Cessna Pilots Association Magazine

May 2006 Cover Story

•Dennis Wolter •1973 Cessna 172M •N4447Q •Cincinnati, OH

EDITOR'S NOTE: The 172M featured on the cover of this month's magazine, is owned by CPA members and advertisers, Dennis and Cynthia Wolter of Cincinnati, Ohio. Dennis and Cynthia own and operate Air Mod, the premium general aviation interior shop in the U.S. The Wolter's designed and installed the custom interior for AOPA's "Better Than New" 172, 182 and 206.

N4447Q was chosen for the cover of John Frank's new "Cessna 172 Skyhawk Buyers Guide", which recently joined a series of model-specific buyers guides published by the Cessna Pilots Association. This buyers guide, illustrated with pictures of various 172s, provides all the information needed to make an educated purchase decision. It's the most comprehensive guide ever written for this model, and could easily save the buyer thousands of dollars. See Page 8416 for MORE information.

Dennis has written the following article about sound proofing piston airplanes, and how far the process has come, when few appropriate materials were available to effectively reduce sound in these very noisy machines in the early manufacturing years.

1973 Cessna 172M, N4447Q
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Soundproofing

By Dennis Wolter — Air Mod

Sound proofing an airplane is an exercise in dealing with extremes. The worlds of academia and industry have experts who know a lot about the characteristics of sound, its quantity as measured in decibels and its pitch as measured in frequency or hertz. Ask most of them how to appreciably reduce the sound level in a given space and often the only significant reduction in sound is the absence of a response from the audio "expert". This silence is actually quite understandable, especially in piston aviation circles because it is a very challenging problem that demands complex solutions, very few of which have been thoroughly evaluated until recently. When I started Air Mod in 1973, I was very surprised to discover how little was known about soundproofing piston airplanes, and how few appropriate materials were available to effectively reduce sound in these very noisy machines.

Piston airplane sound control circa 1973 was maybe a one- or two- inch layer of fiberglass bonded to a tar-backed thin aluminum skin. The only manufacturer to offer super soundproofing at that time was Beech (for an additional charge). A 1/4" layer of early generation aluminum foil-backed urethane foam was bonded to the inner side of all cabin skins. This plus a 1/4" thick windshield produced about a 3 decibel reduction in the cabin sound level, from approximately 93 db to 90 db. Since extended exposure to more than 80 decibels will lead to permanent hearing damage, something else had to be done.

Back to the extremes. This topic can be approached on two very different levels: the ethereal, with its scientific terms and complex mathematics, or the practical, sometimes intuitive level where experimentation, tenacity, hard work, and some science can often lead to good results. Don't worry; I'm not going to explore the ethereal side of this problem. The only one who would be more bored than you reading the document would be me writing it.

With 80 dbs as a benchmark for acceptable and safe sound levels in light piston airplanes, I'll start with identifying two very big problems.

First, in cruise configuration, most single engine Cessnas have a mean sound level of 92-94 dbs at approximately 400 hertz per second at the pilot's ear — a real problem! Second, single engine Cessnas are cursed with having one of the least aerodynamic parts of the airplane located right next to the pilot's and co-pilot's ears. I'm referring to the wingroot area. Add to this the fact that Cessna's engineers decided to install the cabin fresh air inlets at the noisy wingroot. And let's not forget the extra help all the noise gets from these vents also being located directly in the prop blast. Between the rock and roll music of our youth, and our love of Cessna airplanes, it's a wonder we baby boomers can hear at all.

So much for the problem let's get started on the solution. There are three ways to make airplanes quieter inside.

First, reduce the sound at its source. That means quieter engines and propellers, more aerodynamic cabin areas, and less slipstream noise (fly it slower!). Due to implementation costs and engineering limits, changing the engine, prop and cabin aerodynamics is not a practical option, and who wants to fly slower anyway.

Second, keep the sound from getting inside the cabin. That means 1) thicker glass, 2) stabilizing the skins with vibration reducing skin dampers, 3) absorbing sound with sound attenuating insulation materials such as fiberglass, closed-cell foam or nomex, and 4) a more aerodynamically efficient ventilation system.

Third, control the sound that gets into the cabin by using sound-absorbing materials rather than sound-reflecting materials in the interior finish out. That means using more fabric than leather or vinyl on the seats and side panels, thicker carpet on the floors, as much carpet as possible in the baggage compartments, and most importantly covering those acoustically live plastic headliners with stretchy sound-absorbing wool fabric. We also even bond fabric to the back sides of those pesky plastic headliners to achieve an extra measure of sound damping. Works great.

All that being said, here's the bottom line when it comes to soundproofing piston-powered airplanes. The absolute best result we've ever had was to remove 10 decibels from a stock Beech Bonanza, a more aerodynamically clean airplane in the cabin than any high wing Cessna. We installed a 1/2" sloped windshield, 1/2" pilot and 1/2" copilot windows, 3/8" center opening windows and 3/8" long 3rd windows. We also installed later-style fresh air intake scoops with sound muffs on the fresh air tubes, and then painstakingly covered every square inch of the inner cabin skins with expensive frequency- and amplitude-specific composite soundproofing materials (all 28 lbs of it). And last but not least we installed all new cabin door and window seals which were very carefully fit to ensure no leaks.

The reason I'm using a Bonanza as a reference is that it's an easier airplane to work with for a couple of reasons. It is a low wing airplane with the cabin air vent intakes located further from the prop blast, effectively reducing the amount of prop noise that gets into the air system. And all Beech cabin windows happen to be very gently curved, resulting in a greater noise reduction when thicker glass is installed. All side glass in Cessnas is flat, and a flat surface is more easily energized by sound waves. Also Cessna windshields have a flat area right in their centers, unfortunately meaning more vibration and less reduction with increased thickness. I had LP Aero make the first Cessna 172 1/4" windshield for me back in 1979. I initially flew the subject airplane with the original 3/16" windshield and using a digital sound meter I recorded sound levels, power settings, and outside air temperature. After installing the new 1/4" windshield, I repeated the in-flight sound tests with the same meter and identical flight conditions, and guess what? No change. The best we've ever done at our shop with a high wing Cessna is to remove 8 decibels. If most of you were to ride in an 82db Cessna without wearing head phones, you would be happy that it was the quietest single engine piston airplane you had ever flown in. However, if you bought a new car that had a cabin noise level of 82db at 60mph, you would quickly be back at the dealer asking for your money back. (It's worth noting here that a turbo-charged or pressurized airplane will generally be a few decibels quieter.)

The rule of thumb in the sound game is that there is a logarithmic relationship between interior sound reduction and outside noise. In English that means that if you reduce the inside cabin noise by 8db it's the same thing as reducing the outside noise by 64db. It's a tough engineering problem to solve.

Typical corrosion found under the aft headliner of a 1974 172.

One final engineering issue to discuss is weight. Anyone could make an airplane quieter if weight were no object. As things exist today, there are three systems available for consideration in the sound reduction vs. weight increase challenge.

System 1: Fiberglass. A maximum effort using fiberglass will reduce the sound level in the cabin by approximately 4db, enhance the thermal properties of the cabin noticeably and add about 8 lbs of weight to the airplane over the original skimpy factory insulation package.

System 2: Single density, engineered, one-material-for-all-planes systems. This is usually a closed cell, non-hydroscopic (won't absorb moisture) foam material that is applied equally to all cabin skins. This type of system usually reduces the cabin sound level by 6db for a weight increase of about 10-12lbs.

The same 172 cabin top cleaned and chromated.

System 3: An aircraft type-specific system where several different types of amplitude- and frequency-specific materials are applied to the back side of the cabin skins, and the dead space between the cabin skin and the inner upholstery panels. It's quite common for these special systems to also include bonding of a skin damping material to the back sides of the forward interior panels. Here's the kicker: two, sometimes three, different materials must be bonded to the backside of the firewall—all of it. No fun to say the least. To design such a system the study airplane must be flown with the interior components and old insulation removed, every section is measured with a digital sound meter and mapped as to amplitude (db) and frequency (hertz). The engineers then develop both skin dampers and attenuating materials for each area based on test results. With the system installed the airplane is test flown, adjustments are made and re-measured until the greatest sound reduction to weight increase is attained. And for, say, a 210 that's about 82 db with a 26 lb weight increase. Sounds like a lot of trouble for so little gain, but as engineering would have it, the closer you get to the absolute limit of reduction the more difficult the solution becomes. Sounds like the old horsepower-to-speed thing, doesn't it?

As for cost, the fiberglass installations add up to about $150 in materials and usually about 8 hours of labor; total about $600 installed. The one-material-fits-all type of foam packages cost about $600 for materials and 8 hrs of labor, adding up to around $1100 installed. The engineered systems we like (kits available from Skandia, Inc., 815-393-4600) sell for about $1600 for 182-210 series and require 40 hours to install. So that level of quiet will cost you approximately $4000.

So much for the lecture part of this, let's go out into the lab (hangar) and get into the job. I'm going to go though the installation of the fiberglass system and the Skandia high-end system. Since the installation method of the middle system is so similar to the fiberglass installation, all bases will be covered.

Before thinking about installing new insulation, it's mandatory that you prepare the inner cabin skins. It is absolutely imperative that all of the old insulation, lead vinyl panels, glue and corrosion are thoroughly removed from the skin and a well-bonded layer of zinc chromate is applied to every nook and cranny of the entire cabin area. We like to use Tempo A7-6889A avaition chromate, available from Aircraft Spruce or Wag Aero. It will take six cans for a 172, eight for a 210.

The subject of aircraft corrosion and its removal and prevention, particularly in Cessna cabin areas, is rather extensive, and I will do two or three articles on this subject in the future.

With the inner cabin cleaned and chromated, it's time to install the fiberglass insulation. I think the best bang for the buck is to use a two-part system. The method of installing this two-part system is first to bond a 5/8" thick, semi-rigid, somewhat dense fiberglass layer directly to the now clean and chromated skin. We have found that Owens Corning fiberglass ceiling tiles (with the vinyl finish layer removed) are light, locally available, flame proof, and dense enough to per-form well in this application. Cut pieces to shape and carefully fit in every space between each bulkhead and stringer. This first layer is a skin damper intended to stabilize the skins and thus reduce sound-induced vibration. By first eliminating as much skin vibration as possible, we reduce the amount of sound energy the second lofted layer of fiberglass has to attenuate.

Self-stick, mylar-coated closed-cell foam insulation.

The next step is to bond as much lofted fiberglass as possible to the first layer of material. The mission here is to fill all the space between the first damping layer and the backsides of the interior components. Don't overstuff the space since compressing the lofted fiberglass reduces both its acoustical and thermal performance. We use commercial non-backed 3" thick fiberglass available at local building supply stores.

Buy only tested and approved materials (the picture says it all). This stuff was taken out of a 210

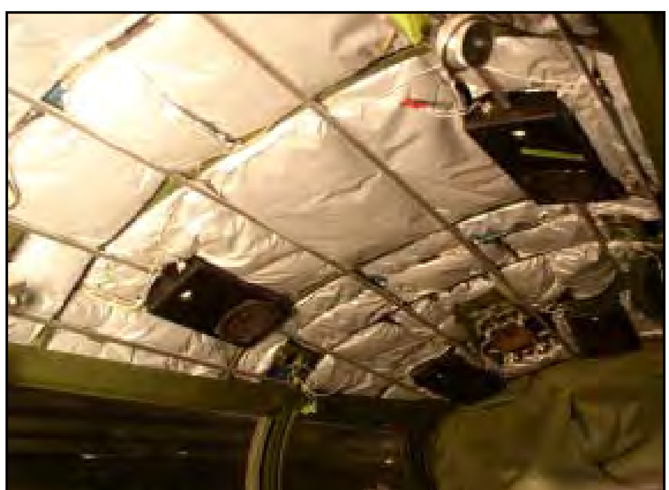
Before moving on it's important to discuss some gluing technology. We use 3M 08046 upholstery adhesive (contact cement) that is both brushable and sprayable, available at almost any automotive upholstery supply house. Read the label! I know it's the last thing we pilots like to do, but here's one time it will pay off. All contact cements are temperature and humidity sensitive and following directions will help to ensure a good bond.

Brush the glue onto the skin's surface and spray it onto the fiberglass material. Allow it to cure per the instructions on the can and stick it in place. Remember, less is more so don't apply too much glue, especially to the fiberglass. Never try to brush glue on to the fiberglass—a big mess will be the result of that effort. A cheap $30 paint gun works great and will not clog up. One final gluing detail: if you are bonding the semi-rigid first layer to a surface that is curved, score the bonded side about halfway through along the bend axis of the curve. This will allow the material to thoroughly form to the shape of that curved surface, ensuring a good bond. The proper bond between the fiberglass and the cabin skin is essential if the vibration is to be dampened as much as possible.

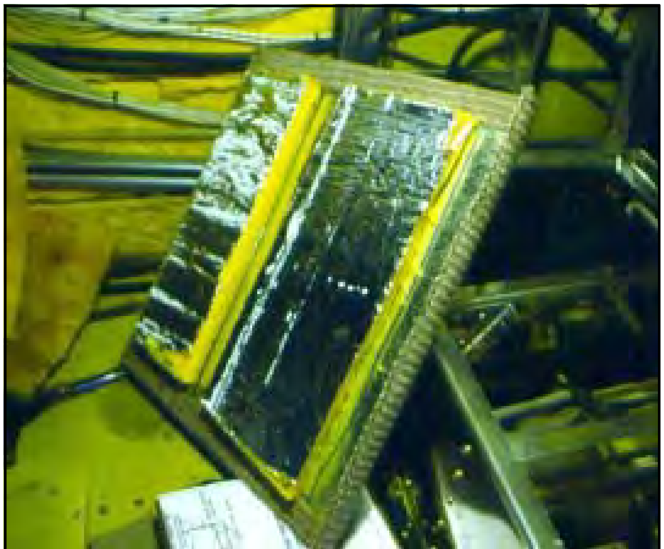
Frequency- and amplitude-specific materials as supplied in the Skandia kit, which comes with a very well written installation manual.

By now many of you are surely thinking, what about FAA approval? Well, it's quite simple. For about $75, Skandia, Inc. (815-393-4600) will test and certify these materials and provide you with the necessary flame test report and FAA 8110-3 form. We have tried all the FAA fiberglass materials out there and this stuff works as well or better than the more expensive fiberglass materials from aircraft supply houses.

The second level of insulation is to use one of the one-size-fits-all, usually closed cell foam self-stick systems you see on the market today. As with any system, corrosion removal and protection is a pre-installation must. These systems are often available in pre-cut kits as well as raw material format. Being



The Skandia kit installed in a 310R.



It's important to apply both damping and attenuating materials to the back side of the aft bulkhead access panel.

that they employ the same material for all places in the cabin they are simple to install and do produce a 4-6db reduction in sound level. The cost seems to be between $400 and $600, depending on how finished the kit is.

The final system is an engineered installation involving the installation of frequency- and amplitude-specific materials to both the inner skin, the dead space between the outer skin and the upholstery panels, and in many forward areas where damping materials are bonded to the back sides of the upholstered side panels. This system will reduce the sound level 8-9db at an installed weight of between 22 lbs (in a 172) and 40 lbs (in a 310). The kits are between $1400 and $2300. Installation labor is 40 to 60 hours. We like the system developed by Skandia; they are great folks and can ship kits on very short notice.

Even the backsides of the forward upholstery panels have damping materials bonded to them.

That's pretty much the sound proofing story as it exists today. Believe me when I say this is a very technical subject that I've tried to keep simple. Here's my personal opinion, for what its worth. If you can stand wearing active noise canceling headsets, and don't carry young children or pets, I probably wouldn't go beyond the less expensive fiberglass insulation system. Save the weight, and spend your money on something more fun for airplane. Until next time, fly safe.