There has always existed a rare and good thing in aviation in the form of cooperation and sharing of information among technical artisans. As our treasured Bonanzas age, this extensive network becomes even more important. We owe a great deal to the dedicated, talented and generous people who help keep us safe and comfortable in our aging fleet.

WINDOW WISDOM

BY DENNIS WOLTER, CINCINNATI, OHIO

Imagine asking someone what time it is and then having to endure a dissertation on how to build a watch—clearly more information than you need. As I pondered how best to present the complex subject of Beech windows, my first inclination was to touch only on the highlights. Then I thought that would really be a disservice to Beech owners.

Since several good articles have already appeared in the magazine on specifics of the broad subject, I think it's time to bring the entire scope of this information together.

Another motive for taking an in-depth look at this subject is that—having been a very active Beech window installer for more than 30 years—it has become apparent to me that an endless supply of misinformation is floating around on the subject. Hard lessons learned need to be shared. I hope my years of experience in installations and product research will be of benefit to fellow members.

It's important to mention at the get-go that there is usually more than one way to skin a cat, and the cliché definitely applies to installing aircraft windows. I have no doubt that other technicians have come up with their own very effective installation methods.

A little later I will expound upon some of the tricks of the trade, many of which we have developed here at Air Mod, and also many that have been suggested by manufacturers and other installers.

Due to the complexity and physical characteristics of Beech windows, their installation has never been a profitable part of the business of our company. Installing windows is labor-intensive, skill-demanding and, at times, precarious to execute.

OK. Now I'll step down off my soapbox and we can get started on the topic of what Beech windows are made of and how they are installed.

To properly understand this topic, we will examine the material itself (Plexiglas), review the wide variety of window options, and outline a plan to follow for window installation. Then we'll share some techniques and point out some shortcuts you should avoid. Once installed, you should know the best way to maintain your windows. If you decide you'd rather keep the windows you have, we'll also suggest some ways to restore and protect them.

Why Plexiglas?

As with most design/engineering choices, research, experience and compromise lead to the best solutions. All things considered, acrylic (Plexiglas) is the best material for most aircraft windows for a number of reasons:

STRENGTH Acrylic plastic has a very high strength-to-weight ratio. Thanks to this high tensile strength combined with its flexibility, acrylic can deflect an impacting object, giving it good impact and crack resistance.

FORMABLE When heated, acrylic becomes very fluid. With skill and patience, it can be heated to approximately 350° and formed to almost any reasonable shape. Once cooled, it is quite stable and strong.

DURABLE As clear plastics go, acrylic is one of the more UV-tolerant materials out there. Sunlight, more than age, degrades most plastic materials. With proper care and storage (avoiding the sun), acrylic windows can last 30 years or more.

HIGH QUALITY OPTICS Quality aircraft windshields and windows are made from cell-cast acrylic sheets. This material is fabricated by pouring 100 percent clear or tinted acrylic plastic between two pieces of plate glass and allowing it to cool.

Lesser grades of clear plastics (lexan, styrene or low-grade acrylic) can be extruded or rolled into sheets, but this method reduces the molecular stability and optical qualities of the finished product.

THERMAL STABILITY—TOLERANCE Almost all materials expand and contract as they heat and cool, and plastics are some of the more thermally active materials we deal with. Acrylic happens to be fairly low on that thermally active scale, making it favorable for use in airplanes.

It is very important that, when machining and fitting this material, mounting holes are enlarged and slight clearances are maintained between the window and its mounting frame to allow for thermal changes between -40°F to +160°F.

WORKABLE I love machining acrylic. With proper cutting, drilling and polishing tools and techniques, one can do wonders with this stuff. Two of my quarters in college were spent at a co-op job building technical models for NASA, GE and Boeing using - guess what - Plexiglas! We milled it, turned it on lathes,

heat-formed it and even made a windshield for my motorcycle. (That part didn't count toward my grade.)

ABRASION RESISTANT When it comes to scratch-resistance, actual glass would be the better choice, but it's too heavy and unfriendly to being formed into large compound shapes like Beech windshields—and it is inflexible. With proper care, however, formed acrylic is hard enough to remain relatively scratch-free for years.

CHEMICAL RESISTANCE When compared to similar clear plastics such as styrene or polycarbonate (lexan), acrylic is reasonably tolerant to flash exposures to aviation fuels, cleaning solvents like mineral spirits or naphtha, and airborne pollutants. Recurrent or prolonged exposure, however, could cause permanent damage. Detergents, alcohol and approved polishes are completely safe to use.

REPAIRABLE If you do scratch Plexiglas, the surface can be buffed to like-new condition. If it cracks, bonded repairs (though unsightly) can be made, allowing the aircraft to remain in service. Although windshields and windows are not load-bearing, serious aerodynamic problems would occur if a windshield would depart the airframe, so take care of those cracks.

We've made a pretty good case in defense of using acrylic as the ideal material for these windows, but we acknowledge that nowhere do the adjectives "perfect" or "fool-proof" come into play. As we later discuss installation and maintenance of windows, the limitations of this material (all quite manageable) will become obvious.

Let's take a look at how Beech installed windows in the Bonanza family of airplanes. Having installed windows in everything from J-3 Cubs to Sabreliners, I can state without reservation that Beech windows are installed in the strongest way using the highest quality methods employed by light aircraft manufacturers. That's not to say that the others are inferior but, in their tradition of quality, Beech really did go the extra mile. As might be expected, better isn't free, and in most cases Beech windows are more labor-intensive to fit and install.

Methods of installation

Five basic methods of installation were used by Beech to originally install the various windows in Bonanza-type airplanes:

1) The separate frame method. Windshields, pilot's windows and cabin door windows are installed using a two-piece formed aluminum frame that is bonded to the inner and outer surfaces of the glass with a very strong catalyst-cured rubber sealer (PRC). Once the sealer is applied to the window's perimeter, the metal frames are brought together at the window's edge and permanently attached to one another with electric spot welds. The window and frame assembly is then mounted in the airframe using rivets or machine screws.

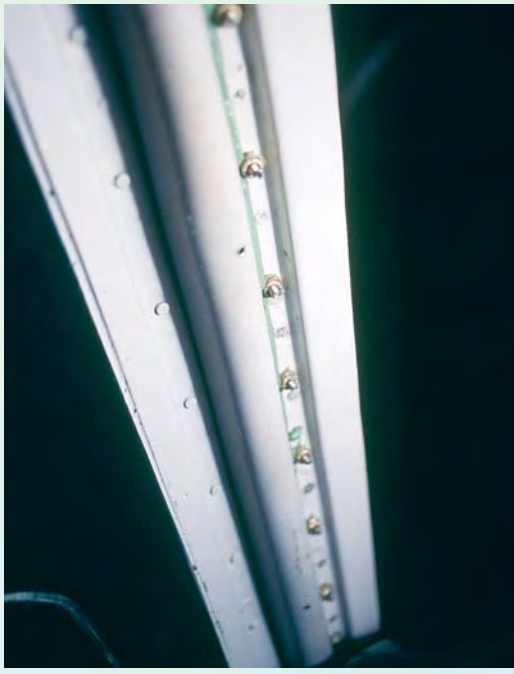
There are three distinct advantages to this method:

(a) The window floats in a strong but flexible seal, eliminating leaks and stress points caused by direct plastic-to-metal contact.

(b) This installation eliminates having to drill holes in the plastic, reducing the potential for cracks and leaks.

(c) The metal frame allows for a strong metal-to-metal mounting of the window assembly when secured to the airframe using rivets or machine screws.

2) With the exception of early 33s and 58Ps, center-opening windows are bonded and mounted to a similar but slightly thicker metal frame as used in the previous description. The similarity ends there. Instead of being permanently riveted to the airframe, these framed windows have a piano hinge riveted to their top edge, allowing them to pivot open for emergency egress or ground ventilation.

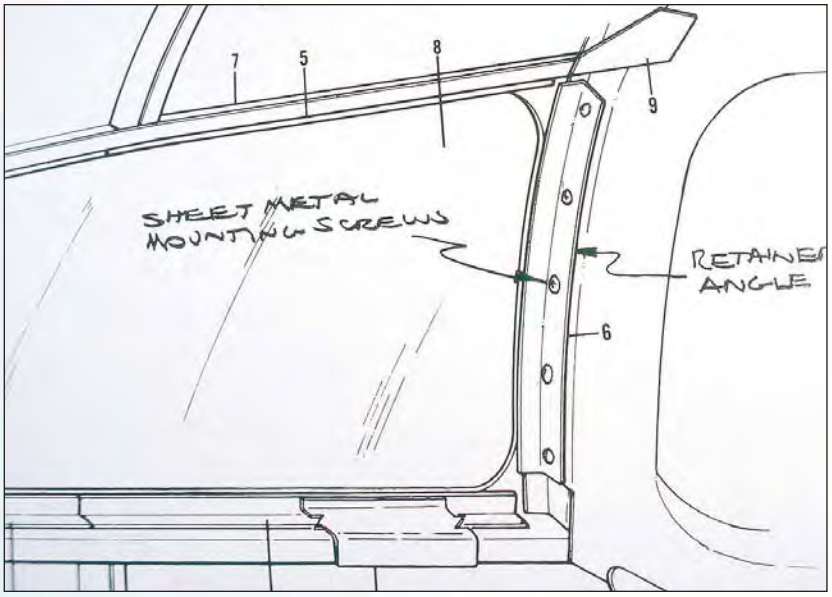


(1) Original frame-type installation showing shakeproof nuts holding the framed windshield assembly in place.

(2) End view of the center-opening window frame showing the 3/32" rivets used to fasten the inner and outer frame sections together.

Due to the realities of drilling holes in acrylic and the potential for cracks, there has always been an ongoing debate as to the best installation method. The bottom line is probably what the installer feels most comfortable with.

(3) Forked inner frame mounted window in an A36 cargo door. shows the 3/32" (on center) flush rivets holding the inner frame snugly against the window.



(4) Long third window mounted with all internal angles and screws—no hardware through to the outside of the airframe.

3) Early 33s have nonopening center windows permanently mounted to the airframe using a formed inner frame that is through-riveted to the airplane and sealed with catalyst-activated rubber sealer. This system is also common to the aft four windows in A36s, nonpressurized 58s and the small triangle-shaped third windows found in E thru M35, early Travel Airs and early 33s.

4) The large teardrop-shaped third windows common to post-1961 airframes are the easiest to install. These windows are pressed firmly in place by a number of formed .050" aluminum retainer angles, held in place with sheet metal screws. The screws are attached to the load-bearing structure that forms the frame of the window opening. Beech sealed the windows with either a nonhardening chromate putty or the catalyzed rubber sealer.

Here's a good one on the Beech factory: During the late '70s and early '80s, Beech installed these windows without removing the protective paper that had been applied to prevent damage during shipping (I think they did this to save masking time before painting). Definitely a big mistake! In time, ultraviolet light lensed in behind the frame and degraded the paper, releasing the window from the sealer, causing leaks, corrosion and related upholstery problems.

5) Windows in pressurized 58s, and the front three windows in current production 36s and 58s, employ the frameless direct-mount method that requires drilling 1/4" stress-relief holes near the windows edge, then mounting the windows to the airframe using machine screws and nuts. This installation requires the use of the catalyzed rubber sealer as well. Many after-market STC'd window manufacturers prefer this method of mounting.

Since the windows are held directly to the airframe with screws, an argument can be made that this installation is somewhat stronger than the frame-type installation depicted in Photo 1.

(5) Direct structural mounting method showing 1/4" holes drilled near the window's edge. Mounting hardware and sealer can also be seen in this photo.

Due to the realities of drilling holes in acrylic and the potential for cracks, there has always been an ongoing debate as to the best installation method. The bottom line is probably to use the method the installer is most comfortable with.

I definitely prefer reducing the risk of cracks by using framed windows. It takes a little longer, but we have yet to get one back for a warranty claim.

A PLANNING NOTE: Due to extensive thru-the-airframe fastening, new windows should definitely be installed before new paint.

Next month, we'll finish our dissertation on windows by covering various installation methods and tricks of the trade in total detail. Armed with all of this valuable, interesting (?), information, you can form your own opinions as to what method is best, and jump in with the best of them the next time the debate comes up at a weekend hangar get-together.

ABS member Dennis Wolter started Air Mod in1974 to bring innovative design and high quality renovations to the general aviation market. Dennis, his wife Cynthia and 10 dedicated employees complete about 40 renovations each year at their facility on the east side of Cincinnati. Dennis has a degree in industrial design from the University of Cincinnati. He is an A&P, IA and a 3,000-hour instrument-rated pilot.