t have a good 0.5000 inch reamer, take your
extrusions to a machine shop - they may charge you a six-pack for such an involved procedure...

The bushings are a press-fit (can be installed in a vise), with an outside diameter of 0.5013. If you have the opportunity to install these bushings with a wet coat of a good epoxy-based primer on the bushing OD, all the better. The primer helps a bit more on the corrosion side of things. Chromate-based aircraft sealant also is a good option. I used JB Weld the last time I made up a set of Long-EZ mounts. Mind-you, there is no reason to seek something for bushing installation with the thought of "bonding" the bushings in - the interference fit between the bushing and the extrusion is what is important. The 0.5" reamed hole is essential.

8.4 Tire Inflation Technique

Go to your local truck terminal or a major truck stop with a truck accessories store. Buy a six-inch long valve extender and a set of hex-head, steel valve caps. The truck valve extender should have a hex-head socket on the female screw on end. Use the extender like a socket wrench through the hole in the wheel pant to remove (and replace) the hex-head valve cap. The truck valve extenders are like long Schraeder valves and make filling of the tire a snap.

To speed up the process, place a visible mark on the outboard side of the tires to indicate the position where the tire valve lines up with the hole in the wheel pant. – Bob Eckes

8.4.1 Tires - Source

A great mechanic suggested 10 ply tires because the EZ steering is with brakes. The sidewalls of 10 ply will hold up better than 6 ply tires.

One warning about 10 ply! The stiff sidewall of the tire does not bend with the weight of the empty EZ (980 pounds). There is no indication of low tire pressure unless a person is in the aircraft. Then, it is obvious. When you apply throttle and the plane just sits there, you probably have 15 pounds of tire pressure instead of 45. Planes do talk to you, if you will listen!

A pair of 5.00 x 5/10 recaps cost about $70 ($35 each) in 1996, and they still have plenty of tread. The Long-EZ has over 1,000 hours flight time, including many landings. I try to fly every week, even though I may not fly cross-country.

Wilkerson provides interesting information about tires and tire pressure, probably more than you want to know:
http://members.aol.com/jamesl1013/tires/airpressure.html

8.5 - Wheel Pants - Small (Lamb) Tires

He makes all kinds of fiberglass/composite pieces for various engines and aircraft. He even has plenums. His website:

http://www.jamesaircraft.com/Our_Products.html

Pilot Report:

Going from 5.00 x 5's and no wheel pants to Lambs and Klaus's wheel pants, with no other mods, I picked up 15 knots on an O-235 Long-EZ.

9.0 Refueling – Static Electricity Protection

Marc Borom -- After moving from NY to AZ, I was very concerned about the increased danger of static electricity sparks during fueling my electrically non-conductive plane. I talked with the GE scientist in charge of protecting polymer mixing vats from static electricity induced explosions. Here is the skinny.

The worst case is when one pours a non-conductive liquid (like gasoline) from a non-conductive container (like the red plastic containers many of us use) into another non-conductive container like epoxy coated fiberglass wing tanks. Low humidity (like in AZ) makes things worse.

A static electrical charge builds up on the surface of the flowing liquid as it rubs along the non-conductive nozzle, and it is always looking for a place to discharge (the gasoline/air mixture in the fuel tank is the KaBoom site). Even if you are fueling from a grounded fuel nozzle, the non-conductive gasoline will pick up a static charge just by falling through the air (turbo-static charge). So how do you protect yourself from the KaBoom syndrome?

This is what I was told. One must devise a technique to strip the charge off the falling liquid before it can jump a spark. On the advice of the Anti-KaBoom scientist, this is what I did, and, so far, no KaBoom.

I went to Home Depot and bought a 1 ½" x 12", flanged brass tail piece for a sink drain (Moen #803B for $4.47). I cut a slit along the axis of the tail piece from the flanged end for about 8 inches (long enough to clear the fuel cap locking wire and to allow the tail piece to be inserted in the fuel tank).
The flanged end rests on the bottom of the tank. I chose to have the flange rest on the bottom of the fuel tank to minimize scuffing of the tank surface. A grounding wire is bolted to the top of the tail piece (the tail piece can be cut to an appropriate length less than 12\textquotedbl{}). I used 12 gauge, stranded copper wire for the grounding lead with an alligator clip on the end for attaching to a good earth ground.

Fuel is allowed to flow along the tail piece\textquotesingle s internal surface and any charge is transferred to ground. Do not use an aluminum tube for the charge stripper since aluminum oxidizes readily and the oxide layer will insulate the fuel from the ground.

Attaching the fuel hose nozzle ground to the exhaust stack does nothing for you. Remember that it is the fuel rubbing against a non-conductor and just plain falling through the air that is the problem. The tank insert nips the problem in the bud. The whole tail piece device will fall to the earth if you throw it in the air, but it weighs less than 8 oz.

Note: Ed: I think this is the definitive re-fueling static protection technique. Not withstanding the relatively small amount of fuel we usually transfer to a single tank and the resultant reduced opportunity to build up a static charge, this technique is as foolproof as it gets.

More on this subject:

I\'ve re-read through all these static and fuel related posts on the Canard board and Cozy boards. Let me see if I can summarize things. There are multiple problems and solutions needed.

Problems...
Static potential on:
- fuel surface within the tank,
- exterior aircraft skin,
- fuel falling into the tank,
- your clothes,
- that thunder-cell within 10 miles

What\'s the likelihood? Sparks and fires have happened multiple times with EZ airplanes.

Solutions...

1) Regarding "grounding the fuel within the tank"... I\'m seeing "metal cap & filler ring with dangling chain" and Marc Borom\'s solution. These are to be grounded with an external grounding wire, FIRST CONNECT AIRCRAFT, then connect ground. Also, there\'s at least one EZ with an internal grounding wire running from the metal filler ring & cap, thru the tank wall to aircraft ground. He can ground on the tail-pipe.
2) Regarding "falling fuel"... I think Marc Borom's approach specifically addresses this, although I still can't fully visualize it, yet. Does this address refueling from a plastic jug?

3) Regarding "static potential on external aircraft skin"... This isn't always resolved with a "grounded cap & filler-ring with dangling retention chain". The solution for this is to wipe down the surrounding surface with a damp cloth or use a "anti-static pad" as shown on the recent "Lindberg crosses the Atlantic in Lancair"

4) Regarding "bad grounding sequence": If you externally ground your filler-ring & cap (as opposed to a built-in internal grounding wire), have a personal grounding wire. YOU connect first to aircraft then to ground. If you have an internally grounding wire from the filler-ring & cap to aircraft, the tail-pipe will do.

The refueling procedure is to:
1) Be aware of and take action regarding static buildup in your clothes. (dry with static-cling strips, strip or cover static-y things)
2) Be aware of lightening potential conditions. Lightening does hit and kill people 10 miles from the nearest cloud, almost annually in Colorado but less now with global warming.
3) YOU! connect your personal grounding wire, firstly to the metal filler ring, secondly to ground. (if you're using Marc Borom's solution, skip to next step)
4) Wipe the aircraft skin widely around the filler port with a damp rag or throw on an "anti-static pad"
5) Open the gas cap.
6) If you're using Marc Borom's solution, insert and ground.
7) Keep the fuel nozzle against the metal filler ring at all times.

Petroleum Equipment Institute Report

Three points may be of special interest to pilots. A lot of information has been published grounding our fiberglass tanks, the nozzle, and tank caps. No one has stressed clothing and static electricity created outside the gas tank.

Point One: Some clothing creates static electricity in low humidity conditions. Remember the spark in the winter up north?

Solution: Ground yourself before removing the gas cap and before pumping gas.

Point Two: Women have a high percentage of auto fires from static sparking.

Solution: Ladies and men, avoid wearing clothing made from
man made fibers with high static electricity potential when putting gas in your car or being around planes being gassed. Ski suits may stop that cold wind around our EZ feet, but there may be a spark risk involved.

Point Three: Ladies, do not gas the planes.

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Bob Renkes of Petroleum Equipment Institute is working on a campaign to make people aware of fires as a result of "static" at gas pumps.

His company has researched 150 cases of these fires. His results were very surprising:

1) Out of 150 cases, almost all of them involved women.
2) Almost all cases involved the person getting back in their vehicle while the nozzle was still pumping gas. When finished, they went back to pull the nozzle out, the fire started as a result of static electricity.
3) Most were wearing rubber-soled shoes.
4) Most men never get back in their vehicle until completely finished. This is why they are seldom involved in these types of fires.
5) Don't ever use cell phones when pumping gas.
6) The vapors given off the gas cause the fire when exposed to the spark from the static charges.
7) During 29 fires, the driver reentered and exited the vehicle, then they touched the nozzle during refueling.
   There was a variety of makes and models. Some resulting in extensive damage to the vehicle, to the station, and to the customer.
8) Seventeen fires occurred before, during, or immediately after the gas cap was removed and before fueling began.

Mr. Renkes stresses to NEVER get back into your vehicle while filling it with gas. If you absolutely HAVE to get in your vehicle while the gas is pumping, make sure you get out, close the door TOUCHING UNPAINTED METAL, before you ever pull the nozzle out. This way the static from your body will be discharged before you ever remove the nozzle.

The Petroleum Equipment Institute and several other companies are trying to make the public aware of this danger. You can find more information by going to:

http://www.pei.org Then, click in the center of the screen where it says "Stop Static".

10.0 Web Sites and Flying Information

**AOPA and EAA** – Members can check their web sites.
San Diego EZ Squadron – www.ez.org (Jerry Hansen, Webmaster) - Articles, CP Source, Contact directory for many canard owners worldwide, Hangar Flying section to request help and information.

Canard Aviators – forum on Yahoo – 20-30 messages daily – help source, advice (more good than bad), some very knowledgeable canard builders and flyers. Try following e-mail to join. Request messages in digest form to reduce e-mail quantity.

http://login.yahoo.com/config/login?.intl=us&.src=ygrp&.done=http://groups.yahoo.com%2Fgroup%2Fcanard-aviators%2Fjoin%3Freferer%3D1

Landings – www.landings.com - wide assortment of software, information, flight planning, N-numbers assignments, cheap gas sources, and etc.

Overhead Aerial Views – www.terrafly.com
Enter street address. Then, click any edge to fly from that spot. Zoom in or out for more or less details.

Example: 410 Airport Drive, Manteo, NC gives view of MQI, Dare County Airport. Fly north across the water to Kitty Hawk (First Flight Airport). Zoom In to see original flight track location and Kill Devil Hills Monument.

Lycoming Support – Key Reprints for Operation and Maintenance


There are many documents for downloading - every thing you need for operating, leaning, and breaking in new cylinders. This information is directly from the horse’s mouth. Too often, our advice comes from the wrong end of the horse.

What are some other sources of information of interest to canard builders?

Canard.com (http://www.canard.com) is another online resource for canard builders, owners and pilots.

The Central States Association (CSA) is perhaps the most valuable source of support for builders and owners of canard aircraft. They publish a nice newsletter and maintain a directory of members. Dues are a reasonable $25 a year (US and Canada).

Central States Association
[Builders/owners association]
Terry Schubert
9283 Lindbergh Blvd.
Olmsted Falls, OH 44138-2407
Other Useful addresses

Vendor Guide

Vendor Guide ([http://exp-aircraft.com/vendors/vendors.html](http://exp-aircraft.com/vendors/vendors.html)) is your source for finding companies that make products and provide services for the experimental aircraft marketplace. This alphabetical listing contains over 230 vendors appears along with each vendors group code (accessories, avionics, builder assistance, engines, electrical, materials, tools, etc. etc. etc.).

You can browse the list alphabetically by company name.

You can use your browser's "find" function to locate a particular word like "engines".

You can click on any vendor to see a detailed listing. Each vendor's detailed listing is a unique page which includes company and product information, as well as a hot link to their website.

**Aero Aviation**
…Aero Aviation (800) 362-3044 - the lowest on prices, and very good to work with.
MetaSearch: links to 30 sources of Aircraft Parts.

**AeroCad Inc.**
[Makes the Aerocanard kits]
2954 Curtis King Blvd.
Ft. Pierce, FL 34946
(561) 460-8020
http://www.aerocad.com/

**Aircraft Spruce (Shop other sources if price is important)**
[Supplier of aircraft materials]
So. California Location
Administrative Offices and
Main Warehouse
225 Airport Circle
Corona, California 91720
Tele: 909-372-9555
Fax: 909-372-0555
Order Dept.: 877-4-SPRUCE
Customer Service: 800-861-3192
email: info@aircraft-spruce.com
Eastern Regional Office and Warehouse
900 S. Pine Hill Road
Griffin, Georgia 30223
Tele: 770-228-3901 Fax: 770-229-2329
Order Dept: 877-4-SPRUCE
Customer Service: 800-443-1448
email: east@aircraft-spruce.com
URL: http://www.aircraft-spruce.com/

Co-Z Development Corp
[Developer of the various Cozy plansbuilt planes]
2046 N 63rd Place
Mesa AZ 85215
480-981-6401
http://www.cozyaircraft.com/

David Orr
[Canard Finder service]
33812 Diana Dr.
Dana Point, CA 92629
(949) 248-5725
e-mail: canardfinder@worldnet.att.net

Feather Lite - April 2004
[Manufacturer of prefab composite parts and propellers]
1327 South State Street
Ukiah, CA 95482Box 781
707-462-2939
Email: fthrlite@pacific.net

Featherlite COZY IV Parts and Price List as of May ’01
<http://www.cozyaircraft.com/fthrlite2.jpg>
Featherlite COZY Parts and Price List as of May ’01
<http://www.cozyaircraft.com/fthrlite.jpg>

Ken Brock Mfg.
[Manufacturer of hardware]
11852 Western Ave.
Stanton, CA 90680
(714) 898-4366
http://www.kenbrockmfg.com

Light Speed Engineering (Klaus Savier)
[Manufacturer of electronic ignition modules]
P.O. Box 549
Santa Paula, CA 93060  
email: klaus@lightspeedengineering.com  
http://www.lsecorp.com/

**Renaissance Composites** [Makes the Berkut kit]  
3025 Airport Avenue  
Santa Monica, CA 90405  
(310) 391-1943  
http://www.berkut.com/

**Rutan Aircraft Factory** [The Source]  
1654 Flightline  
Mojave, CA 93501  
email: raf@hughes.net

**Shirl Dickey Enterprises**  
[Developer of the E-Racer plans built aircraft]  
P.O. Box 828  
Aguila, AZ 85320  
(520)685-3148

**Vans Aircraft**  
Catalog - Three pdf files  
Spark plugs - $13 and instruments - good prices

**Velocity Inc. (Factory Headquarters)**  
200 W Airport Dr.  
Sebastian FL 32958, USA  
(561)589-1860 - Fax: (561) 589-1893  
email: info@velocityaircraft.com  
http://www.velocityaircraft.com

**Wicks Aircraft**  
[Supplier of aircraft materials]  
410 Pine Street  
Highland, IL 62249  
Orders: 1-800-221-9425  
Help Line: 618-654-7447  
Fax: 618-654-6253  
email: info@wicksaircraft.com  
http://www.wicksaircraft.com/

Hardware:

**Cowling Attachment Screws (TORX)**
11.0 Soldering Large Wire Connectors

Bob Nuckolls
6936 Bainbridge Road, Wichita, Kansas 67226-1008
Voice/Fax: 316-685-8617, E-mail: nuckolls@aeroelectric.com

Big Connections . . . Terminal Installations on Big Wires
Originally appeared in Kit Aircraft Builder, Fall 1996

The last time I wrote for these pages, the topic was solderless terminals for small wires. I'll suggest "small" wires are those accommodated by ordinary hand crimping tools; 22 AWG through 10 AWG (AWG = "American Wire Gage" a measurement system that says big wires shall be known by their small numbers.)

Most light airplane wiring falls in the 22-10 AWG range. However, starter, hydraulic pump, alternator, ground power, and power distribution circuits are exceptions that require much larger wires in the 8 AWG to 2 AWG sizes.

Battery wiring carries starter current so both battery and starter circuitry are at least 4AWG and in most cases 2AWG wire. Alternator feeds are proportioned to the alternator's output rating. 40-amp or smaller can use 8 AWG, 50 to 75 amp machines are wired with 4AWG, 90 to 125-amp alternators are wired with 2AWG wire. Of course, the airplane's limits on consumption of energy are tightly tied to alternator capacity. So, main power distribution paths are wired with the same size wire used to attach the alternator b-lead to the rest of the system. A handful of high current, 30-50 amp loads like hydraulic pumps call for wire in the 8 AWG to 6AWG range.

Solderless, crimp terminals are available for all these sizes but you won't find them in the normal electronic and automotive parts outlets. Further, the tools to apply "fat" terminals are equally robust and expensive. If your heart is really set upon using top-of-the-line, solderless terminals throughout your project, by all means, check with local electrical contractors. Quite often they'll have both tools and terminals. They would probably install terminals on wire segments supplied by you and brought to their facility.

Ideally, terminals should be installed right on the airplane because in some situations, "clocking" of a terminal is important. "Clocking" refers to orientation of a terminal on the wire when installation is completed; wires larger than 6AWG are difficult to twist. Proper clocking insures terminal alignment with its mating stud.

For the less discerning or more frugal builders, there is an alternative to the high-dollar termination of fat wires in airplanes. You can solder them on, SOLDER? Yes, the
dreaded "S" word. I don't know how many articles I've seen in recent years wherein
readers are advised against using solder for wire joining and cite a variety of pitfalls
including heat damaged wire or insulation, and rampant corrosion resulting from poor
selection of materials. I believe most people's aversion come from lack of understanding
of solder's limitations and capabilities.

Soldering is an ancient technology for joining metals and will be the topic of a future
article. In the mean time, please consider the following and trust me - it works!

Terminals to be soldered must be all metal, un-insulated type as shown in Figure 1. If
you have access to insulated terminals but not the tools to apply them, you can twist the
insulators off with a pair of pliers. The terminal barrel should be a snug fit over the wire.
The best joint will occur if the strands can be fairly "packed" into the barrel. My favorite
way to tighten a wire in a loose barrel borrows from the technique of using wedges to
secure a hammer head to a wood handle. In this case, the material needs to be
compatible with the soldering process so how about copper wedges? The finished
termination is going to get dressed up with a sleeve of heat shrink over the wire and
terminal barrel.

Now's the time to slide the heat shrink over the wire. With the heat shrink in place, strip
back the wire to be terminated so that when the strands are just flush with the wire
barrel, a .10" to .15" gap exists between end of insulation and the terminal's wire barrel.
If the terminal you're about to apply seems too loose, get a short piece of 14 or 12 AWG
house wire and strip off the insulation to get a bare strand of solid copper wire. Cut a
piece of wire about a half inch long and use a file or sanding disk to sharpen the end.
My favorite tool is a cutoff wheel in a hand- held hobby motor.

Push the wedge into the end of stranding - toward the center clear of the terminal barrel
as shown in figure 2. If it's still too loose, you can try a second wedge, make bigger
wedges from 10AWG or 8 AWG solid wire, or find the right size terminal! The only
cautions I'll urge with wedging is that some terminals are not brazed shut at the joint
where the barrel is formed from the flat stamping. Aggressive wedging can spread the
barrel open.

Now, you're almost ready to solder. Check the clocking of the terminal. This means that
the terminal should be oriented with respect to twist on the wire so that the terminal will
drop onto it's mating stud without twisting the wire. Oh yeah, you do know that the parts
to be soldered need to be clean? If the terminals have been laying around in a junk box
for 10 years or if the wedge wire is less than shiny, use Scotchbrite pads or similar to
brighten things up before assembly.

Now comes the fun part. You've got a range of choices for sources of heat to flow the
solder. I've used an ordinary propane torch adjusted to a very small, inner blue flame of
about 1/4". If your work area is VERY free of drafts (moving air cools your work rapidly)
you can use one of those little butane torches.
You can also use a soldering iron with as few as 50 watts of heat capacity - IF it's a small 50 watt iron that gets all the heat out to the tip. My favorite is an Ungar handle with screw-in heating elements. We used to have similar tools for "wood burning" art when I was a kid. They may still sell these tools in craft shops. The solder you're going to use will be electronic grade 60/40 or 63/37 alloy with a rosin core. The ideal size is the .062" diameter.

Poor torch technique can make it look like you tried to clone the Mona Lisa with a paint roller so listen up. If you use a propane torch, heat for this task is always applied on the back side of the terminal about even with the tongue end of the wire barrel (Figure 4). Angle of the applied flame should blow hot gasses away from the wire's insulation (If you're using a soldering iron or tiny butane torch, you can move the heat source around the barrel so that it's opposite where the solder is going in). About 10-15 seconds after initial application of heat, feed solder into the space between wire strands and the terminal barrel. Start out immediately opposite the flame. Molten solder is the conductor of heat from barrel to strands; after the first inch or so of solder has been fed into the joint, start around the barrel always pushing it into the space between wire and barrel until about 6" of solder have been fed into the joint. Now, you're almost done. Turn your attention to the other end of the barrel where we left a "window" between insulation and barrel; keep feeding solder in and watch for the appearance of solder which will flow by capillary action to the wire end of the barrel. Don't be surprised if it takes 10" or more of .062 diameter solder to finished the joint! Resist the urge to feed solder into the other wire end.

When solder first appears at the wire end, reduce the heat and see how the exposed stranding looks at the cut end. If the stranding matrix isn't filled with solder, you can now begin to feed solder directly into the stranding wherever the solder has not already flowed. As soon as the ends appear "covered" you can take the heat off. A little "toasting" of the insulation may be unavoidable. Trim away the lumps with a knife and go to the next step.

Let it cool, wipe down with rag or paper towel wet with acetone or lacquer thinner. The insulation may pull back from the joint a little bit; put the heat shrink in place over the barrel and shrink down to finish the joint.

Sources for materials and tools:

Heat shrink tubing is commonly stocked by electronic and automotive parts houses. I prefer double-walled products with an inner-wall of melting sealant.

Terminals should be tin plated solid copper. Electrical supply houses will have big'uns both insulated and uninsulated.

Irrespective of what the supplier says the matching wire gage is for any terminal he offers, you're more interested in how well it fits before crimping. Take a piece of stripped wire with you when you shop for terminals.
Small quantities of electronic grade solder are available from Radio Shack, electronic supply houses will want to sell you a full pound. If you do invest in a pound spool, I recommend Kester Resin 44 in a 63/37 alloy and .032 diameter. This is a good all around size for OTHER soldering jobs. For soldering big terminals, take four, 12" strands of .032" solder and twist them together to make solder stock.

The AeroElectric Connection stocks fat wire termination kits, which include terminal, double wall heat shrink, wedges and solder.

A hardware variety propane torch can be used with care. An electric soldering iron is probably ideal and easier to control. Check with electronic tools supply stores and hobby/craft stores. You need the concentrated-heat 45-60 watt type tools shown in Figure 3. The little butane hand torch is also a good choice. It's slow but you're not in a hurry and It's very unlikely to over-heat the joint. This little guy does need a draft-free workspace to do the job.

Check hobby shops for heat guns used to shrink model airplane covering. They cost about $20.

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Here are the "rules" by which Bob Nuckolls would wire his own airplane:

RULE 1: First choice for joining/terminating any wires up through 22 through 12AWG are PIDG style terminals as described in http://www.aeroelectric.com/articles/terminal.pdf using tools like http://www.aeroelectric.com/Catalog/tools/tools.html#rct-1

or better.

RULE 2: Where there is a choice, I would select fast-ons over threaded fasteners in the 22 to 12 AWG range using terminals like http://www.aeroelectric.com/Catalog/wiring/wiring.html#faston

with features as explained in http://www.aeroelectric.com/articles/faston3.pdf
RULE 3: When I have to live with a threaded fastener, then these terminals are in order.

http://www.aeroelectric.com/Catalog/wiring/wiring.html#s816p

RULE 4: For wires larger than 12AWG, then I would solder and heat shrink joints as described in .


Using materials like .

http://www.aeroelectric.com/Catalog/wiring/s812.jpg

which are supplied with double-wall heat shrink for finishing.

RULE 5A: Permanent splicing of single conductors to be accomplished with butt splices like .

http://www.aeroelectric.com/Catalog/wiring/s816.jpg

RULE 5B: but if it was deemed desirable to break the splice open for future convenience, a knife splice and heat shrink would be used thusly:

http://www.aeroelectric.com/Catalog/wiring/ksplc2.jpg

RULE 6: When the accessory items are supplied with nylon connectors like AMP Mate-n-Lock or Molex, pins are installed with a tool like:

http://www.aeroelectric.com/Catalog/tools/tools.html#bct-1

used thusly .

http://216.55.140.222/articles/matenlok/matenlok.html

These connectors would only be used as an accommodation for the use of an accessory that comes with them already installed. They are not my connector style of
RULE 7A: When working with accessories supplied with D-sub connectors, the first choice of mating connectors is the removable pin variety that will accept machined pins like:

http://www.aeroelectric.com/Catalog/connect/connect.html#S604

installed with a tool like

http://www.aeroelectric.com/Catalog/tools/tools.html#rct-3

and removed with a tool like . . .

http://www.aeroelectric.com/Catalog/tools/tools.html#dse-1

RULE 7B: if for any reason the crimped-pin mating d-sub is not available, then soldering is my second choice using techniques described in . . .

http://www.aeroelectric.com/articles/dsubs/d_solder.html

and tools like

http://www.aeroelectric.com/Catalog/tools/tools.html#s101_1

or better

RULE 7C: If options 7A and 7B are not practical, then the lowest order choice for working with d-subs is open barrel crimped pins installed with tools and techniques like those described in RULE 6.

----------------------------------------------------------

RULE 8: Installation of connectors on coaxial cables to antennas are installed per

http://www.aeroelectric.com/articles/bnccrimp.pdf

using tool . . .

http://www.aeroelectric.com/Catalog/tools/tools.html#rct-2

and wire . . .

http://www.aeroelectric.com/Catalog/antenna/antenna.html#rg-400
RULE 9: A single point ground system shall be established behind the instrument panel with sufficient attach points for all accessories in the cockpit area. In deference to RULE 2, a forest-of-fast-on-tabs ground block similar to:

http://www.aeroelectric.com/Catalog/wiring/wiring.html#gndblk

The threaded stud on the ground block assembly would penetrate the firewall and be used to terminate battery (-) leads on either side of firewall and the crankcase ground strap on the engine side of the firewall.

In the case of canard pushers with the battery up front, the ground bus would be mounted forward of the instrument panel. If the airplane’s firewall is metallic, then a brass bolt and appropriate washers and nuts would be used to provide an engine compartment ground stud and connection of the ground lead to the firewall. A ground strap will be used to connect the crankcase to the firewall ground stud.

http://www.aeroelectric.com/Catalog/wiring/wiring.html#bbs

Any ground straps provided around the rubber biscuits of an engine mount will be removed. Engine mounts are for holding engines on airplanes and not use for any part of the electrical system.

RULE 10: Tefzel wire used throughout with the exception of cranking circuit fat wires where 4AWG or 2AWG welding cable would be used. An alternative FAT wire could be one of the new copper-clad aluminum wires. These new materials can be soldered and cramped.

Caution

To get the same electrical performance, you need to use about 2AWG steps larger wire than for copper but the installed wire will still be lighter.

In parallel universes, there are differing rules which may well prove to be as useful or perhaps even better than those cited in Bob’s universe. With what Bob has learned up to and including Sunday, October 27, 2002 the rules cited above are his personal choices for practical, solid techniques using moderately priced materials, and tools. Adherence to these rules is likely to produce an electrical system where (1) component wear-out and failure are the sole causes for maintenance, and (2) the wiring can be expected to perform as intended over the life of the airplane.
Crimping or Soldiering Electrical Terminals

It's worth noting that, at least with smaller wiring, the 'experts' are split. King terminals remain crimp-on, while Garmin and others utilize pins with solder cups. The latter simply can't be crimped. I've seen King terminals pull loose during Avionics upgrades. Properly soldered terminals won't do that. Nor do properly soldered wires become brittle.

Here's my technique:

1) Make sure wires to be soldered are perfectly clean. If you stripped them yesterday, cut and strip again today. Don't handle bare wire with dirty hands - wash first. No grease, no oil, nothing.

2) Use liquid flux on the bare wire and terminal and apply it with a small, clean brush wherever you want solder to stick. The brush-in-bottle kind is perfect. Use flux designed specifically for electronics that does not leave a residue after soldering. Details on the bottle.

3) Immediately tin the wire and terminal, or both wires if it's a wire-to-wire joint. Tinning means to apply just enough solder to coat the area to be soldered on a terminal, or to turn the stripped portion of the wire a bright silver prior to putting the two pieces together.

Wire will 'wick' the solder up; you don't have to move it around. Use a damp sponge to clean the iron, put a small dab of new solder on the tip, and transfer heat through that dab of solder. If the liquid flux had time to dry before you tin, start over.

4) Use an appropriate wattage, 40 for larger wires and terminals, 25 for everything smaller. If you need a torch for electrical work, you don't need solder. Be patient with your iron and give it time to properly heat. Never solder with a warm iron.

5) Don't use too much solder or take too long at it. It doesn't take much of either to tin using this technique. You should not have blobs of solder anywhere, nor should you singe any insulation.

6) You never have to put a curve in a solder joint. The wire is always tinned straight. To solder two pieces of wire together, just place the tinned ends side by side and heat briefly. No additional solder is needed.

7) I prefer 63/37, because it has a very narrow liquid to solid heat range. If you move a solder joint after removing the heat and before it's solid, you may have fractured the joint. This may not be visible externally.

8) Even though there is no requirement to clean the residue after soldering, I keep a small bottle of alcohol and some q-tips and cotton swabs handy to clean the area
afterwards. Not necessary, but professional. The liquid flux becomes sticky and whatever it drips on will hold dirt.

9) Always use shrink tubing to protect your solder joints where possible. Use the good stuff that starts out very flexible. The stiff, shiny radio shack stuff becomes too brittle after heating. If you forget to slide it on before soldering a joint and can't get it on afterwards, take the joint apart and start over.

Don't use electrical tape for any reason on any solder joint; it will not age well.

["Liquid tape" seems to work.]

Don't use a match or torch on heat shrink; use a heat gun, and use just enough heat. You don't want the shrink tube to become brittle or to split. If a joint has sharp edges, smooth these before applying the shrink tube so the edge doesn't work through the tube over time.

10) As in all skills, practice makes perfect. Practice on loose bits of wire when you aren't trying to install a $7,000 radio in time to impress your friends at that really cool fly-in.

11) Finally, use heat sinks whenever you are working around delicate equipment. I usually use forceps.

Note that 63/37 solder has a melting point of 361 degrees Fahrenheit. CHTs routinely exceed 361F in air-cooled engines, and all exhaust systems do. That's why I wouldn't use a solder joint close to the engine exhaust.

Apart from the heat aspect, solder connections on really large wires are not necessary. When you're working with large hunks of metal and big wires crimping is effective, and for really large joints you'd have to use a torch. That's OK for plumbing, not for electronics. You never want to heat insulation or components that much.

Len Johnson <lgjohnson@adelphia.net>

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There is a lot of neat stuff on wiring at http://www.terminaltown.com/, which is run by some people who know homebuilders and their needs.

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12.0 FAA Identifier Codes -- For filing flight plans:

  Cozy = COZY,  
  Defiant = DEFI,  
  Solitaire = SOLI,
VariEze = VEZE  
Long-EZ = LGEZ,  
Velocity = VELO,  
Berkut = BKUT  
VariViggen = VVIG.

There are other designations such as RV6 etc., but just those for the composite canards are included here.

If in doubt, these general codes apply:

HXA for cruise speeds less than 100 KIAS,  
HXB for cruise speeds 100 – 199KIAS,  
HXC for those with cruise speeds above 200KIAS.

These are from recent changes to the FAA controllers’ handbook. Many controllers do not know much about homebuilts, and they may ask what type you are. See next paragraph.

ADDENDUM

APPROACHING TOWER CONTROLLED AIRPORTS

In call-ups to tower controllers, give call-up as Long-EZ 12345, not Experimental 12345. This was explained to me at one of America’s busiest airport towers. They prefer that we announce on call-up the type of aircraft so they know your airspeed for spacing.

Experimental aircraft can have airspeeds from 40 knots to 500 knots. Saying “Experimental” gives them no useful information.

Slow Flying Can Be A Lifesaver

Kinetic Energy Is The Killer in An Emergency Landing!

"If an engine-out landing is unavoidable, check wind direction, choose your landing area, and establish your glide at 70 to 75 knots... Your landing gear should be down, even for an off-airport landing in rough terrain or water."

"Long-EZ Owner's Manual", p 22

Every homebuilt is an individual flying machine, but an engine out emergency risk applies to all. You can determine minimum air speed and descent rate for your aircraft by testing your skills and your aircraft flight response at a safe altitude. Impact speed
and aircraft weight affect survival probability. Expect a rough field landing to rip off the landing gear at touchdown.

It is possible to reduce this impact speed even more. An EZ can fly slowly. Practicing above 3,000 feet AGL enables us to learn to fly controlled, shallow turns while the plane mushes down with throttle closed, nose high, full aft trim, and full aft stick. It is very important that the weight and balance be within the CG envelope established by Rutan to avoid a deep stall in this unusual attitude.

The canard and main wing will be stalled, but you can control the plane with rudders (WWII Army Air Corps "falling leaf" maneuver). You can overpower the built-in pitch and recover action of the canard that maintains flying speed when flying straight and level at slow speed. This maneuver requires practice, preferably before an engine-out occurs. My Long-EZ descends at 600 feet per minute in this attitude.

The Long-EZ has a take-off weight limit of 1,425 pounds. The upper weight limit increases the kinetic energy factor in an off-field, emergency landing. However, weight does not increase the risk as dramatically as does high impact speed. (See table below.)

The air speed indicator will be inaccurate due to the high angle of attack. I tried to check the true air speed with this exaggerated nose-up attitude with a friend flying a Taylorcraft. Gradually, I pulled away from him as he maintained 50 mph. My forward speed was less than the normal landing speed of 70 knots, probably around 55 knots. My inaccurate air speed indicator indicated about 40 knots.

The lower impact force at 55 knots combined with the strength of the airframe should protect pilot and passenger at the lower speed. Increasing air speed by 13 knots could be a killer.

The 600 feet per minute descent rate is only 10 feet per second, which is less speed than Army paratroopers descend during their jumps. The 1947 Army 28 feet parachutes descended at 12-20 feet per second, depending on the weight of the paratrooper and equipment. The EZ gear should absorb most of the combined forward/vertical impact, even if it is ripped off.

**Kinetic Energy Is The Killer in An Emergency Landing!**

**High Impact Speed** is the most dangerous variable.

Kinetic Energy Formula: \( \text{Energy} = \frac{\text{Weight}}{2} \times \text{Velocity}^2 \)

A 40% increase in speed almost doubles the kinetic energy.
A 40% increase in weight increases the kinetic energy by 40%.
<table>
<thead>
<tr>
<th>Weight (lbs)</th>
<th>Velocity (mph)(kts)</th>
<th>Kinetic Energy</th>
<th>Multiple (same weight)</th>
<th>Multiple (same speed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000</td>
<td>50 43</td>
<td>1,250,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,000</td>
<td>55 47</td>
<td>1,512,500</td>
<td>almost doubles</td>
<td></td>
</tr>
<tr>
<td>1,000</td>
<td>60 52</td>
<td>1,800,000</td>
<td>kinetic energy</td>
<td></td>
</tr>
<tr>
<td>1,000</td>
<td>65 55</td>
<td>2,112,500</td>
<td>at any weight.</td>
<td></td>
</tr>
<tr>
<td>1,000</td>
<td>70 60</td>
<td>2,450,000</td>
<td>1.96</td>
<td>1.0</td>
</tr>
<tr>
<td>1,200</td>
<td>50 43</td>
<td>1,500,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,200</td>
<td>70 60</td>
<td>2,940,000</td>
<td>1.96</td>
<td>1.2</td>
</tr>
<tr>
<td>1,300</td>
<td>50 43</td>
<td>1,625,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,300</td>
<td>70 60</td>
<td>3,185,000</td>
<td>1.96</td>
<td>1.3</td>
</tr>
<tr>
<td>1,400</td>
<td>50 43</td>
<td>1,750,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,400</td>
<td>70 60</td>
<td>3,430,000</td>
<td>1.96</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Compare 1,000 lbs at 50 mph and 1,400 lbs at 70 mph

Kinetic Energy: 1,250,000 3,430,000 = 2.744

Though weight and speed are within limits, higher speed increases kinetic energy by almost three times!

Excerpt from an Internet Article on Hypoxia

Oxygen

Oxygen Flow Requirement = 1 liter per minute for each 10,000 feet.
New surge or pulse systems lengthen endurance of bottled oxygen for low demand use.

Nitrogen Considerations.

There is a new breathing problem with the advent of the high rate of climb of 250+ horsepower, non-pressurized homebuilts.

Sustained rates of climb in excess of 2,000 feet per minute are possible with the Glasair and Lancair type of aircraft. Total time to climb to 20,000 feet can be less than 10 minutes. The problem here is that the average person’s body cannot adapt to that change of altitude in that time period.
It takes at least 20 minutes for the body to adjust to that change. The problem is nitrogen gas bubbles in the body. This is called "the Bends", the same problem that can occur in deep sea diving. Extreme pain can occur and if nitrogen gas bubbles occur in the brain, death can result. Climbing to 25,000 feet increases the possibility of the bends even more. Some people may make it to 20,000 feet OK, but an even greater number of people may not make it to 25,000 feet in short time periods. To make things worse, there are no FAA requirements or recommendations about the effects of high rates of climb.

Hopefully the FAA and the manufacturers of these aircraft will advise pilots about the problem. There are two ways to solve the problem for most situations. One is to limit the climb rate to 20,000 feet to less than 1,000 feet per minute. The other suggestion is to start using oxygen as soon as you start the engine, and let your body start adapting sooner.

---------------------------------------------------------------------------------

Oxygen

"They" say that medical oxygen has more moisture in it. That is partly true.

The oxygen going to a hospital bed is plain oxygen that comes from liquid oxygen. At the bed location, there is a unit on the wall that adds moisture. At this moment, it becomes medical oxygen.

If the oxygen is in a pressure vessel or in a manifold system (like inside a hospital) then it is regular oxygen. The cost of medical or welding oxygen is normally much less than the oxygen you get at an airport.

In the San Diego, CA area, to refill a small oxygen bottle costs:

- Aviation FBO on Airport $26 ("Labor cost," they say.)
- Welding supply $15
- Medical oxygen source $11.50

Medical sources require a prescription to dispense oxygen. The medical supplier in San Diego accepted the prescription, then said I could get only one fill for the one prescription. They interpreted the instructions for "using as needed" to mean amount of oxygen flow. The next prescription (good for one year) must state 99 refills, the maximum number of refills permitted during the next year. To refill in another city, I must have a separate prescription to present for each refill.

A welding source must fill the bottle through a non-medical valve. Apparently, the bottom line about the different suppliers of oxygen is in the insurance liability of the oxygen supplier. The gas is the same but the insurance liability is different.
The suppliers of welding oxygen state that the purity level required for welding and cutting purposes is more critical than for breathing.

Aluminum oxygen cylinders should be hydrostatically tested every 5 years. The hydro test cost at a San Diego, CA welding supply center was $13.50 (October 2002).

Steel cylinders are usually tested every 10 years. Specially constructed oxygen cylinders could have a shorter period for hydrostatically testing. There could also be a limit on how long the cylinder may be used when it was supplied as original equipment with a factory installed, built in oxygen system. Most cylinders can be used indefinitely. However, some aircraft may be required to replace the cylinders after 25 years. Factory supplied built in oxygen systems will have the necessary maintenance information in the aircraft manual.

Around the neck of the cylinder are letters and numbers stamped into the cylinder. Of importance to the pilot are three items.

1) At the beginning of the numbers are the letters, DOT. This indicates that the cylinder has been approved by the Department of Transportation, which means they can be commercially filled. European cylinders may not have the DOT stamped on the cylinder. This could prevent the cylinder from being refilled in the USA. Owners of imported aircraft from Europe should be aware of this problem.

2) After the DOT label, there will be 4 numbers. These indicate the rate cylinder pressure; 2015 and 2216 are common.

3) After the end of all the numbers will be two numbers followed by a letter that looks like an inverted capital A and then two more numbers. This is the date of manufacture of the cylinder. The first numbers are the month (03 for example would be March) and the last two being the year of manufacture (96 for would be for 1996).

The date testing required is based on this date, not when the cylinder was purchased.

WARNING:

An instructor warned against the excessive use of lipstick and Chapstick type material on lips when using oxygen. He also said the you should not eat peanuts during the use of oxygen. In both cases, the excess oil along with ignition by a static electricity spark could cause a potential reaction with oxygen. This reaction is called "fire".
CONDITIONAL INSPECTION – LONG-EZ

N __________________ Date ______________ Expires: ____________________

PREPARATION

Remove:
- Canard
- Cowlings
- Wheel Pants
- "Hell Hole" Cover over Main Gear
- Wing Attachment Covers
- Propeller Spinner
- Propeller Bolt Safety Wires

FUSELAGE

Lights – landing, position, and strobe ________________________________
Drag Brake _______________________________________________________
Pitot Tube _______________________________________________________  
Fuel Vents, clear ____________________________________________________
Fuel caps and seals, lubricate “O” rings _________________________________
Canopy Hinges ____________________________________________________
Canopy seals _____________________________________________________
Static ports and system _____________________________________________
Nose bumper – secure ______________________________________________
Dry Lubricate nose gear friction plate _________________________________
Check nose wheel shimmy dampener (2-4 pounds) ______________________
Check paint cracks and cause _______________________________________
Rudder and cable connections (Rudder throw – 2.1 inch maximum) ______
Elevator trim friction and cables ______________________________________
Aileron and rudder hinge pins _________________________________________
Thump test (use $0.25) - delamination of fuselage, wings, and canard ____
Brake line and cables ______________________________________________

CABIN AND COCKPIT AREA

Clean interior ______________________________________________________
Seat belts – check security and wear _________________________________
Upholstery and headrest ___________________________________________
Instruments operational ______________________________________________
Liquid Compass – add mineral spirits or kerosene _______________________
Warning system – canopy latch and gear _____________________________
Canopy latch operation (Check safety catch) __________________________
Have second person check each canopy latch for correct movement and no binding.
Flight Controls, check for play and lubricate _________________________
Fuel valve – ease of operation and leaks _______________________________
Fuel sight tubes ________________________________
Rudder/brake cables and connections ________________________________
Battery connections/corrosion and fluid level ________________________________

WINGS
Check wing bolts ________________________________
Check spacing washer(s), if any ________________________________

ENGINE AREA
Oil leaks ________________________________
Fuel leaks ________________________________
Fuel filter ________________________________

Cylinder compression: 1 - ________ 2 - ________ 3 - ________ 4 - ________

Engine Oil
Change (oil and filter) ________________________________
Analyze oil sample ________________________________
Check screens for metal ________________________________

Drain carburetor sediment bowl ________________________________
Clean fuel strainer bowl ________________________________
Carburetor screws – 40-50 in. pounds; Carburetor drain plug – 144 in. pounds
Brake fluid – fill reservoirs ________________________________

Engine Mounts:
Secure ________________________________
Free of Cracks ________________________________

Engine Controls – cables and adjustments
Throttle ________________________________
Mixture ________________________________
Carburetor Heat ________________________________
Hoses ________________________________
Clamps ________________________________

Air Filter – replace ________________________________
Vacuum Filter ________________________________

Engine Baffles ________________________________

Spark Plugs (Clean and gap or replace - Spark plug gap - .017”) __________
   Spark plug torque – 420 inch pounds
Cowl Mounting – Replace worn nut plates and screws ________________________________

Exhaust System
Springs, pipes, supports ________________________________
Valve cover – Rocker box screws – torque 50 inch pounds ________________________________
Check and adjust valve tappets - .008” hot; .010” cold ________________________________
   Valve gaskets (20 inch pounds torque)

Landing Gear
Wheel pants secure ________________________________
Gear tabs and mounting bolts ________________________________
Gear spread and track

- Wheels: Wear and pressure (5.00x5/10 45 lbs. pressure; nose also 45 lbs.)
- Wheel bearings, clean and grease (three wheels)

**Nose Gear**
- Retraction
- Check down lock
- Clean and grease cam track
- Dry lubricate pivot axle
- Check nose wheel well doors
- Check shimmy damper friction (2-4 lbs.)

**Brakes:**
- Clean and check pad wear within 0.1-inch
- Clean and dry lubricate brake cylinder pins
- Check line from master cylinders to wheel

**Canard and Elevator**
- Check hinges for corrosion, wear, and lubricate
- Check canard attach bolts
- Check attach tabs for corrosion and cracks
- Canard alignment pins
- Canard opening seals for clearance and fit

**Propeller**
- (See Bruce Tifft information sheet, **Paragraph 6.4** above for wood prop repair hints)
- Inspect for cracks and nicks
- Check balance and track
- Check blades and hub for cracks
- Check spinner for alignment and cracks
- After reinstalling spinner, check run out
- Check engine flange, extension, and bolts
- Tifft prop – torque 180 inch pounds (15 ft. lbs.)
- (Up to 350 in. lbs. on one side for track alignment)

Follow your prop manufacturer’s instructions

**Electronics**
- Check operation
- Clean/check connections and plugs
- Check VOR/ILS accuracy
- Transponder check
- ELT check operation and replace battery (24 months)
- Marker beacon (sensitivity, beacon lights, dim/bright)
- Intercom operation
- Instrument and panel lights
Inspect wiring for loose connections, corrosion, and wear ____________

Documents Required
- Weight and Balance ____________________________________________
- Aircraft Registration __________________________________________
- Station Radio License _________________________________________
- Pilot’s Operating Handbook ____________________________________

Miscellaneous
- 24 month check - static system, VOR, ELT, altimeter _____________

Time: Total Airframe _______ Total Engine _______ TE since OH _______

Date Inspection Completed: ________________________________

Signature: _______________ Number: ____________ Name: _____________