Renovation:

Seats

By Dennis Wolter

We finished last month's article with the interior and insulation removed from the airplane. Before going any further with our renovation, I would like to include something here that perhaps should have been mentioned last time. I believe that it is important to have in place a job start-up outline that we, and you, should be very committed to following.

1 Stay organized. Have a parts identification and storage system in place from the get-go (we did talk about this last month).

2 At project start, pre-check everything in the airplane for fit and function before any of the interior components are removed.

3 Take notes and/or pictures of how it all goes together, especially small details such as seat belt attachments, door handles, etc.

4 Weigh components as they come out, and again just before they are reinstalled. Even small changes add up, and proper weight & balance records must be maintained.

5 Save invoices, packing lists and FAA paperwork so that proper logbook entries can be made.

With the above list in place, it's back to the job.

Now that the cabin is gutted out and all those interior components are organized and evaluated, it's time to start on the next step. Where to start is the big question. At Air Mod, we like to start with seats. Bringing the seat frames and mechanisms up to like-new condition will often require the ordering of some factory parts, or possibly sending a back or a base to a professional welder to repair a crack. This outside parts ordering and subcontract work usually means some loss of our timeline control, so it's a good idea to start here to avoid unnecessary delays. The good news here is that Cessna is very good about supplying replacement parts.

Like Rodney Dangerfield, airplane seats don't get much respect. The FAA says otherwise. The laws of physics will tell you that the condition of seat structures and their mechanisms can play a huge role in the event of an accident. History has shown that many serious accidents have actually been caused by a seat failure. For example, you're at 60 knots, and just as you rotate the seat stop lets go, or a worn seat back reclining mechanism fails, and there you are, nose up at low speed with no altitude. As you fall back, you inadvertently pull the yoke as you head for the back seat. I'm sure you can visualize the rest. Believe me, you will run out of airspeed, altitude, and ideas very quickly.

Checking seat frame and mechanisms (this can also be done in the airplane).

We frequently find unairworthy things in these seats, often right after the airplane has just come out of an annual inspection (I have yet to see an annual signed off by Rodney Dangerfield). For some reason, seats don't seem to be a high priority inspection item. Ask your mechanic to take a close look at your seats at every annual. The FAA considers seats to be primary structure. Anyone who has asked the FAA for a field approval to build a seat back taller will quickly realize just how important the seat structures are; the FAA requires extensive engineering and testing to modify a seat frame.

With the seat frames completely stripped, reattach the back and base and install the seat on the seat rails in the airplane. We have test rails mounted to a work bench for this purpose. Carefully inspect every moving part for condition and function, paying very close attention to the seat stop pins and linkage. Also pay particular attention to the seat stop spring. This is a very special, high strength spring that we often find to be either incorrect (ie: hardware store type) or so old that it has lost much of its tension. This may prevent full engagement of the seat stop pins.

Some years ago, Cessna realized that their seat latching system, especially the earlier single pin types, could be better.

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Old thrust washers on left, new teflon washers pictures at right.

As part of their safety enhancement program, Cessna offers a secondary seat latching kit that greatly enhances the seat stop system. Basically, it's a notched rack system that bolts to the inner side of the pilot's seat. This notched rack engages a spring-loaded paw mechanism that bolts to the floor. The system allows the seat to freely roll forward on the rails, automatically locking firmly in place when the desired seating position is reached. To slide the seat aft you must pull the original stop release handle while reaching down with your right hand to release the stop paw on the floor. Simple, light, inexpensive and very reliable.

I commend Cessna for this and many other safety enhancing systems for their older airplanes, and here's the best part. The prices for and the availability of these kits are very reasonable. I wish some other manufacturers would follow Cessna's lead on these all-important safety issues!

Another issue that almost always needs to be addressed deals with the plastic thrust washers that are located at the inner and outer edges of each seat roller. These plastic washers have two functions. First they act as a low friction guide to help keep the seat rollers and the locking pins centered on the seat rails. Second, they serve as an anti-abrasive member, eliminating metal to metal contact between the seat frame foot and the aluminum seat rail. Cessna fabricated the original washers from the same material they made the plastic window frames from. Need I say more? When it comes to durability, these things don't stand a chance. In very little time they become so worn that the seats are wobbling down the rails as the steel seat feet are scraping material off the side surface of the rails. Off to the landfill for these bad boys, and on with new and infinitely more durable FAA-approved Teflon washers, available from Beuco (800-325-6163). They come eight to a bag for about $1.50 each. You will need two bags, or 16 washers, for a 172 or 182.

While you're looking at all of this, it's important to check the seat rails themselves for worn holes and cracks. Check the applicable AD notes for your airplane for specific details.

Next we check the seat back reclining mechanisms. Over the years, Cessna used three very different mechanisms to recline their various types of seat backs.

The earliest system is a cam and paw system that allows for four different seat back angles. Inspect the four position cams for missing or damaged teeth and the locking paws for spring tension and paw wear. These mechanisms must be in good condition since you rely on the integrity of the seat back to hold you in place in an accident. The second type of reclining mechanism is a jack screw crank type system common to most articulating seats. This system employs a bell crank located at the point where the seat back attaches to the base. The purpose of this bell crank is to allow the seat back to lean back as the occupant turns the reclining crank. The concern here is that these bell cranks are made of 4130 chromoly steel that tends to crack at the two mounting holes that attach this bell crank to its actuating shaft. The third and least common reclining system is the hydraulic type. This is a very reliable system that uses a controllable hydraulic cylinder to allow for the seat back to be reclined through a wide range of motion and to be positioned at any angle whenever the reclining handle is released. The main thing to look for here is evidence of fluid leaks in the hydraulic cylinder. If a leak is detected the cylinder can be sent to G Nichols Co (810-329-7083) for rebuild.

Worn seat track stop hole

Those of us who have the vertically ad-

Damaged reclining cam

justable articulating seats know that, over time, they seem to develop a lot of play in them to the point that they are quite wobbly. To correct this condition, several issues must be addressed.

First, the two jack screws that actuate vertical and seat reclining functions are meant to be shimmed so there is only a few thousandths of an inch of longitudinal play in them. To reshim these jack screws one must remove the roll pins that hold the jack screw assembly together and disassemble the shaft. Then shims can be added to eliminate the excessive play in the mechanism. Next check the clevis pins that hold the reclining and height linkage together. Any excessive play at these points is eliminated by reaming the holes to the next largest pin size.

Another source of play is in all the roll pins that are used to hold the seat and its mechanisms together. Again, the fix is to drill the holes larger to accommodate a larger roll pin. We think it's a good idea to also secure the roll pins with safety wire – an ounce of prevention is worth a pound of cure.

Now for the biggie. The height adjustment is facilitated by two large span wise shafts (1½" diameter) that rotate in the main frame. Seems like no one ever lubricates these shafts where they pass through the cast aluminum mainframe. If the wear at these points is excessive, the only fix is to remove a seemingly endless number of roll pins, disassemble the seat, take the frame to a machine shop, press in and ream a bushing to recreate four new standard diameter holes, and put the whole mess back together. No one said it would always be easy! A little lube at every annual will eliminate this problem to start with.

If all the above steps are taken and new Teflon rollers and thrust washers are installed, you will have wiggle free seats that glide along the rails and latch with ease.

With the seats still on the rails, the structural integrity of the frame must be determined. Every tube, weld and piece of hardware must be inspected for condition and possible cracks. We've even had to replace seat frames that were severely compromised by corrosion caused by improper flame treatment of the old upholstery material.

Cessna fabricated their seat frames from both aluminum and 4130 chromoly steel tubing. Cracks in aluminum seat frames must be heliarc welded. This is a job for a professional.

1 If a steel framed seat needs a welded repair, use a professional welder.

2 Mig or tig welding is best, as these methods allow for better heat concentration, resulting in a stronger and more controlled weld.

3 Use the correct materials and welding rod alloy. You can weld almost any ferrous material with an old piece of a coat hanger, but the tensile strength of coat hanger wire is a fraction of that of an appropriate, high-tech welding wire. It's all about the weakest link!

4 Get an FAA approval. If a new seat latch is not available from the factory, for example, and therefore must be fabricated, it can become an approved part by following the procedure in FAR 21-303, paragraph B2, "Parts produced by an owner or operator for maintaining or altering their own product" (cus-

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Badly worn paw

tomer-approved parts). What, you ask? – I can have my own parts approved? Yes, you can. The FAA realizes that perfectly airworthy, older airplanes shouldn't be grounded for the need of an out of production component that can be properly fabricated in the field. The owner submits a signed request to a qualified A & P or FAA-approved repair station, asking that the component in question be fabricated as a duplicate of the original. The mechanic or repair station must then research the component as to original design, material, function, fabrication process, etc, and produce the part accordingly (everything must conform to AC 43.13-1B). This data is included in the resulting logbook entry with a reference made to the owner's request. Such a deal!

Fortunately most structural seat repairs just involve repairing a crack in the frame. However, he is wise who goes beyond

Point of frequent cracks in reclining bellcrank

simply welding the crack. Analyze why the crack occurred in the first place and add additional reinforcement to keep it from recurring. Often it's as easy as adding a corner gusset. For those of you doing this work yourselves, the inspection and repair of seat frames and mechanisms definitely goes beyond the scope of owner performed preventive maintenance. Once you have stripped the seats down to their bare frames, give them to your A&P/ IA and let him handle this part of the job. It's money well spent and you still have plenty to keep you busy with the rest of the interior.

If the customer has chosen to have their seat backs built taller as an alternative to using headrests, these components go from our sewing room back out into our hangar or "shop". The seat back extensions we make for most seats are permanently installed, semi-monocoque .050" aluminum structures, secured with aircraft cherry max rivets – very strong! This process does require FAA approval involving a pull test witnessed by an FAA D-ER (designated engineering representative). Be very careful when having a seat extension done. I receive several calls a year from owners who either have had this done without an approval, or who have been told by someone that

Hydrolock type of reclining mechanism - great system!

an approval is not required. It's a scary world out there.

Here's the reason for requiring an approval. As mentioned earlier, a failed seat back can lead to serious consequences, either during normal operation or during an accident. Accordingly, the FAA has a "reaction load test" that all certified seats must pass to verify the structural integrity of the seat back. Basically, one must pull the seat back with a 200 lb force, as measured by a calibrated scale halfway between the mounting point at the base and the structural top of the seat. If you extend the top by 8" you must raise the test point by 4" (more leverage equals more stress at the mounting point).

Prior to 2002, the FAA permitted their airworthiness inspectors to witness the pull tests, and issue a field approval for this seat mod. But the rules changed in 2002, and the FAA now requires a DER study and approval. This means a full engineering drawing of the seat back and proposed modification must be made, with complete materials identification and call-out. Using this drawing, the DER performs a structural analysis of the modified seat back, and submits the data to an FAA engineering office for a test plan approval. Then the DER must witness the pull test and, if successful, issue an FAA 8110-3 form. This approval document accompanies the FAA

337 form, a copy of which you keep and a copy of which is submitted to the local FSDO. Some things were definitely easier in the good old days!

Before building and installing new seat foam we install a new sling. Open frame seats (common to most light aircraft) employ a stretched canvassling system to attach the foam to the seat frame. In time, the canvas stretches, the glue tends to let go, and the sling, along with the seat occupant, sags into the frame. Eventually, you will begin to feel the frame pushing into your derriere (not exactly desirable). Since we go to great lengths to build an ergonomically correct seat shape, a sagging sling represents even more of a problem. If the sling sags an inch or inch-and-a-half after a year or so, all of that carefully planned seat geometry is going to be in the wrong place, and your body parts will be unhappy.

Jack screw shims for crank type of seat adjusters

Seat back attach point compromised by severe corrosion

The best system we've developed is to stretch two lengths of seat belt webbing drum-tight fore to aft on the seat bottom, securing the webbing with contact cement and hog rings at both ends. Then, using heavy Dacron canvas, we stretch a new sling. You now have two structural members holding the foam in place – light, durable and reliable (we like to keep the weight down!). In over thirty years we have yet to have one failure. Since there is far less pressure on a seat back, only a new tightly stretched Dacroncanvas sling is needed.

Before diving into how to build seat foam, we should first discuss the foam itself. There are two types of flame retardant foam commonly used on light aircraft seats: multi-density urethane foam and thermal-elastic foam (temper foam). The most common is urethane foam. It's lightweight, durable and available in multiple densities and thicknesses. Density refers to resistance to compression. Light density foam is very soft, compresses easily and is used as a top layer to give the component a soft and plush feel. Heavy density foam is used for base builds and high-load areas such as overhangs and corners. Medium density foams are used for general shape building, lumbar and thigh shapes. These densities are rated 20 for light, 40 for medium and 60-70 for firm. Since we have the option of measuring a person for a custom seat build, multi-density urethane foam is the material

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Riveted natural seat back build

of choice. It gives you precise control and support based on the physical dimensions of the seat's occupant. Urethane foam seats that are properly built to the "standard measure of man" are very comfortable for 90% of our population. We usually build the pilot's seat to fit the owner pilot, and the remaining cabin seats to fit that standard measure. We also will custom-build the co-pilot seat for a spouse or partner if requested by the customer.

Thermal elastic foam, or temper foam, has been around since the sixties. I think the two neatest materials I got to work with during NASA projects in college were velcro and thermal elastic foam. Thermal elastic foam can be used to fabricate a comfortable seat for a wide range of human shapes and sizes. But it is more expensive, heavier, less durable, and cannot give the precise support that can be obtained with multi-density urethane foam builds.

Thermal elastic foam is available in various densities indicated by color: green is heavy density, blue is medium, pink is light. When we are faced with fitting a very tall person in a seat, a combination of multiple densities of urethane and temper foam really works. If you are doing your interior yourself and are unsure of your ability to build an ergonomically correct seat, temper foam is probably the way to go. It will form to the seat occupant's shape with heat and pressure. If you fly your airplane in the mountains, or in and out of unimproved airstrips, consider thermal elastic foam for the seat bases. This material compresses at a very controlled rate, giving an extra measure of energy attenuation and perhaps reducing the possibility of a back injury. These materials are available from Skandia, Oregon Aero and Aircraft Spruce. All of these materials must pass FAR 25.853a, meaning they will not support combustion. The interior becomes part of the fire prevention, rather than fire support system – big safety enhancement!

For cutting foam, we and other professional shops use fast cutting foam knives that are prohibitively expensive. For a one-time user, an electric kitchen knife will do the job. It's slower going, but with a little patience and practice you'll get there.

Gluing the foam together presents another challenge. We use 3M #051135-08046 trim adhesive, available through automotive and upholstery supply houses. Don't even consider brushing this adhesive on foam. You will apply too much, and it is quite difficult to evenly spread this product over the foam's surface with a brush. We bought an expensive glue pot, but you can apply glue yourself with an inexpensive spray gun. It should hold about a quart of glue, doesn't clog up, and with a little practice you can do a beautiful job of evenly applying just the right amount.

In building the seat, we obviously start with the base foam first. Since most of a person's weight is carried by the seat base, two and sometimes three layers of base foam are needed to ensure proper comfort. We usually start with a 1" layer of firm (density 70), and top that with a 1" layer of medium (density 40). Very little body weight is carried by the seat back, so we usually use a 1" layer of medium foam as the base build for the back.

We now begin to sculpt the seat by adding foam shapes that create the ergonomically correct contours that ensure proper body support. Using the notes taken and drawings made when

Seat back pull test being performed before the seat back is extended taller

we previously fit the customer, we cut the various density urethane foam pieces to very precise contours and dimensions. We then carefully bond these shapes to their intended locations on the seat base or back. The seat slowly morphs into the perfect shape necessary to accommodate the customer's back and lower body shape. How comfortable!

If we are accommodating a tall customer, and desperate for some space between the seat base and cabin top, we will often build the seat base foam using one 1" layer of high-density temper foam for a somewhat heavy customer, or a 1" layer of

New seat sling with strong seatbelt webbing reinforcement - good forever

medium density temper foam if the customer is of average weight. We then build the rest of the foam as described above.

The final pre-upholstery step in the seat process is to paint the seat frames. The hardest part of this stage is cleaning. Our tools of choice are small stiff paintbrushes, mineral spirits, Scotchbrite pads and a compressed air nozzle. Scotchbrite is much better than sandpaper because it can be worked into tight places, and actually sands as it cleans.

We prefer painting the seat frames and other non-upholstered interior trim with acrylic lacquer. It is safe to use, fast drying, durable, repairable, and easily custom-mixed to match any interior color scheme. I do recognize the appeal and durability of powder coating. However, since later Cessna seats contain heat treated aluminum structural parts, there is a concern that the heat required to implement the powder coating process might put the temper of those components at risk.

It generally takes about 30 man-hours to strip, inspect, repair, sling, paint and foam four Cessna seats. A lot of elbow grease, but consider the process to be the foundation upon which a beautiful and comfortable interior is built. If you only plan to install pre-sewn seat covers that you purchased from, say, Air Tex, take the time to add at least some lumber support. Here's your chance for extra comfort. Air Tex (215-295-4115) manufactures high quality pre-fabricated interior kits for the do-it-yourselfers. We've had a great relationship with them over the past 33 years. Dodd and the gang know what they are doing and can mentor you through the installation process. They also do custom installations in Pennsylvania.

With the seats inspected, repaired, reslung, painted and foamed, we are at a good stopping point. Next month it's on to sewing and mounting the finished seat covers. Until then, fly safe!

This photo says it all, from the base foam build to a finished sculpted seat.